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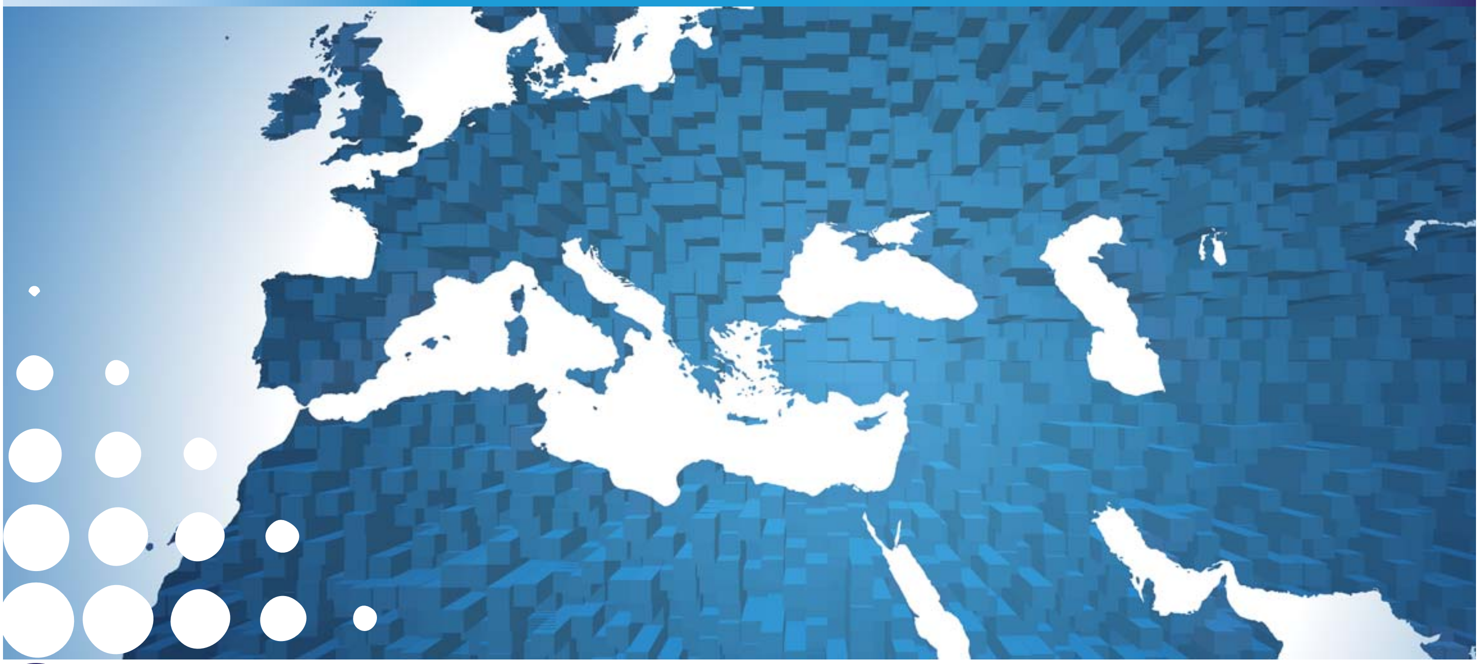

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Firm exports, innovation, … and regions.
Lessons from Spain.

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Abstract: This paper uses firm-level data for each of the Spanish NUTS2 regions to estimate the effect of product and process innovations on firm's export performance. It shows that the firm's propensity to innovate and its export activity vary substantially across regions. Remarkably, results prove that the effect of innovation on exports is far from regionally uniform. The gap in the propensity to export between innovative and non-innovative firms, conditional to other sources of firm heterogeneity, is shown to be particularly wide in regions with high extensive margin of exports. However, differences in the propensity to innovate do not originate regional disparities in the share of sales abroad by exporting firms. The evidence from Spanish firms allows us to derive some implications for the ENC. For instance, the effectiveness of the stimulus of firm's innovation to increase the share of exporting firms in these countries, and the emergence of regional polarisation due to the concentration of exporting firms in the best-endowed areas of each ENC.

Keywords: export propensity, export intensity, product and process innovations, Spanish regions, firm heterogeneity

JEL codes: F14, R10

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1. INTRODUCTION

Recent contributions to the trade literature suggest a close connection between firm's characteristics and its volume of exports. Theoretical models such as the seminal by Bernat et al (2003) and Melitz (2003) advocate that firm heterogeneity is a crucial element for explaining export activity. Actually, they are consistent with a stylised fact observed in the real world, which is that some firms in a given industry of an economy export while other firms in the same industry of that economy produce solely for the domestic market. It is firm heterogeneity within industries the origin of such difference in export status. The standard model of trade with firm heterogeneity can also account for other observed regularities regarding export activity, such as the low share of exporting firms in the economy (extensive margin), the low share of exports in firm's turnover for exporting firms (intensive margin), the higher productivity of exporting firms, and their larger size (for comprehensive surveys see Bernard et al, 2007 and Greenaway and Kneller, 2007).

Empirical studies exploiting firm-level data have provided wide evidence supporting the role played by productivity and other sources of firm heterogeneity in explaining firm export activity (Bernard and Jensen, 2004; Wagner, 2007 and 2012). Particularly, several recent papers have compared the export performance of innovative and non-innovative firms, concluding that there is a significant positive correlation between innovation and exports (Basile, 2001; Castellani and Zanfei, 2007; Cassiman and Golovko, 2011). Although it can be argued that such correlation is the result of exporting firms been more prone to innovate (e.g. Aw et al, 2007; Bratti and Felice, 2012), the evidence available so far provides strong support in favour of a causal effect of innovation on exports, particularly in the case of product innovations (Nassimbeni, 2001; Roper and Love, 2002; Nguyen et al, 2008; Caldera, 2010).

Nonetheless, all the studies that have analysed the link between innovation and firm exports so far have neglected the role of space. That is to say, they conclude on the effect of firm's innovation on its exports regardless of the particular location of the firm. However, several studies using aggregate regional data showed sharp disparities across regions in exports, that are in a way or another linked to some regional characteristics (Sun, 2001; Coughlin and Wall, 2003; Gil et al, 2008; Naudé and Gries, 2009).

Actually, a bunch of recent firm-level studies recognise the potential role played by agglomeration economies and other regional factors, and add them to the list of firm-level characteristics when explaining firm export performance (Bernard and Jensen, 2004; Koenig et al, 2010; Farole and Winkler, 2013; Rodríguez-Pose et al, 2013). Their results indicate that exports of otherwise similar firms depend on the characteristics of the regions in which they are located. However, none of these studies have put the stress on the role of innovation and, in particular, in studying if regional differences in the firm's propensity to innovate are behind those observed for the extensive and intensive margins of exports. In fact, all of them assume that the change in the propensity, and intensity, of exporting as a result of increasing firm's innovative activity is the same in all locations. In contrast, our starting point in this study is that such a response is shaped by regional factors, which causes the effect of innovation on firm exports to be regionally heterogeneous.

Our analysis provides evidence on the effect of firm's innovation on both the propensity to export and the export intensity for exporting firms, in each of the Spanish NUTS2 regions. Despite the evidence in the literature supporting the *self-selection* hypothesis is somewhat stronger than that supporting the *learning-by-exporting* hypothesis, we deal with the endogeneity of the measures of innovation when estimating the coefficients of the corresponding empirical specifications for the extensive and the intensive margins of exports. In selecting instruments for firm's innovation we follow the recent literature, which suggests using as instruments measures of education, training, and firm's investment strategy, impulses and obstacles to the innovative activity, and public support to R&D (Lachenmaier and Wößmann, 2006; Nguyen et al, 2008; Caldera, 2010). Instrumenting for innovation also prevents the bias in the estimates caused by unobservable characteristics simultaneously affecting firm's innovation and export activity. In that regard, it should be mentioned that the cross-section sample used in our analysis does not allow us controlling for unobservable firm effects, though it is rich enough to guarantee the inclusion of a large set of controls in the specifications used to estimate the effect of innovation on firm export activity (such as productivity, size, and sector of activity).

The regional effects of innovation on the extensive margin are estimated from probit (under the assumption of exogeneity of the measures of innovation) and biprobit (controlling for endogeneity of the measures of innovation) models for the probability of exporting. In turn, least square (under the assumption of exogeneity) and instrumental variables (to control for endogeneity) estimators are used to estimate the regional effects of innovation on the intensive margin from a linear specification of the share of exports in firm's total sales on the set of firm characteristics. The estimated coefficients in each region are then combined with the sample values of firm characteristics to compute counterfactual margins of exports in each region, under different scenarios for the propensity to innovate in products and in processes. Comparison of actual and counterfactual regional margins allows more intuitive assessment of the impact of regional differences in innovation on those observed in export performance.

Results from the sample of Spanish firms, and from each of the regional economies, allow us to derive some implications for the likely effectiveness of policies aiming at promoting exports in the ENC. For instance, the reported evidence suggests that the stimulus of firm's innovation (in products and in processes) is an effective policy to increase the share of exporting firms in the ENC in the medium and long term. In turn, it points to a sort of regional polarisation within each of these countries since it has been proved that increasing trade has a positive and significant association with regional disparities, this effect being significantly higher for low- and middle-income countries (Rodríguez-Pose, 2012).

The rest of the paper is organised as follows. Section 2 presents the dataset and the definition of the main variables in the analysis. It also provides a description of the amount of regional disparities in the margins of exports and on firms' innovative activity. The effect of innovation on firm's propensity to export, i.e. on the extensive margin, in each Spanish region is estimated in section 3, whereas the effect on the share of exports, i.e. the intensive margin, is obtained in section 4. In both sections, we discuss the selection of the specification used to obtain the estimates and then summarise and discuss the results. Section 5 describes the results for the counterfactual regional margins of exports obtained under alternative scenarios for the propensity to innovate. Finally, section 6 concludes and derives some implications for the ENC.

2. LITERATURE REVIEW. FIRM AND REGIONAL CHARACTERISTICS

A key ingredient of the trade literature based on firm heterogeneity is that export performance is closely linked with firm specific characteristics, whereas the aggregate features of the economy and the industrial mix play a much minor role. In fact, three types of firms are deduced from the theoretical models. A first category constituted by the less productive firms, which cannot face competition and, unless subsidised, are forced to exit the market. Firms with an intermediate level of productivity, that allows them to compete in the internal market but which is not high enough to allow them facing the extra costs of exporting and competing in foreign markets, compose a second group. Finally, there are firms with level of productivity above a threshold, which makes them competitive in foreign markets. This is the group of potentially exporting firms. In other words, only firms with high enough level of productivity are able to sale abroad, in a sort of self-selection into the export market. Actually, this theoretical argument provides an explanation for the observed positive correlation between firm's productivity and export activity.

Nowadays there is abundant empirical evidence showing that exporting firms differ in several respects from non-exporting firms (e.g. Bernard and Jensen, 2004). Exporting firms are larger, more productive, employ more physical and human capital, and are more likely to be part of a group, particularly an international one. Interestingly, they are also more innovative, in the sense that they invest more on R&D and implement more innovations. In this respect, the literature has also stressed the positive effect of, broadly speaking, innovation on firm performance, and showed that it accounts for part of the observed differences in productivity and competitiveness across otherwise similar firms (Basile, 2001; Nassimbeni, 2001; Roper and Love, 2002; Nguyen et al, 2008; Caldera, 2010; Cassiman and Golovko, 2011). However, not all types of innovations seem to exert the same effect (e.g. Hall et al, 2008). Product innovations are associated with changes in the demand of firm's output, whereas process innovations affect efficiency and productivity. Based on such arguments, it is reasonable to expect a stronger impact on export activity of product rather than of process innovations. Actually, some studies focus on the effect of only product innovations on firm's export activity (e.g. Roper and Love, 2002). In any case, the existing evidence reports a significant link between measures of innovation (in products and processes) and export activity.

Have a new product helps increase the firm's foreign demand, while improving production and/or delivering processes has an effect on firm costs and therefore on its competitiveness. Hence, the decision to sale abroad is strongly conditioned by firm's innovations, in a kind of *self-selection* process. In other words, under this view, the self-selection of innovative firms explains the positive correlation observed between firm's innovation and export activity. But this is not the only possible explanation for such a positive correlation, since it can be argued that exporting allows firms to have greater and faster access to knowledge on new products and processes, and competing in more demanding foreign markets forces them to improve continuously their products and processes. In addition, by operating in international markets, firms obtain higher returns to R&D investments as well as lower the risk of such investments by avoiding excessive fluctuations of the demand of local markets. Export is, therefore, making the firm more prone to innovate, in what has been called the *learning-by-exporting* hypothesis to explain the positive correlation between firm's innovation and exports.[1] The empirical literature investigating the link innovation-exports at the firm level provides strong support to the *self-selection* hypothesis, that is a causal link going from innovation to export activity (e.g. Basile, 2001; Nassimbeni, 2001; López and García, 2005; Cassiman et al, 2010). The evidence supporting empirically the *learning-by-exporting* explanation is somewhat weaker, although some recent studies point out that addressing appropriately the issue of endogeneity leads to not reject the causal effect of exports on innovation (Aw et al, 2007; Bustos, 2011; Bratti and Felice, 2012).

As for the spatial or regional component in the study of firm's export activity, Farole and Winkler (2013) indicate that location has typically been reduced to a control dummy in firm-level analyses (e.g. Roberts and Tybout, 1997; Bernard and Jensen, 1999). Regional dummies would be actually capturing a big deal of the differences between exporting and non-exporting firms; those originated by geography and disparities across locations in the endowment of certain characteristics. For instance, Redding and Venables (2004) advocate that geography affects countries' export

[1] Similar hypotheses have been formulated to account for the positive correlation between firm's productivity and exports (see, for instance, Wagner, 2007).

performance by easing or hindering access to foreign markets (external geography), and through the distribution of population within the country (internal geography). They show that disparities across countries in export performance depend on other domestic supply-side factors as well, such as institutional quality. In a similar vein, studies at the sub-national level have aimed at explaining differences in export performance at some aggregate regional level. Coughlin and Wall (2003) review the subnational aggregate export studies and estimate a gravity equation for the US States to show that the effect of NAFTA on merchandise exports varied sharply across states. Gil et al (2008) also estimate a gravity equation for exports in the NUTS2 Spanish regions with the aim of assessing the impact of regional trade agencies abroad. Their results indicate that the impact is not evenly distributed across the Spanish regions. A similar conclusion about regional heterogeneity is obtained by Sun (2001), regarding the role played by FDI on provincial exports in China, and by Naudé and Gries (2009) in their analysis on exports by the South African magisterial districts. The empirical evidence from the latter paper suggests that regions with a larger economy, with good access to foreign market, competitive transport costs, good institutions, and high proportion of skilled workers are more successful in terms of exports.

The evidence provided by studies using aggregate regional data on the amount of spatial disparities in the volume of exports, and on the role played by external and internal geography and domestic factors advices on the importance of including the regional dimension in firm-level studies of export performance. In the words of Farole and Winkler (2013), *although the inclusion of regional dummies in those studies might capture regional differences, they do not reveal which specific characteristics of regions determine the propensity of exporting*. With the aim of filling this gap, some of the most recent contributions to the literature on firm's export performance have replaced the set of regional dummies by proxies for geography and characteristics of the region in which each firm is located. A first group of papers explore the influence of agglomeration economies on firm's export propensity and intensity, under the assumption that market and non-market interactions of other local firms reduce the costs of exporting. Although Bernard and Jensen (2004) find no evidence that export or agglomeration spillovers affect firm's export propensity in their study for the US, most recent evidence suggests a positive external effect. For instance, using a sample of French firms Koenig (2009) and Koenig et al (2010) conclude that the pool of local exporters stimulates the decision to start exporting to a destination, this effect being larger for remote markets. They also observe the presence of export spillovers on the decision of exporting but not on the volume of exports, which is interpreted as evidence of spillovers acting through fixed rather than variable costs. In any case, the evidence from French firms confirms that the effect of other exporting firms declines with distance. Anderson and Weiss (2012) reach a similar conclusion from a sample of Swedish firms, indicating in addition that the positive effect of local exports spillovers is more intense in contract-intensive industries and for small firms.

In addition to agglomeration and export spillovers, another group of recent papers have included in the analysis of firm exports the effect of the business environment and of the institutional setting of the region in which the firm is located. That is to say, they assume that not only the firm characteristics and agglomeration economies affect firm export performance, but that regional features, such as the endowment of education and infrastructures, the investment climate, and the quality of local institutions, also exert an effect on the firm decision of exporting and on the amount of its exports. The argument is that firms in well-endowed regions take advantage of the large pool of qualified workers, the high stock of knowledge and infrastructures, and trade facilities, boosting their export potential. In contrast, firms located in regions that lack or have a lower endowment of such regional characteristics face higher costs of exporting. Results in Mukim (2012) confirm that, besides agglomeration, institutional factors in each region affect export performance of Indian manufacturing firms. Similarly, Rodríguez-Pose et al (2013) show that the regional endowment of education and transport infrastructure play a crucial role in Indonesian firms' export propensity. They also report evidence suggesting that the characteristics of the neighbouring regions matter as well in explaining firms' export performance. Whereas the above-mentioned studies exploit the information from a sample of firms in a single country, Farole and Winkler (2013) assess how firm location affects the likelihood of exporting in a large sample of manufacturing and services firms in 76 low and middle income countries. Their multi-country sample allows them to obtain results distinguishing between core and non-core regions. Interestingly, they report that firm characteristics matter more for firms located in non-core regions, whereas in core regions agglomeration economies and regional characteristics are the most important determinants of firms' exporting performance.

These recent studies thus include measures of agglomeration and regional endowments in addition to firm characteristics in empirical models aiming at explaining export propensity and intensity. By doing so, they assume that regional determinants shift export performance conditional to firm characteristics, but neglect any influence that regional factors may have on the effect of firm characteristics on exports. In other words, they impose similar effects of firm characteristics regardless of its location. In the particular case of innovation, firstly it should be mentioned that most of the studies containing the regional dimension do not include such source of firm heterogeneity. Secondly, we would like to stress that the approach followed in the above-mentioned studies (adding regional-level variables) does not account for regional specific effect of innovation on exports, since it imposes the same effect in all firms regardless of the regional environment.

In contrast, in this study we follow a different route. Instead of pooling firms in all regions and adding variables for capturing regional diversity, we estimate the effect of firm characteristics, in particular of innovation, for each region. This allows us assessing to what extent the observed differences across regions in firm's innovation activity account for regional disparities in firms export performance, taking into consideration that the effect of innovation on firm exports is likely to vary across regions. Our assumption is thus that the different regional impact of firm characteristics, particularly of innovation, results from the influence of agglomeration economies and some regional characteristics, such as those highlighted in the studies reviewed above. As far as we are aware, a similar approach has been applied only by Wagner (2008) in the study of the huge difference in the propensity to export between West and East German plants. His results confirm that the effect of plant characteristics on export propensity differ between the West and the East, and that differences in characteristics only explain 20% of the gap in export propensity between western and eastern plants (being the rest explained by differences in the effects and by unobservable factors).

3. DATA AND DESCRIPTIVE ANALYSIS

3.1. The dataset.

The study of the regional impact of firm's innovation on export performance demands data on proxies for these two magnitudes, and for other control variables of firm heterogeneity, from a sample that needs to be representative of the population of firms in each of the regions. In the particular case of Spain, such data is available from the Innovation in Companies Survey (ICS), undertaken by the Spanish Statistical Office (INE) on a yearly basis since 2002. The ICS provides detailed information on technological and non-technological innovations (organisational and marketing innovations) following a methodology based on the OCDE Oslo Manual.[2] Interestingly, the ICS also provides information on firm performance, including sales abroad, total sales, number of employees, employees with tertiary education (from 2005 onwards), and the firm's sector of activity.

The sample in the ICS is representative of firms with 10 and more employees in the agriculture, industry, construction, and services. Therefore, micro-firms are not represented in the sample, which is important information when assessing the figures on margins of trade in this paper. Since trade among micro-firms is a rather rare event whereas they account for a large share of the total number of firms in the economy, excluding them causes much higher estimates of the margins of trade in the economy. On the other hand, in this paper we focus the attention on firms in the manufacturing sector since, as in most of previous literature, we assume that they are the ones producing tradable goods, at least in a much higher proportion that firms in other sectors of activity.

Unfortunately, the ICS does not allow us to track each firm in the sample over several years, which means that we cannot treat the information as a panel data set.[3] Actually, in this paper we exploit the cross-section information corresponding to the 2005 ICS wave. In choosing that year we took into account the availability of some important data for our analysis (such as a measure of the use of human capital in the firm, that is not

[2] Information contained in the ICS is closely related to the one in the Spanish wave of the Community Innovation Survey. Further details on the ICS can be found in http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft14%2Fp061&file=inebase&L=1

[3] The Survey on Business Strategies (ESEE) and the Technological Innovation Panel (PITEC) provide information based on panel data for a sample of Spanish firms. Although it includes information on export activity, innovation, and other sources of firm heterogeneity, it does not guarantee representativeness at the regional level, and thus are not useful for the study in this paper.

available prior to that year), and that the phenomenon under study was not contaminated by the turbulence caused by the current crisis.[4]

As mentioned above, the ICS sample is designed to guarantee representativeness at the regional level. Specifically, it contains samples that represent the population of firms in each of the NUTS II regions in Spain. NUTS is the French acronym for Nomenclature of Territorial Units for Statistics, a hierarchical classification established by EUROSTAT which provides comparable regional breakdowns of EU Member States. In Spain, the NUTS II regions correspond to the 17 Autonomous Communities, which are historical, geographical, and administrative regions with a high level of political and financial autonomy. It needs to be indicated that the Spanish regions differ in terms of the size of the economy and, even more importantly for this study, as regarding the size of the manufacturing sector. This means that the number of manufacturing firms included in the sample varies markedly among regions.

As shown in the last column of Table 1, there are 14078 manufacturing firms in the sample for the entire country, whereas the number of firms in each regional sample varies from the maximum of 3118 in Catalonia –the region with the largest manufacturing sector– to the minimum, only slightly above 200 firms, in the Canary and the Balearic Islands –regions specialized in tourism with a scarce presence of manufacturing activities. Besides Catalonia, the number of firms in the sample is high in large regions and/or in those specialized in the manufacturing sector, such as Valencia, Madrid, the Basque Country, and Andalusia (sample above 1000 firms). In the opposite side, regions with a small sample size, besides the islands regions, are Extremadura, Cantabria, La Rioja, and Asturias (sample below 500 firms). Despite being representative of the population of firms in those regions, the moderate number of observations in their samples will make us to interpret with some caution the results from the estimates of the impact of innovation on trade margins for this particular group of regions.

3.2. Definition of the main variables.

[4] Results were also obtained for the ICS wave of 2009, leading to similar conclusions to the ones in this paper for the 2005 wave.

We used the primary information in the ICS 2005 to build the variables in the empirical analysis. As mentioned above, it includes the volume of total sales and of sales abroad made by the firm in the surveyed period. This information was used to compute, on the one hand, a binary variable for the firm decision to exporting, and a continuous variable for the share of exports in total sales of the firm. The latter is a truncated variable since it equals zero for non-exporting firms. The sample average of the dummy export variable is an estimate of the *extensive margin of exports* (share of exporting firms in the economy), whereas the average of the share of exports variable for exporting firms is an estimate of the *intensive margin* (share of sales abroad by exporting firms). Given this correspondence and to facilitate interpretation, we will use this terminology, extensive and intensive margins, in referring to the dummy and the continuous export variables.

As for innovation, the ICS includes detailed information on the inputs and outputs of the innovation process. Following the arguments in the previous related literature, we opted for measures of output instead of those for inputs, such as firm's R&D expenditures and personnel. Among the available output measures, we also followed the innovation-internationalization literature (e.g. Lachenmaier and Wößmann, 2006) in selecting product and process innovations implemented by the firm, and distinguished between the two types because they are supposed to have a different impact on the extensive and the intensive margins of exports.[5] Accordingly, a dummy variable was defined for *product innovations* that takes value 1 if the firm implemented some product innovation in the last two years, and 0 otherwise. Similarly, the dummy variable for *process innovations* takes value 1 if the firm implemented some process innovation in the last two years, and 0 otherwise. Finally, we computed a dummy variable that accounts for the implementation of innovation regardless of its type. This *innovation(prod/proc)* variable takes value 1 if the firm implemented product and/or process innovations, and 0 if it did not implement any innovation.

[5] In any case, we included these measures of inputs in the analysis and confirmed that their power to explain firm's export activity was much lower (and even in some cases insignificant from a statistical point of view) than the one obtained for the output measures. Similarly, other outputs of the innovative process, such as patents, also provided poorer results for all regions than those corresponding to product and process innovations. Results using this alternative measures are available upon request.

It is important to stress that the ICS defines product innovation as the introduction on the market of new goods or services, or improved in a significant way with respect to their fundamental characteristics, technical specifications, incorporated software or other intangible components, intended uses, or user friendliness. Changes of a solely aesthetic nature and the simple resale of new goods and services purchased from other companies are not considered as innovation. As for process innovation, the ICS defines it as the implementation of new and significantly improved production technologies, or new and significantly improved methods of supplying services and delivering products. In both cases, the outcome of such innovations should be significant with respect to the level of output, quality of products, or costs of production and distribution. In any case, the innovation must be for the firm, but not necessarily for the industry or the market.

Beyond export and innovation activity, the ICS includes information regarding other sources of firm heterogeneity. Concretely, we combined data on total sales and number of employees to compute a simple measure of labour productivity[6], and the number of employees with tertiary education and total employment to build an indicator of skilled labour or human capital used by the firm. In this regard, it is important to stress that the ICS includes information for these magnitudes for the surveyed year, and also for the values observed two years before. So, to prevent endogeneity of labour productivity and human capital we used the values for these variables measured in 2003.[7]

Finally, several dummy variables were defined to control for differences between firms of different size (10 to 49, 50 to 249, and 250 and more employees), branch of activity (12 manufacturing branches), and integration into a group (no part of a group, part of a national group, and part of an international group).

3.3. Exports and Innovation in Spanish regions. Descriptive analysis.

The extensive and intensive margins of exports for manufacturing firms in each of the Spanish regions and for the country as a whole are reproduced in the first two columns of Table 1. Figures indicate that slightly above 50% of the Spanish manufacturing

[6] We were not able to compute a measure of total factor productivity because data on physical capital, or any other related information, is not included in the ICS.

[7] Previous studies also included the lag of some firm characteristics to mitigate the harmful effect of potential endogeneity (e.g. Bernard and Jensen, 2004; Koenig et al, 2010).

firms exported in 2005, which is in line with the evidence reported elsewhere (see for instance Barba Navaretti et al, 2010). They also reveal sharp regional disparities in the propensity to export. Whereas the share of exporting firms were just around 35% in Andalusia, Asturias, Cantabria, Castile La Mancha, and Extremadura, the extensive margin of export was well above the country average in Catalonia (68.4%) and the Basque Country (62.1%). This can be read as the propensity to export for a representative firm in the latter group of regions almost doubling the one observed for the representative firm in the former group.

As for the intensive margin, the amount of regional disparities seems to be much lower than the one observed for the extensive margin. In the country as a whole, exports amounted at 26% of total sales for the exporting firms, while it was around 20% in regions with the lowest share and 30% in the ones with the highest. Interestingly, the intensive margin is similar in regions with opposite values for the extensive margin (such as Extremadura and Catalonia). Actually, such an evidence agrees with that reported when comparing margins for different countries, and with the argument which suggests that firm and economy-wide factors affect the decision to sale in foreign markets, but not the relative amount of sales abroad for exporting firms.

Table 1 also provides the share of manufacturing firms that innovate in product, in process, and in at least one of these two types of innovations. In the entire country, just 32.4% and 38.1% of firms reported that they implemented some product and process innovation, respectively. The share increases to almost half of the firms under the softer criteria of reporting at least one of the two types of innovation. The data also show that regions differ markedly in the firm's propensity to innovate. Whereas the share of firms reporting product innovations is 42.8% in Catalonia, 35.8% in Madrid, and 35.5% in the Basque Country, in regions such as Extremadura (15.1%), Castile La Mancha (23.1%), and Andalusia (24.1%), the share is well below the country average –not to mention the low values for the share of innovative firms in the Island regions. As for process innovation, the share of firms reporting such type of innovation is somewhat higher. In Spain as a whole 38.1% of firms did it, while the share ranges between 46.9% in Catalonia and 42.7% in the Basque Country to 21.5% in the Balearic Islands and 26.5% in Extremadura. A wide regional gap exists as well when both types of innovation are considered together regardless of the type –column labelled *Innovation (Prod/Proc)* in Table 1.

Comparing the regional figures for the extensive margin with those for the share of innovative firms (product, process, or either of the two) suggests a connection between the two magnitudes. The share of exporting firms is higher in regions where innovation is more abundant; the opposite also holds true. Actually, the correlation coefficient for the regional figures of the extensive margin and product, process, and both innovations is, respectively, 0.82, 0.84, and 0.86. Such an intense positive relationship with the measures of innovation does not seem to hold in the case of the intensive margin. As a matter of example, Catalonia and Extremadura, which were mentioned above as two regions with similar intensive margins of exports show very different figures for innovation output. The correlation coefficients are, in this case, 0.24, 0.33, and 0.28 for, respectively, product, process, and both innovations. On the other hand, it should be stressed that the correlation between the regional propensity to innovate in product and in process is as high as 0.96, suggesting a close connection between the two types of innovations.

Finally, the last column in Table 1 reproduces the figures for the average firm labour productivity in each region and in the entire country. In brief, they reveal sharp disparities across regions in average firm's productivity that, as derived by arguments in the previous literature, might be explaining part of the gap observed in export margins. Actually, the simple evidence derived from the regional aggregate figures in Table 1 suggests a positive intense correlation between the extensive margin and the average firm productivity (correlation coefficient of 0.51), and a much lower association with the intensive margin (correlation coefficient of 0.11).

All in all, results from the descriptive analysis in Table 1 confirm that i) regional disparities in export margins are sizeable, particularly in the extensive margin, ii) differences across regions in the propensity to innovate in products and processes are linked with disparities observed in firm's export activity, and iii) regional differences in informal innovations that are likely to affect firm's productivity are also correlated to the extensive margin of exports. In the following sections we further investigate these issues using the firm level data available for each region, thus controlling for other sources of firm heterogeneity that are far from homogeneously distributed across regions (such as firm size and branches of activity).

4. REGIONAL IMPACT OF INNOVATION ON THE EXTENSIVE MARGIN OF EXPORTS

This section focuses on the study of regional differences in the impact that innovation has on firm's propensity to export. The main aim is to provide evidence supporting our hypothesis that, once controlling for other sources of firm heterogeneity, the difference in export propensity between innovative and non-innovative firms varies across regions. In other words, to show that the impact of innovation on the extensive margin of exports is far from regionally uniform.

As a sort of initial evidence, we report the extensive margin of exports for innovative and non-innovative firms in each region and in the whole of Spain in Table 2. The raw data show that the extensive margin is much higher for innovative firms (regardless of the type of innovation) in all regions. Figures also indicate that the gap between innovative and non-innovative firms varies across regions, which suggests that the impact of implementing innovation on firm's export propensity might well depend on its spatial location. On the other hand, comparison of the gap in the extensive margin of exports reveals that it is somewhat wider for product than for process innovations. This agrees with the premise that having new or substantially improved goods contributes to a higher degree to the firm export opportunities than having implemented new or improved technologies of production or methods of delivery.

4.1. Empirical specification

The raw data in Table 2 is informative about the gap in the extensive margin of exports between innovative and non-innovative firms in each region. However, it neglects the effect of other sources of firm heterogeneity that might be behind the gap. To obtain an estimate of the impact of innovation on firm's propensity to export in each region, controlling for the other sources of heterogeneity, we follow Robert and Tybout (1997) in assuming that a firm will decide to export if profits obtained when exporting exceed those obtained if only serving the country market. Being π_{ir}^{exp} such difference in profits made by firm *i* in region *r* when exporting,

$$
\begin{aligned}
&export_{ir} = 1 \quad \text{if} \quad \pi_{ir}^{exp} = \beta^r Inn_{ir} + X_{ir}\gamma^r + u_{ir} > 0 \\
&export_{ir} = 0 \quad \text{otherwise}
\end{aligned} \tag{1}
$$

Therefore, the export status for each firm in each region (*export*$_{ir}$) conditional to other variables in X_{ir} is supposed to depend on firm innovation status (*Inn*$_{ir}$). Under the assumption of normality for the random component, u_{ir}, the estimate of the impact of innovation can be obtained from a probit model:

$$
P\left(export_{ir} = 1\right) = \Phi\left(\beta^r Inn_{ir} + X_{ir}\gamma^r\right) \tag{2}
$$

where Φ is the cumulative normal distribution function.

The empirical specification for the export status in (2) assumes exogeneity of the measure of innovation and the other factors in *X*. As stressed in section 3.2, the measurement of productivity and human capital in 2003 (two years before) prevents an issue of endogeneity regarding those variables, particularly in the case of productivity due to the learning-by-exporting hypothesis. But the same argument casts doubts on the exogeneity of the firm innovation status (*Inn*). Actually, as discussed in section 2, there is some evidence in the literature on the effect of export status on firm innovation activity (complementarity and learning-by-exporting hypotheses). In such a case, the probit model in (2) will provide inconsistent estimates for the impact of innovation on exports.

Since innovation is a discrete variable, the treatment of endogeneity in the framework of a probabilistic (thus non-linear) model is far from simple. Actually, the standard IV approach is not suitable in this case.[8] As in other studies in the literature analysing the link between firm innovation and export status (e.g. Aw et al, 2007; Nguyen at al, 2008; Girma et al, 2008), we opted for accounting for endogeneity by mean of the estimation of a bivariate probit model.[9] Here, we assume that a firm *i* in region *r*

[8] See for instance Cameron and Trivedi (2005) and Angrist and Pischke (2009).
[9] We also estimated the impact of innovation on export status by IV on a linear probability model. However, we preferred to focus the analysis on the bivariate probit framework given our interest in simulating the margins of exports for the Spanish regions under different scenarios of firms' innovation

implements an innovation (either of a product or a process) if the profit it obtains by doing so exceeds that of not implementing the innovation,

$$\begin{aligned} &Inn_{ir} = 1 \quad \text{if} \quad \pi_{ir}^{Inn} = Z_{ir}\delta^r + v_{ir} > 0 \\ &Inn_{ir} = 0 \quad \text{otherwise} \end{aligned} \tag{3}$$

where π_{ir}^{Inn} is the difference in profits, Inn_{ir} the innovation status, Z_{ir} the set of factors affecting that status, and v_{ir} an error term. Under the normality of the error term, the probit specification for innovation status is:

$$P\left(Inn_{ir} = 1\right) = \Phi\left(Z_{ir}\delta^r\right) \tag{4}$$

If $\text{Cov}\left(u_{ir}, v_{ir}\right) = 0$, i.e. the errors of the two decisions are independent, the univariate probit model in (2) can be used to obtain consistent estimates of the impact of innovation on export status in each region r. Otherwise, the errors of the two processes are related to one another, $\text{Cov}\left(u_{ir}, v_{ir}\right) = \rho \neq 0$, and estimates from the probit model in (2) in isolation will not be consistent. This will be the case if, for instance, unobservable firm characteristics affect simultaneously its export and innovation statuses. In such a case, consistent estimates of the impact of innovation on exports, and of the other unknown parameters, can be obtained by estimating the bivariate probit conformed by (2) and (4).

As for identification in the bivariate probit model, it needs to be said that we included in *Z* all the variables in *X* plus a set of instruments for the innovation status of the firm. Among the information available in the ICS we selected as instruments the share of firm employees with tertiary education, a dummy indicating if the firm received public financing support for innovation activities, and two variables proxying for the cost of innovation for the firm. One proxies for the importance assigned to shortage of available funds within the firm or within the group in the decision to innovate, and the other to the high cost of implementing innovations. It needs to be mentioned that in selecting the instruments we adopted the reasoning in previous studies analysing the innovation-exports relationship. Particularly, Nguyen et al (2008) include in the list of

activity. The bivariate probit model guarantees obtaining values for the predicted probabilities within the logical range, while the linear probability model does not.

instruments for innovation the number of employees with college education, whereas Caldera (2010) uses a variable measuring whether or not the firm is a recipient of public support for R&D. In turn, Lachenmaier and Wößmann (2006) exploit information regarding impulses and obstacles to innovation reported by the firm. In all cases, the authors argue that the variables influence firm innovation while are likely to be unrelated to exports. Unfortunately, proper tests do not exist to check for the validity and strength of instruments in the context of the bivariate probit model.[10]

The bivariate probit model was estimated using the three alternative measures of innovation –only product innovation, only process innovation, and product and/or process innovation.[11] It could be argued that both types of innovations could simultaneously affect the export status, and do it with different intensity. Therefore, a trivariate probit should be specified, with a separate equation for each type of innovation. However, the estimation procedure for the trivariate probit is quite demanding, computationally and in terms of number of observations to guarantee the required properties. Actually, convergence of the simulated maximum likelihood estimation method suggested in the literature to deal with trivariate and higher-dimensional normal distributions was not achieved when we implemented the procedure for some of the Spanish regions.[12] On the other hand, the exploration of the product and process innovation variables in each region indicated that a big deal of the information contained in one overlaps the information contained in the other, which means that there is not substantial improvement when including both of them simultaneously in the analysis. This was confirmed by the results obtained using the sample for the entire country and for some of the regions with the largest samples (such as Catalonia).

Finally, it should be noticed that the empirical specification in (2) does not include the lag of the firm's export status to account for the effect of sunk costs. A panel data setting is required for the econometric treatment of such a dynamic specification that, as mentioned in section 3.1, is not available in our case. Farole and Winkler (2013)

[10] As an alternative, we tested for the validity and strength of instruments using linear specifications for the probabilistic models in (1) and (3). Although we should take these results with care, they suggested that the set of instruments is appropriate.
[11] Results were obtained by means of the command biprobit in Stata 12.
[12] See Capellari and Jenkins (2003) for further details on the trivariate probit, the simulation-based estimation procedure, and its implementation in Stata (mvprobit).

face a similar issue, suggesting an alternative to the inclusion of the lag of the export status for controlling for the effect of sunk cost. They apply a threshold of 10% of export intensity to define exporters, under the assumption that they are those that have already paid the bulk of sunk entry costs. We obtained the full set of results applying their criteria to define exporters, and thus to account for sunk cost. However, the results were very close to those obtained by defining exporters using the standard criteria discussed in section 3.2, that are the ones discussed next.[13]

In the rest of this section we summarise the results obtained when estimating the impact of each type of innovation on firm's export status through the univariate probit in (2), i.e. under the assumption of exogeneity, and through the bivariate probit in (2) and (4), using the instruments described above. It is worth mentioning that the corresponding marginal effects are used to measure the impact associated to the innovation variable in the univariate and the bivariate probit models. For each region *r*, they were computed as the difference between the sample average predicted probability of exporting when Inn_{ir}=1 and when Inn_{ir}=0.

4.2. Results

To save space, we only report results on the estimates corresponding to the measures of innovation for each of the 17 Spanish regions, but not those for the full set of firm characteristics. As a matter of illustration we summarise in Table A1 of the Appendix the full results corresponding to the entire sample of manufacturing Spanish firms. It can be observed that the estimates of the marginal effects of the three measures of innovation (that will be discussed in detail next) and of the other firm characteristics are statistically significant both in the probit and in the bivariate probit specifications. On the other hand, the coefficient measuring the correlation between the error terms of exports and innovation (in equations 1 and 3) is statistically different from zero, thus supporting the bivariate probit model as the preferred specification. The detailed results for each region, measure of innovation, and each of the specifications used for the extensive and intensive margins are, in any case, available from the authors.

[13] Results corresponding to the threshold suggested in Farole and Winkler (2013) are available upon request.

Table 3 reproduces the estimated marginal effects from the univariate probit model for each region and the country as a whole. The first two columns correspond to the effects of a specification that includes simultaneously product and process innovations as separate variables. It can be observed that in the entire country and for most regions, the impact of product innovation is higher than the one of process innovation. In the entire sample of Spanish manufacturing firms, innovating in products increased the probability of exporting by 12.5 percentage points (pp), whereas firms that innovated in processes had a probability of exporting 7.2pp higher than those that did not implement any process innovation. Results also reveal disparities across regions in the effect of innovations. The estimated marginal effect for product innovation is 19.1pp in Aragon and 14.6pp in Navarra, but not statistically significant –at 5% level– in a large group of regions (Asturias, Balearic Islands, Canary Islands, Cantabria, Extremadura, and Murcia). Interestingly, the impact of process innovation seems to be stronger in some of the latter group of regions, becoming significant in Cantabria, Extremadura, and Murcia. In contrast, it is weaker than that observed for product innovation in regions such as Andalusia, Castile Leon, and Navarra.

Nevertheless, the lack of significance for the estimated marginal effect of product and process innovations in some regions when both measures are included simultaneously in the univariate probit specification could be caused by the high correlation between the two measures.[14] This suspicion is confirmed by results from the specification that includes each of the measures in isolation, reproduced in the next two columns of Table 3, and from the one that combines the two in a single variable, in the last column of the table. With the only exception of the islands, the marginal effects are significant in all regions in these specifications. In any case, results confirm that the effect of product innovation is somewhat higher than the one of process innovation in the entire country and in most regions, and that the impact of product and process innovations differs across regions, once other sources of firm heterogeneity are accounted for. As a matter of example, the net difference in the probability of exporting for innovative firms vis-à-vis non-innovative firms is around 20pp in Aragon and Extremadura, whereas is just slightly above 10pp in Asturias, Castile Leon, and Murcia.

[14] In the sample for the entire country the correlation between the two types of innovations is 0.44, while it is between 0.4 and 0.5 in almost all regional samples.

As mentioned above, estimated marginal effects obtained from the univariate probit model will be inconsistent in case of endogeneity of the innovation measures. Under such circumstance we advocate computing the marginal effects from the bivariate probit model using the instruments described in section 4.1. Results are summarised in Table 4. It can be observed that the estimated marginal effects are much higher than those obtained when assuming exogeneity. For the country as a whole, after controlling for other sources of firm heterogeneity, the probability of exporting for innovative firms was more than 30pp higher than for firms that did not innovate. In any case, these results also confirm substantial disparities across regions in the impact of innovation. The estimated increase in the probability of exporting associated to product innovation is as high as 44pp for firms in Aragon and the Basque Country, 39pp in Asturias, and 38pp in Valencia. On the opposite side, apart from the island regions, the lowest impact is shown by firms in Castile La Mancha (26pp), Cantabria (25pp), and Castile Leon (21.5pp). Regional disparities are also observed in the impact of process innovation, with the highest marginal effect in Valencia (38pp), Madrid (37pp), and the Basque Country (37pp), and the lowest in Andalusia (24.4pp), Castile La Mancha (21.3pp), and Castile Leon (16.5pp). Accordingly, a similar pattern is observed when the two types of innovation are combined in a single variable, as shown by the estimated marginal effects in the last column of Table 4.[15]

As a general rule, we can say that the marginal effect of innovation is higher in regions with high extensive margins of exports, with the opposite being true as well. Actually, the correlation coefficient for the extensive margin of exports in each region and the corresponding marginal effect of product innovation, process innovation, and the combination of the two innovations is, respectively 0.60, 0.77, and 0.76. Therefore, combining this evidence on the impact of innovation with that from the descriptive analysis in section 3, led us to conclude that firms in regions with a high extensive margin of exports tended to innovate more than firms in regions with a lower margin and, in addition, they obtained a higher payoff from innovations in terms of export status.

[15] The bivariate probit model does not allow considering the effect of the two types of innovations simultaneously. We explored further this issue by estimating by IV a linear probability model for the probability of exporting, using a linear model as well for the innovation status in the first-stage equations. When the two types of innovations were included in the equation for export status, strong colinearity between the two variables caused highly unstable estimates of all the coefficients in the model.

5. REGIONAL IMPACT OF INNOVATION ON THE INTENSIVE MARGIN OF EXPORTS

In this section we assess regional disparities in the impact that innovation has on export intensity for exporting firms. That is to say, we analyse if the effect that product and process innovations have on the intensive margin of exports varies across regions. In doing so, we complement the analysis performed in the previous section regarding the effect of innovation on the extensive margin of exports in each region.

As a sort of preliminary evidence, Table 5 shows the intensive margin of exports for each region and the country as a whole, distinguishing between innovative and non-innovative firms. As in the case of the extensive margin, the three measures of innovation (only product, only process, and at least one of the two types) are used in the analysis. As already mentioned in section 3.3, the intensive margin is much lower than the extensive margin in all regions, regardless of the firm propensity to innovate. Figures in Table 5 also show that the gap in the intensive margin between innovative and non-innovative firms is much narrower than the one discussed for the extensive margin in the previous section. This is so for the three measures of innovation, although some regional disparities can also be observed. For instance, the gap is sizeable in Asturias, Catalonia, Madrid, Navarra, and the Basque Country, whereas it is almost negligible in some other regions such as Andalusia, Valencia, and La Rioja. Finally, it is worth mentioning that the analysis for the intensive margin in this section uses only the sample of exporting firms in each region, which imposes further limitations as regards the number of observations available to estimate the impact of innovation in some particular regions. Although for the sake of completeness we include in this section results for all regions, those corresponding to the Balearic Islands, Canary Islands, Extremadura, Cantabria and, to a lesser degree, Asturias should be interpreted with caution due to the limited number of available observations.

5.1. Empirical specification

The moderate, and even negligible for some regions, difference in the intensive margin of exports between innovative and non-innovate firms suggests that the impact of innovation on firm export intensity is likely to be modest in all regions. However, such perception is based on the analysis of the raw figures for the intensive margins, and thus does not account for the effect of other sources of firm heterogeneity. As in the case of the extensive margin, we should obtain the impact of innovation on the intensive margin in each region conditional to the effect of other firm characteristics. As in much of the contributions to the previous literature, we formulate an empirical specification linking the share of firm sales abroad to its innovation status and the other observable characteristics:

$$margint_{ir} = \alpha^r Inn_{ir} + X_{ir}\tau^r + \varepsilon_{ir} \tag{5}$$

where *margint* denotes the intensive margin of exports, *Inn* the corresponding measure of innovation, *X* is a matrix with the other variables accounting for sources of firm heterogeneity different from innovation, and ε is a well-behaved error term. It should be noticed that the impact of innovation, α^r, and of the other variables in *X*, τ^r, are allowed to vary across regions.

Since the intensive margin equals zero for non-exporting firms, the specification in (5) corresponds to a corner-solution model (Cragg, 1971; Wooldridge, 2002). Actually, the analysis in the previous section already dealt with the modelling of the mass of probability at zero value, while in this section our interest is on the impact of innovation on the share of sales abroad just for exporting firms.[16] Therefore, specification in (5) for exporting firms corresponds to a truncated model, which means that the OLS estimator, based on the assumption of a linear model, will not provide consistent estimates of the effect of the variables of interest for the sample of exporting firms. However, the implementation of an alternative estimator abled to account simultaneously for truncation and endogeneity of innovation status is far from straightforward. Fortunately, estimators based on the assumption of linearity, and thus leaving aside the control for truncation, have been shown to provide similar results than those accounting for truncation in the sample average of the variables under analysis (Wooldridge, 2002). For these reasons, in this section we show and discuss the impact

[16] Notice that the so-called Tobit model is not appropriate in this case as it imposes the same effect of firm characteristics for the extensive and the intensive margins. The two-parts model proposed by Cragg (1971) is more appropriate under such circumstance.

of innovation on the intensive margin in each region based on the OLS and the IV estimates of the specification in (5).[17]

5.2. Results

As in the case of the extensive margin, space constraints prevent the reproduction in this section of the full set of estimates for all regions. Instead, we only reproduce the estimated effect of innovation in each region and, as a kind of synthetic evidence, the full set of results for the entire sample of manufacturing Spanish firms, in Table A2 in the Appendix. Besides the evidence on the effect of innovation that will be discussed in detail next, results in this table confirm the significant effect of firm characteristics on the share of sales abroad. Interestingly, the only exception is the effect associated to productivity. That is to say, once controlling for the full set of observable firm characteristics and the location of the firm, there is no evidence of a significant effect of productivity on the intensive margin of exports. On the other hand, results on the battery of tests of endogeneity and appropriateness of the instruments used in the IV estimation, confirm the endogeneity of the measures of innovation and the suitability of the instruments used.

Table 6 displays the OLS estimate of the impact of innovation on the intensive margin in each region and for each measure of innovation. The first two columns of results correspond to the specification that includes simultaneously the variable for product innovation and the one for process innovation. As indicated above in the case of the analysis for the extensive margin, both variables are highly correlated and thus colinearity is likely to affect somehow the precision of the estimates. The next three columns correspond to estimates from the specification that includes each of the measures in isolation. It is observed that for the entire sample of Spanish exporting firms, innovation stimulates the share of sales abroad, though with a moderate impact. The intensive margin for innovative firms is between 2pp and 3pp higher than for

[17] As an alternative to OLS we estimated the Cragg model, thus controlling for truncation in the distribution of the intensive margin. However, as suggested in Wooldridge (2002), the corresponding sample average marginal effect of innovation conditional to exporting in each region was very close to estimates obtained by applying OLS to the specification in (5) using the sample of exporting firms (results available upon request). We therefore base our confidence on results from the IV estimator in a similar (non-checkable) correspondence.

otherwise similar non-innovative firms.[18] In any case, the effect of product innovations seems to be a bit higher than the one associated to process innovations. As for regional results, they suggest that the significant effect observed in the entire Spanish sample is driven by the impact of innovation on the intensive margin in a small number of regions. Actually, the estimated effect of product innovation is statistically significant only in Asturias, Catalonia and, marginally, in Navarra and the Basque Country. As for process innovation it is only in Catalonia, Madrid, and Cantabria (though we should be cautious in the case of the last region due to the low number of available observations).

Controlling for endogeneity of the measures of innovation does not change the general picture derived from results in Table 6. Results of the impact of innovation from the two-stage least square estimates are collected in Table 7. The same set of instruments discussed in section 4.1 was used here to analyse the impact on the intensive margin. It is observed that controlling for endogeneity causes an increase in the estimated effect of innovation (to around 10pp in the country as a whole). But still, the effect is statistically significant in a low number of regions, although this seems to be driven by large standard errors in some regions (particularly in those with a limited number of observations). In any case, results from Tables 6 and 7 allow us to conclude that the effect of innovation on the firm share of sales abroad is rather limited and even negligible in most Spanish regions. This being in sharp contrast with the key role played by innovation on firm export status as reported in the previous section. Evidence from Spanish regions thus confirms that innovation has a substantial effect on firms export status, but a rather limited impact on sales abroad by firms already exporting.

6. COUNTERFACTUAL REGIONAL EXPORT MARGINS UNDER DIFFERENT INNOVATION SCENARIOS

As a final step in our analysis of the impact of differences in firm's innovation activity on the amount of disparities observed across the Spanish regions in the margins of

[18] As indicated in footnote 17, the sample average effects estimated from the truncated specification are quite similar to those obtained by estimating the parameters of the specification in (5) by OLS. As a matter of example, for the entire sample of Spanish firms, the estimated effect was 0.029, 0.027, and 0.037 for product, process, and both types of innovations, respectively. They are thus very close to those reported in Table 6 for the OLS estimates.

exports, in this section we discuss the results of a simple counterfactual exercise. Using the sample values for the set of firm characteristics in X, and the estimate of the corresponding parameters for each region *r*, obtained in sections 4 and 5, we compute counterfactual extensive and intensive margins for each Spanish region under alternative scenarios for the share of innovative firms.

More precisely, a counterfactual extensive margin of exports for region *r* is obtained by averaging the marginal predicted probability of exporting for each firm i in *r*, using the estimate of the parameters from the bivariate probit model in region *r*:

$$margext_r^{count} = \Phi \ \beta^r Inn_r^{count} + X_{\iota r}\gamma^r \tag{6}$$

where $margext_r^{count}$ is the counterfactual extensive margin, the bar over the expression in the LHS denotes the sample average, the ^ over the coefficients the estimates from the bivariate probit discussed in section 4, and Φ the cumulative normal distribution function as in (2). The key point here is that the marginal predicted probability of exporting for each firm in region *r* is computed by assigning it a common counterfactual propensity to innovate, Inn_r^{count}, instead of the actual value observed for the firm's innovation status, Inn_{ir}. That is to say, the counterfactual extensive margin obtained for each region by means of (6) imposes the same propensity to innovate to each firm in each Spanish region. Concretely, results were obtained using the share of innovative firms observed in Catalonia as the common counterfactual propensity to innovate. As indicated in section 3.3 (see Table 1), Catalonia is the region with the highest share of innovative firms (both in product and process), being therefore an appropriate target for the other regions.

A similar procedure was used to obtain the counterfactual intensive margin of exports, using the specification in (5) and the 2SLS estimates for each region discussed in section 5:

$$margint_r^{count} = \alpha^r Inn_r^{count} + X_{\iota r}\tau^r \tag{7}$$

where $margint_r^{count}$ denotes the counterfactual intensive margin, and the symbols used in this expression are similar to those described above for (6). It should be mentioned that in this case we used the share of innovative firms among the exporters in Catalonia as the benchmark. It can be observed in Table A3 in the Appendix that Catalonia is the region that showed the highest share of innovative firms in the subsample of exporting firms.

Comparing the counterfactual export margins with the actual values allows us to evaluate the expected impact of increasing the firm's propensity to innovate in each region to the level shown by an average manufacturing firm in Catalonia. It is worth noting that the expected impact for a region will depend both on its distance to the innovation propensity target, and on the particular effect of innovation on export activity (status and intensity) on that region.

Differences between counterfactual and actual extensive and intensive margins of exports in each region and in the entire country are displayed in Table 8. In accordance with the estimates for the impact of innovation obtained in the previous sections, the change in the extensive margin as a result of the increase in the share of innovative firms is far more pronounced than the change caused in the intensive margin. This is so for the entire country and for most regions. Increasing the propensity to innovate in products for the average manufacturing Spanish firm to the level observed for the average Catalan firm would cause an increase in the Spanish extensive margin of exports of 4.3pp. The change in the extensive margin is much lower if the increase is in process innovation (0.85pp), being a bit less than 4pp when there is no distinction between the two types of innovations. In contrast, the change in the intensive margin is lower than 1pp regardless of the measure of innovation used in the analysis.

Changes in the extensive and intensive margins reported in Table 8 differ across regions because there exist differences in the propensity to innovate of their firms with respect to the one of Catalan firms (as revealed by figures in Table 1), and also because the estimated impact of innovation on export margins differ across regions (as shown in the previous sections). In any case, results of this simple counterfactual exercise suggest that the increase in the share of exporting firms would be substantial in regions with an actual low extensive margin, particularly when we compute the counterfactual extensive margin changing the values of product innovations or the joint measure of innovation. In those cases, it is obtained an increase of above 10% (change in extensive margin over the actual value) in regions with an extensive margin far below the country average, such as Andalusia, Asturias, Cantabria, Castile La Mancha, and Extremadura.[19] Results also indicate that, with few exceptions (Extremadura and La Rioja), increasing the share of firms innovating in processes up to the level observed in Catalonia would have a rather limited impact on the extensive margin of the Spanish regions.

As for the change observed in the intensive margin, results in the right panel of Table 8 show different regional responses as well. However, broadly speaking, the relative magnitude of the change in the intensive margin caused by the increase in the propensity to innovate in each region is lower than that obtained for the extensive margin. This is the consequence of the lower estimate of the marginal effect of innovation in the case of the intensive margin with respect to the one estimated for the extensive margin.

Finally, we also computed counterfactual margins of exports for each region and the country as a whole, by modifying not only the propensity to innovate but also firms' labour productivity. As mentioned in section 2, it can be argued that innovations other than those in products and processes are likely to affect export activity through improving firm's productivity. It might be also the case that past innovations determine current productivity. Undoubtedly, there are sources of disparities in firm productivity other than those linked to innovation, but there is strong empirical evidence indicating that innovation indeed constitutes the most important source of productivity differences between firms (e.g. Crepon et al, 1998; Griffith et al, 2006; Cassiman and Golovko, 2011). Therefore, we believe it is interesting to make a further assessment of the regional impact of innovation considering the simultaneous effect of regional differences in the level of firm's productivity. In fact, the figures in Table 1 and Table A3 indicate large disparities between regions in the average productivity of firms, suggesting the critical role of this magnitude in explaining regional differences in export performance. Results of the counterfactual exercise are summarised in Table 9. It is clearly observed that increasing simultaneously the share of innovative firms and the level of productivity to the values observed in Catalan manufacturing firms raises

[19] We do not add to this group the Balearic and Canary Islands due to the particularities commented above for these two regions. Also notice that the non-linearity of the model for the extensive margin causes a value of the counterfactual margin for Catalonia, obtained by averaging across the sample of Catalan firms, that slightly differs from the actual one.

substantially the extensive margin of exports in all regions. Actually, the change in the margin is between two and three times the one obtained before when only increasing the propensity to innovate. The change in the counterfactual extensive margin with respect to the actual margin for the country as a whole ranges between 10pp and 12.7pp, depending on the measure of innovation used to compute the results.

Still, results show large regional disparities in these figures, which are now caused by differences in the innovation and productivity gaps of each region with respect to Catalonia, and by regional heterogeneity in the effect of innovation and productivity on firm export status. As a matter of example, the extensive margin in Asturias would rise to 55.11% if the share of firms that innovate in products was similar to the one observed in Catalonia, and the level of labour productivity of all its firms were as that observed for the average Catalan firm. As expected, the change in the margin is much lower in regions with values for these two magnitudes much closer to those in Catalonia, such as Madrid, Navarra, and the Basque Country.

As for the counterfactual intensive margin, results in the right panel of Table 9 are essentially similar to those commented before regarding the modification in the share of innovative firms only. The change in the intensive margin is much lower than that observed for the extensive one in all regions and in the country as a whole. This evidence thus confirms that the increase in the propensity to innovate and in the level of productivity would substantially encourage firm’s decision to export in all regions, but would have an almost negligible effect on the share of sales abroad made by exporting firms.

7. CONCLUDING COMMENTS

This paper has provided evidence on the effect of firm innovation on export performance from a regional viewpoint. So far, previous contributions have reported a positive effect of innovation (particularly in new products) on the firm’s export status, but none of them have checked if such effect varies with the location of the firm. Using firm-level data, we have shown that innovative firms are more prone to export than otherwise similar non-innovative firms, in all Spanish NUTS2 regions. However, our results indicate that the effect of innovation is far from regionally uniform. On the contrary, the increase in the propensity of exporting due to innovation has been estimated to be larger in regions where the extensive margin of exports is high; this result being robust to the alternative measures of innovation considered in the analysis. Regional disparities have been reported also for the effect of innovation on the share of sales abroad by exporting firms. However, the impact of innovation on the intensive margin of exports is moderate, and even negligible, in most regions, which lead us to conclude that the regionally differentiated effect of innovation on exports is due mostly to differences in its effect on the extensive margin.

The evidence on the differentiated regional effect of innovation on firm’s exports is a novelty in the literature, since previous studies have added either regional dummies or controls for regional endowments and agglomeration economies, but have imposed the same response of exports to the set of firm characteristics. In contrast, in the modelling strategy followed in this paper, the impact of regional factors and agglomeration is captured by the region-specific intercept of the specifications for the export margins, whilst the impact of firm characteristics, particularly of innovation, is allowed to differ between regions as a result of the influence of the particular conditions in each region. Actually, none of the previous studies that included a regional dimension in the analysis of firm’s export performance put the stress on the effect of innovation. Our results confirm the key role played by firm’s innovative activity and suggest that the particular location of the firm should be considered when assessing its contribution to stimulate firm’s export propensity.

Although the investigation of the sources of the observed regional disparities in the effect of innovation on firm’s exports is beyond the scope of this paper, we can speculate that regional differences in export sunk costs might be causing differences across regions in the export’s response to innovation. Innovation contributes to raising future firm’s productivity and/or to having more attractive products, and thus to making easier for the firm to face the extra costs of exporting. Even under the assumption that firms in all regions are similarly effective in translating innovation into higher productivity and competitiveness, it is sensible to think that geography, agglomeration, and certain regional endowments cause differences across regions in sunk costs. As a result, the benefits of innovation allow covering extra exporting cost for firms in some regions but not in others. This argument can explain the greater effect of innovation on export status estimated for regions with a high extensive margin of exports. The deeper study of this hypothesis is in our future research agenda.

Results from the sample of Spanish firms, and from each of the regional economies, allow us to derive some implications for the likely effectiveness of policies aiming at promoting exports in the ENC. For instance, the reported evidence suggests that the stimulus of firm's innovation (in products and in processes) is an effective policy to increase the share of exporting firms in the ENC in the medium and long term. Innovation, developed by firms within the ENC or generated elsewhere but adopted by firms in these countries, increases competitiveness and thus the chances to sale abroad, raising the volume of exports from ENC. Our results also imply that for the direct policies aiming at stimulating exports in the short run to be effective, they should focus on innovative firms from the ENC with a level of productivity above a given threshold. They are the group of firms with the highest chances of success in foreign markets and therefore they should be the target of such direct policies designed to facilitate sales abroad (by means of providing information, credits, easing contacts with potential costumers, etc).

Finally, our results warn of a sort of regional or spatial divide in the ENC as a result of the increase in the export potential of these countries. The increase in the number of exporting firms is expected to be more pronounced in certain areas within each ENC, which will cause polarization in the spatial distribution of production and income in these economies. This is in line with the evidence provided by Rodríguez-Pose (2012) regarding the link between openness and within-country regional inequality. He stresses that in combination with certain country-specific conditions, trade has a positive and significant association with regional disparities, such an effect being significantly higher for low- and middle-income countries.

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