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Firm exports, innovation, and the regional dimension in Spain.

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Abstract:

Firm-level data is used to estimate the effect of product and process innovations on firms' exports in each Spanish NUTS2 region. Results show 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. An immediate implication is that policies aiming at stimulating innovation, which are likely to be effective in increasing the number of exporting firms, will not exert the same effect in all regions.

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

JEL codes: O31, R12, F19

1. Introduction

Different studies have provided empirical support for the existence of a close link between firms' exports and productivity and other sources of firm heterogeneity (Bernard, Eaton, Jensen, and Kortum, 2003; Bernard and Jensen, 2004; Melitz, 2003). Some of these studies have compared the export performance of innovative and non-innovative firms, concluding in favour of a significant positive correlation between innovation and exports (Aw, Roberts, and Winston, 2007; Becker and Egger, 2013; Bratti and Felice, 2012; Caldera, 2010).

Nonetheless, all the studies that have analysed the link between innovation and firm exports so far have neglected the role of space, despite several studies using aggregated regional data having shown sharp disparities across regions in exports that are linked in one way or another to some regional characteristics (Gil, Llorca, and Serrano, 2008; Nicolini, 2003). Similarly, the still small number of firm-level studies that have recognized the potential role played by regional factors have concluded that the export activity of similar firms in different regions varies depending on the characteristics of the region in which they are located (Farole and Winkler, 2014; Rodríguez-Pose, Tselio, Winkler, and Farole, 2013). However, none of these studies have stressed the role of innovation and in particular studied whether the regional differences in firms' propensity to innovate are behind those observed in their export activity.

Against this background this paper hypothesizes that differences across regions in firms' innovation performance account for an important portion of the territorial disparities observed in export activity. More precisely, the main objective of the paper is to show that, in addition to the well-known disparities in the amount of innovation, regions also differ in the effect that innovation has on firms' propensity to export. From the evidence supporting the causal effect of innovation on firms' exports (Basile, 2001; Becker and Egger, 2013; Brancati, Marrocu, Romagnoli, and Usai 2015; Cassiman, Golovko, and Martínez-Ros, 2010), it can be inferred

that policies favouring innovation will also be effective in enhancing firms' export performance. However, the immediate implication of the hypothesis in this paper is that a similar increase in innovation activity induced by a policy intervention would not necessarily have the same effect on export performance in all regions. Hence, this potential source of heterogeneity should be taken into account when the intervention is designed. To the authors' knowledge, regional heterogeneity in the effect of innovation on exports has not been considered in the literature so far. In this regard it is worthwhile noting that accounting for regional heterogeneity is far less feasible if the analysis of the relationship between innovation and exports is performed using aggregated data at the regional level. In addition, using the macro-level approach to studying the effect of innovation on exports would not allow researchers to control for important sources of firm heterogeneity (such as size, sector of activity, and productivity), increasing the chance of falling into an ecological fallacy.

The contribution of innovation to regional disparities in firms' export performance is analysed using a representative sample of manufacturing firms in each of the Spanish NUTS2 regions. To be clear, in the first stage, the effect of product and process innovation on the probability of exporting for the firms in each Spanish region is estimated using a bivariate probit model, which aims to control for endogeneity of the measures of innovation. In the second stage, the estimated coefficients for each region are combined with the sample values of firm characteristics to compute counterfactual average propensities to export in each region in a counterfactual scenario for the propensity to innovate in products and processes. A comparison of actual and counterfactual regional export propensities provides an intuitive assessment of the impact of regional differences in innovation on those observed in export performance.

Spain is an interesting case study for different reasons. In the first place, there are marked differences in the export activity of its regions. Two regions on the Mediterranean coast (Catalonia and Valencia) and the region of Madrid account for about 55% of the total number of exporting firms in the country and 50% of the total volume of Spanish exports. In relation to the size of the regional economy, the export activity is particularly intense in some regions whilst the contribution of exports in some others is much less important. For instance, the share of exports in the region's GDP is far above the country average in the most developed and industrialized regions (e.g. the Basque Country, Navarre, Aragon, and Catalonia) and below the average in the traditionally less competitive regions (e.g. Extremadura, Castile-La Mancha, and Andalusia). Interestingly, the contribution of exports is relatively low in Madrid, due to the particular features of its economy as a capital city-region, and in the two island regions, highly specialized in tourism activities, while it is very high in Galicia, due to the presence of dynamic activities that are highly oriented towards foreign markets. In addition, the analysis in this paper is motivated by the large regional disparities in innovation activity in Spain. For example, the total intramural R&D expenditure over the GDP is several times higher in regions such as the Basque Country, Navarre, Madrid, and Catalonia when compared with the regions with the lowest R&D intensity (Castile-La Mancha, Extremadura, and the Balearic and Canary Islands). Unsurprisingly, similar disparities are observed in the spatial distribution of patent applications as an output measure of the innovation process.[1] Finally, it is worth noting that the Spanish regions have the competence to develop and implement policies to stimulate both the innovation and the exports of the firms located within their borders (e.g. Fernández, Mas-Verdú, and Tortosa, 2010; Gil et al., 2008). The hypothesis in this study implies that increasing the coordination of the regional agencies in charge of these policies is likely to be more effective in increasing the competitiveness of the firms in the region and hence in improving their export performance.

The rest of the paper is organized as follows. The next section briefly reviews the related literature, emphasizing the contributions that have highlighted the role played by location and regional factors in firm export activity. Section 3 presents the data and the definition of the main variables in the analysis. It also provides a description of the amount of regional disparities in firms' export and innovation activities. The effect of innovation on firms' propensity to export in each Spanish region is estimated in section 4, whereas section 5 describes the results for the counterfactual export activity in each region obtained in an alternative scenario for the propensity to innovate. Finally, section 6 concludes.

2. Brief Literature Review

The empirical evidence showing that exporting firms differ in several respects from non-exporting firms is abundant (e.g. Bernard and Jensen, 2004; Bernard, Jensen, Redding, and Schott, 2007). In particular, the literature has stressed the positive effect of innovation on firm performance and showed that it accounts for some of the observed differences in competitiveness across otherwise similar firms (Basile, 2001; Caldera, 2010; Cassiman and Golovko, 2011; Roper and Love, 2002). Having a new product helps to increase firms' foreign demand, while improving production and/or delivery processes has an effect on their costs and therefore on their competitiveness. Hence, the decision to sell abroad is strongly conditioned by firms' innovations, in a *self-selection* process, which may explain the positive correlation observed between firms' innovation and their export activity. However, 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 about new products and processes and that competing in more demanding foreign markets forces them to improve their products and processes continuously (the *learning-by-exporting* hypothesis). In addition, operating in international markets, firms obtain higher returns to R&D investments while reducing the risk of such investments by avoiding excessive fluctuations in the demand of

local markets. Therefore, exporting makes firms more prone to innovate. The empirical literature investigating the innovation–exports link has provided strong support for the *self-selection* hypothesis (e.g. Basile, 2001; Becker and Egger, 2013; Cassiman et al., 2010). The evidence that empirically supports the *learning-by-exporting* explanation is somewhat weaker, although some recent studies have pointed out that addressing the issue of endogeneity appropriately leads to not rejecting the causal effect of exports on innovation (Aw et al., 2007; Bratti and Felice, 2012; Bustos, 2011; Love and Ganotakis, 2013). In any case the strong evidence on the interplay between firms' innovation and their internationalization (with exports as one of its components) led Altomonte, Aquilante, Békés, and Ottaviano (2013) to suggest better coordination of internationalization and innovation policies.

Although evidence based on the analysis of regional exports has revealed sizeable territorial differences in the amount of trade flows, consideration of the regional dimension in the study of firms' export activity remains scarce. As indicated by Farole and Winkler (2014), location has typically been reduced to a control dummy in firm-level analyses. Regional dummies would capture differences across regions in exports originated by geography and disparities across locations in some socio-economic features and in the endowment and quality of the infrastructures that facilitate exports (see for instance Márquez-Ramos, 2016; Naudé and Gries, 2009; Nicolini, 2003). In fact, it is reasonable to think that these factors are behind the regionally differentiated impact of some trade agreements and policies designed to stimulate exports (Coughlin and Wall, 2003; Gil et al., 2008). In any case this evidence provided by studies using aggregated regional data on exports and their determinants advises on the importance of including the regional dimension in studies analysing export performance at the firm level. In this regard some of the most recent contributions to the literature on firms'

export performance have replaced the set of regional dummies with proxies for the geography and characteristics of the region in which each firm is located.

A group of papers explored the influence of agglomeration economies on firm exports under the assumption that market and non-market interactions of other local firms reduce the costs of exporting. Although Bernard and Jensen (2004) did not find evidence on the effect of agglomeration spillovers on firms' export propensity in their study for the US, the most recent evidence has suggested a positive external effect (Anderson and Weiss, 2012; Koenig, 2009; Koenig, Mayneris, and Poncet, 2010). In addition to agglomeration, another group of recent papers has included in the analysis of firm exports the effect of the business environment and the institutional setting of the region in which the firm is located. They have assumed that not only firm characteristics and agglomeration economies affect firm export performance. Regional features, such as the endowment of education and infrastructures, the investment climate, and the quality of local institutions, may also exert an impact on firms' decision to export (Farole and Winkler, 2014; Mukim, 2012; Rodríguez-Pose et al., 2013).[2]

These recent studies include measures of agglomeration and regional endowments in addition to firm characteristics in empirical models aiming to explain firms' export activity,[3] assuming that regional determinants shift export performance conditional on 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 firms' characteristics regardless of their location. In the case of interest to our study, it should be noted first that most studies incorporating the regional dimension have not included innovation as a source of firm heterogeneity. Secondly, the approach followed in the above-mentioned studies (adding regional-level variables to the specification of firm-level export activity) does not account for the region-specific effect of innovation on exports, since it imposes the same impact on all

firms regardless of the regional context. Conversely, in this study we estimate a separate effect of innovation in each region. This allows us to assess the soundness of the study's hypothesis, that is, the extent to which the observed differences across regions in firms' innovation activity account for regional disparities in export performance, taking into consideration the fact that the effect of innovation on firm exports is likely to vary across regions.

3. Data and Descriptive Analysis

The Data Set

The study of the impact of firms' innovation on export performance in each region demands data on proxies for these two magnitudes, and for other sources of firm heterogeneity, from a sample that needs to be representative of the population of firms in each region. In Spain such data are available from the Innovation in Companies Survey (ICS) undertaken by the Spanish Statistical Office. The ICS provides detailed information on technological and non-technological innovations following a methodology based on the OECD Oslo Manual. Interestingly, the ICS also provides information on firm performance, including sales abroad and total sales, as well as some characteristics such as firms' size and sector of activity.

The sample in the ICS is representative of firms with 10 or more employees in all branches of activity. However, this paper focuses on firms in the manufacturing sector, since, as in most of the previous literature, it is assumed that they are the ones producing tradable goods, at least in a much larger proportion than firms in other sectors of activity. The information corresponding to the 2005 ICS wave was exploited. The choice of that year took into account the availability of the firm-level data required for the analysis and the fact that the phenomenon under study was not contaminated by the turbulence caused by the great

recession.[4] Unfortunately, the ICS did not allow us to track each firm in the sample over several years, which means that the information could not be treated as a panel data set.[5] However, the ICS sample was 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. They correspond to the 17 autonomous communities, which are historical, geographical, and administrative regions with a high level of political and financial autonomy, including the promotion of trade and innovation within their boundaries.

It should be noted that the size of the manufacturing sector varies between the Spanish regions. This means that the number of manufacturing firms included in the sample varies markedly among regions: from a maximum of 3118 in Catalonia – the region with the largest manufacturing sector – to a minimum of only slightly above 200 firms in the Canary and the Balearic Islands – regions specializing in tourism with scarce manufacturing activities (see last column of Table 1). In any case it should be mentioned that the size of the entire sample, 14078 manufacturing firms, is large enough to guarantee the quality of the estimates provided in the following sections.

Definition of the Main Variables

As mentioned above, the ICS 2005 includes the volume of total sales and sales abroad in the surveyed period. This information was used to compute a binary variable for the firm decision on exporting, which equals 1 if the firm exported in 2005 and 0 otherwise. The sample average of the binary export variable in each region is an estimate of its *extensive margin of exports* (i.e. the share of exporting firms in the region).

As for innovation, the ICS includes detailed information on the inputs and outputs of the innovation process. Following the arguments in the previous literature, measures of outputs

rather than measures of inputs were selected. Among the available output measures, we also followed the innovation internationalization literature (e.g. Becker and Egger, 2013) in selecting product and process innovations implemented by firms and distinguished between the two types because of their expected differentiated impact on exports. Accordingly, a dummy variable was defined for *product innovation* that equals 1 if the firm implemented some product innovation in the last two years and 0 otherwise. Similarly, the dummy variable for *process innovation* equals 1 if the firm implemented some process innovation in the last two years and 0 otherwise. Finally, a dummy variable that accounts for the implementation of innovation regardless of the type was computed. This *innovation (prod/proc)* variable equals 1 if the firm implemented product and/or process innovations and 0 if it did not implement any kind of innovation.

Beyond export and innovation activities, the ICS includes useful information to control for other sources of firm heterogeneity in the empirical analysis. In particular, data on the total sales and the number of employees were combined to compute a simple measure of firms' labour productivity.[6] To mitigate the issue of endogeneity for this variable, the values for 2003, which are also reported in the survey, were used.[7] In addition, several dummy variables were defined to account for other sources of firm heterogeneity: size (10 to 49, 50 to 249, and 250 and more employees), branch of activity (NACE 2 digits), being part of an enterprise group (not part of a group, part of a national group, and part of an international group), and the NUTS2 region where the firm is located (17 regions).

Exports and Innovation in the Spanish Regions. Descriptive Analysis

The extensive margin of exports for manufacturing firms in each of the Spanish regions and in the country as a whole is reproduced in the first column of Table 1. The figures indicate that slightly above 50% of the Spanish manufacturing firms with at least 10 employees

exported in 2005, which is in line with the evidence reported elsewhere (e.g. Barba Navaretti et al., 2010). They also reveal sharp regional disparities in the propensity to export, which ranges from about 35% in Andalusia, Asturias, Cantabria, Castile La Mancha, and Extremadura to above 60% in Catalonia and the Basque Country.

Table 1 also provides the share of manufacturing firms that innovate in products, in processes, and in at least one of these two types of innovation. In the entire country, just 32.4% and 38.1% of firms reported that they implemented some product and process innovation, respectively. The share rises to almost half of the firms under the softer criterion of reporting at least one of the two types of innovation. The data also show that regions differ markedly in firms' propensity to innovate. The share of firms reporting innovations is larger in the most advanced regions (Catalonia, Madrid, and the Basque Country) than in the traditionally lagging regions (Extremadura, Castile La Mancha, and Andalusia) – not to mention the low values for the share of innovative firms in the island regions. A comparison of the regional figures for the extensive margin of exports with those for the share of innovative firms suggests a connection between the two magnitudes. The share of exporting firms is larger 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 the share of firms that innovate in products, in processes, and in at least one of them is, respectively, 0.82, 0.84, and 0.86.[8]

< TABLE 1 NEAR HERE >

In sum, the results from the descriptive analysis in Table 1 confirm that i) the regional disparities in export activity are sizeable and ii) the differences across regions in the propensity to innovate in products and processes are linked with the disparities observed in firms' export activity. In the following sections, we investigate these issues further by

controlling for other sources of firm heterogeneity that are far from being distributed homogeneously across regions.

4. Regional Impact of Innovation on the Propensity to Export

The main aim of this section is to provide evidence supporting the hypothesis that, having controlled for other sources of firm heterogeneity, the difference in export propensity between innovative and non-innovative firms varies across regions. As initial evidence, we report the extensive margin of exports for innovative and non-innovative firms in each region and the whole of Spain in Table 2. The raw data show that the extensive margin is much higher for innovative firms in all regions. The figures also indicate that the gap between innovative and non-innovative firms varies across regions, which suggests that the impact of implementing innovation on firms' export propensity might well depend on regional characteristics. On the other hand, a comparison of the gap in the extensive margin of exports reveals that it is somewhat wider for product than for process innovations. This is consistent with the premise that having new or substantially improved goods contributes to a greater degree to the firm export opportunities than implementing new or improved technologies of production or methods of delivery.

< TABLE 2 NEAR HERE >

Empirical Specification

The raw data in Table 2 are 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 on this gap. Hence, in this section we aim to obtain an estimate of the impact of innovation on firms' propensity to export in each region, controlling for the other sources of heterogeneity. We followed Roberts and Tybout (1997) in assuming that firms decide to export if the profits obtained when exporting exceed those obtained when

only serving the country market. π_{ir}^{exp} being such a difference in profits made by firm *i* in region *r* when exporting,

$$export_{ir} = 1 \quad \text{if} \quad \pi_{ir}^{exp} = \beta^r Inn_{ir} + \tau^r \log(Prod_{ir}) + X_{ir}\gamma + u_{ir} > 0$$
$$export_{ir} = 0 \quad \text{otherwise.} \tag{1}$$

Therefore, the export status for each firm in each region ($export_{ir}$), conditional on the log-level of productivity ($Prod_{ir}$) measured two years before and other firm characteristics in X_{ir}, is supposed to depend on the firm innovation status (Inn_{ir}). Consistent with our main assumption in this paper, the specification in (1) allows for regional differentiated effects of innovation (β^r), while regional heterogeneity is also allowed in the impact of productivity (τ^r). 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:

$$P(export_{ir} = 1) = \Phi[\beta^r Inn_{ir} + \tau^r \log(Prod_{ir}) + X_{ir}\gamma] \tag{2}$$

where Φ is the cumulative normal distribution function and X_{ir} includes dummy variables for the size of the firm, the sector of activity, being part of an enterprise group, and the region where the firm is located.

As discussed in section 2, there are arguments against the exogeneity of the measure of innovation in a specification such as that in (2). Since innovation is a discrete variable, the treatment of endogeneity in the context of a (non-linear) probabilistic model is far from simple, as the standard IV approach is not suitable in this case.[9] As in other studies in the literature analysing the link between firm innovation and export status (e.g. Aw et al., 2007; Girma, Görg, and Hanley, 2008), we opted to control for endogeneity by estimating a

bivariate probit model.[10] We assumed that firm *i* in region *r* implements an innovation if the profit that it obtains by doing so exceeds that of not implementing the innovation:

$$Inn_{ir} = 1 \quad \text{if} \quad \pi_{ir}^{Inn} = \alpha^r \log(Prod_{ir}) + Z_{ir}\delta + v_{ir} > 0$$
$$Inn_{ir} = 0 \quad \text{otherwise} \tag{3}$$

where π_{ir}^{Inn} is the difference in profits, Inn_{ir} is the innovation status, Z_{ir} is the set of factors other than productivity affecting that status, and v_{ir} is an error term. As with exports, a regionally uniform effect of productivity on innovation is not imposed, but it is allowed to vary across regions (α^r). Under the normality of the error term, the probit specification for the innovation status is:

$$P(Inn_{ir} = 1) = \Phi[\alpha^r \log(Prod_{ir}) + Z_{ir}\delta] \tag{4}$$

If $\text{Cov}(u_{ir}, v_{ir}) = 0$, that is, 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 the export status in each region *r*. Otherwise, the errors of the two processes are related to one another, $\text{Cov}(u_{ir}, v_{ir}) = \rho \neq 0$, and the 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 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 formed by (2) and (4).

As regards identification in the bivariate probit model, it needs to be stated that we included in *Z* all the variables in *X* plus a set of instruments for the innovation status of the firm. Finding appropriate instruments is a challenge, as one has to ensure that they do not affect firms' exports in a direct way, but only through their effect on innovation (exclusion

restrictions). In our empirical exercise, we used the type of instruments suggested in the recent literature aiming to identify a causal effect of innovation on firm exports. In particular, as in Becker and Egger (2013) and Lachenmaier and Wößmann (2006), we used information on obstacles/impediments to firms' innovation. To be more precise, the ICS questionnaire includes four possible answers ("very important", "important", "not very important", and "not important at all") to the question concerning the importance assigned by a firm to the lack of its own capital in the decision to innovate. Firms also report the extent to which the fact that the innovation expense is too high is an obstacle to their innovative efforts (the same four possible responses are also available for this item). For each of these two questions, we generated a set of binary variables for each possible response, that is to say, four binary variables for the lack of equity capital and another four for too high innovation expenses.[11] Although the ICS includes information on other obstacles/impediments to innovation, we decided not to use them as instruments, since they are likely to exert a direct influence on firm exports (e.g. a lack of skilled workers and a lack of access to external capital).[12]

On the other hand, consistent with Altomonte et al. (2013), we exploit the variation across sectors (NACE 2 digits) and firm size (small, medium, and large) in the share of firms that benefited from innovation subsidies in each region. The ICS includes information on whether the firm received public financial support for innovation activities in the period 2003–2005. However, we decided not to use the firm-level information on innovation subsidies, given that we cannot ensure that the selection of recipient firms was not based on performance (which would influence exports in 2005). Instead, we used the information on subsidies to compute the share of subsidized firms in the same sector and size category. This measure correlates with firm innovation, while it may be assumed to be exogenous to the export status in our sample as long as the group of firms that might have influenced the set-up of R&D promotion

policies (prior to 2005) did not coincide completely with the group of firms in the sample for which we measured the export status in 2005.[13]

It is noteworthy that, in the empirical exercise, the variable for the measure of innovation was interacted with the set of region dummy variables to obtain separate estimates for the effect of innovation on exports. Therefore, we also included as instruments the interaction between the regional dummies and the set of instruments defined above (see Aghion, Howitt, and Mayer-Foulkes, 2005; Wooldridge, 2002).

Results

The marginal effects calculated from the coefficient estimates of the bivariate probit model are used to measure the impact associated with innovation and the other firm characteristics. The results for the full set of characteristics are shown in Table A.9 of the online Appendix. This table reports the estimates of the marginal effects from the specification that imposes a common effect of innovation and productivity in all regions (the first three columns of results) and from the one in which the effect of innovation and productivity is allowed to vary across regions. It also includes basic statistics for assessing the adequacy of the bivariate probit model. In both cases a set of regional fixed effects is included to control for the impact of contextual factors affecting the propensity to export of the firms in each region. More precisely, they capture the differences across regions in firms' export performance due to geography, the endowment of infrastructures (hard and soft), and any other influence of the socio-economic environment (e.g. Márquez-Ramos, 2016; Nicolini, 2003). Alternatively, estimates were obtained using proxies for some of these regional factors. A summary of these results is reported in Tables A.10 to A.12 of the Appendix. Since there are no significant differences in the estimated marginal effect of innovation for each region between the specification including the fixed effects and that including the regional variables, detailed

results and the corresponding discussion are provided only for the former. In brief, the estimates of the marginal effects for all the characteristics are in line with those reported in the literature: a positive and significant effect of innovation and productivity in all regions, a higher probability of exporting in medium and large firms, and an increase in the probability of firms being in a group, although only when it is an international one. The results also confirm that there are significant differences across industries in the probability of exporting, whereas the differences across regions are only significant when imposing the same effect of innovation and productivity in all regions. This suggests that regional variability in the effect of these two magnitudes accounts for most of regional disparities in the propensity to export, conditional on the observed firm characteristics. On the other hand, the correlation of the errors of the exports and innovation equations (ρ) is highly significant, which supports the bivariate probit model as the preferred specification. Finally, the coefficients are highly jointly significant.[14]

Given the particular interest of this paper, Table 3 reproduces the estimated marginal effects of innovation for each region and the country as a whole. For Spain as a whole, the probability of exporting for firms that declared that they innovated in products is 35 percentage points (pp) higher than for similar firms that did not innovate. The size of the effect is similar for process innovation and for the measure that accounts for both types of innovations. Interestingly, the results confirm the existence of substantial disparities across regions in the impact of innovation. The estimated increase in the probability of exporting associated with product innovation is above 40 pp in Aragon and La Rioja, while on the opposite side, apart from the island regions, the smallest impact is shown by firms in Asturias and Catalonia. Regional disparities are also observed in the impact of process innovation, with the largest marginal effect in Murcia, Aragon, and Galicia and the smallest in the two island regions and in Asturias and Andalusia. Accordingly, regional disparities are also

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 3.[15]

< TABLE 3 NEAR HERE >

Beyond the particular estimate of the effect of innovation in each region, we can say that, as a general rule, the marginal effect of innovation is greater in regions with high extensive margins of exports, while the opposite is also true. Actually, the correlation coefficient for the extensive margin in each region and the corresponding marginal effect of product innovation, process innovation, and the combination of the two innovations is, respectively, 0.66, 0.69, and 0.72. Therefore, this evidence suggests that firms in regions with a high extensive margin of exports tend to obtain a higher payoff from innovations in terms of export status.

5. Counterfactual Analysis

As the final step, in this section we discuss the results of a simple counterfactual exercise. Using sample values for labour productivity and the other firm characteristics in *X*, and the estimates of the corresponding parameters for each region *r* obtained in section 4, we computed the counterfactual extensive margin for each Spanish region in an alternative scenario for the share of innovative firms. More precisely, a counterfactual extensive margin of exports for region *r* was obtained by averaging the marginal predicted probability of exporting for each firm *i* in region *r*, using the estimate of the parameters from the bivariate probit model in region *r*:

$$\widehat{marge}xt_r^{count} = \overline{\Phi\left(\hat{\beta}^r Inn_r^{count} + \hat{\tau}^r \log(Prod_r) + X_r\hat{\gamma}\right)} \qquad (5)$$

where $\widehat{\overline{marg ext}}_r^{count}$ is the counterfactual extensive margin of region *r*, the bar over the expression on the LHS denotes the sample average, the ^ over the coefficients represents the estimates from the bivariate probit discussed in section 4, $Prod_r$ is the vector of values of the labour productivity in each firm in region *r*, X_r is the matrix with observations of the other characteristics of firms in region *r*, and Φ is the cumulative normal distribution function as in (2). The marginal predicted probability of exporting for each firm in region *r* was computed by assigning a common counterfactual propensity to innovate, Inn_r^{count}, instead of the actual value for the firm's innovation status, Inn_{ir}. Concretely, the results were obtained using the share of innovative firms observed in Catalonia as the common-to-all-firms counterfactual propensity to innovate. As indicated in section 3 (see Table 1), Catalonia is the region with the largest share of innovative firms, therefore being an appropriate target for the other regions.

Comparing the counterfactual export margins with the actual values allows us to assess the expected impact of increasing firms' propensity to innovate in each region to the level shown by an average manufacturing firm in Catalonia.[16] Note 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 in that region.

The differences between the counterfactual and the actual margins of exports in each region and in the entire country are displayed in Table 4. It also includes information on the results of a test of equality of the actual and counterfactual margins of exports for each region.[17] According to the estimates of the impact of innovation obtained in the previous section, increasing the propensity to innovate in products in the average manufacturing Spanish firm to the level observed for the average Catalan firm would cause a significant increase of 4.4 pp in the Spanish extensive margin of exports. The change in the extensive margin would be

somewhat lower if the increase is in process innovation (3.5 pp), whereas it would be 4.2 pp when there is no distinction between the two types of innovations.

< TABLE 4 NEAR HERE >

The changes in the extensive margin differ across regions, because differences exist in the propensity to innovate of their firms with respect to that of Catalan firms and because the estimated impact of innovation on the propensity to export differs across regions. In any case the 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. Increasing the propensity to innovate in products leads to a rise of about 10 pp or more in regions with an extensive margin far below the country average, such as Andalusia, the Balearic Islands, Cantabria, Castile La Mancha, and Extremadura. In turn, the impact is much smaller (3–4 pp) in regions with an extensive margin above or about the country average (Valencia, Madrid, Navarra, and the Basque Country). A similar pattern is observed when using process innovation, though in this case the change in the extensive margin is less pronounced in all regions. The only region that clearly deviates from this pattern is the Canary Islands, as its extensive margin is the lowest in Spain while it is among the regions where the effect of increasing innovation is less intense.[18] In fact, the correlation between the change in the extensive margin and its actual value in the set of Spanish regions excluding the Canary Islands is significantly negative (-0.70, -0.88, and -0.88 for product, process, and both innovations, respectively). This result leads us to conclude that, other things being equal, increasing the innovation propensity, particularly in products, would contribute to narrowing the regional gap in the proportion of exporting firms.

The analysis so far has not taken into account the country or area of destination of the firms' exports. It could be the case that the effect of innovation on exports varies between markets, depending on certain characteristics (distance, preference for technologically advanced products, etc.). Unfortunately, the information on export destinations in the ICS data set is rather limited. Still, it is possible to know whether the firm sold products in other EU countries and in countries outside the EU. Hence, estimates of the marginal effect of innovation for each region were obtained for the case of exports to the EU and exports to non-EU countries. The results are reported in Table A.13 of the Appendix. It can be observed that, with few exceptions, there are no sizeable differences in the impact of innovation between the two types of destinations. Accordingly, the differences in the change in the extensive margin of exports (to EU countries in one case and to non-EU countries in the other) induced by innovation are minimal (Table A.14 of the Appendix). On a priori grounds, it could be thought that innovation should be more important for non-EU destinations (for instance to compensate for the higher trade costs of markets outside the common trade area). However, the importance of the Latin American and Moroccan markets for a substantial number of Spanish exporting firms must be kept in mind. In the case of the former destination, the greater distance is compensated for by the lower costs associated with the common language and cultural ties. As for Morocco, it is worthwhile noting that it is a closer destination than most of the EU countries and that different trade agreements favour trade between Spain and this country. Last, the income per capita in these destinations is still rather low in comparison with most of the EU countries, which acts against the demand for new and more technologically advanced products produced by innovative firms.

6. Concluding Comments

This paper has shown that innovative firms are more prone to export than otherwise similar non-innovative firms in all the Spanish NUTS2 regions. However, the results indicate that the

effect of innovation is far from being regionally uniform. The increase in the propensity to export due to innovation has been estimated to be larger in regions where the extensive margin of exports is high; this result is robust to the alternative measures of innovation considered in the analysis.

The evidence on the differentiated regional effect of innovation on firms' 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 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 firms' export performance stressed the effect of innovation. Our results for Spain confirm the key role played by a firm's innovative activity and suggest that, when assessing its contribution to stimulating a firm's export propensity, one needs to take into account the characteristics of the region in which the firm is located.

Although the investigation of the sources of the observed regional disparities in the effect of innovation on firms' exports is beyond the scope of this paper, we can speculate that the differences in export sunk costs across the Spanish regions might be causing territorial disparities in the exports' response to innovation. Innovation contributes to raising future firm productivity and/or having more attractive products and thus to making it easier for firms to face the extra costs of exporting. Even under the assumption that firms in all the Spanish regions are similarly effective in translating innovation into higher levels of 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 the entry exporting costs to be covered by firms in some regions but not in others. This argument can explain the greater effect of innovation on the export status estimated for some Spanish regions with a high extensive margin of exports. A deeper study of this hypothesis is part of our future research agenda.

An immediate implication of the evidence in the paper is that policies aiming to stimulate innovation, which are likely to be effective in promoting exports by increasing the number of exporting firms, will not exert the same effect on exports in all the Spanish regions. Therefore, the *ex ante* assessment of innovation policies should include the positive expected effect on export performance but take into account the possibility that geography and certain locational endowments can affect the particular impact of these policies in each region. In addition, the results on the effect of innovation on the export status lead us to recommend focusing the effort of direct policies aiming to promote exports preferably on the group of innovative firms in each Spanish region that are not exporting yet. They are the potential candidates to become exporters if the locational disadvantages are compensated for in some way by the effect of these policies.

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Notes

[1] The data used in this paragraph for all Spanish regions can be found in Tables A.1 and A.2 of the online Appendix.

[2] Interestingly, as indicated by an anonymous referee, the studies analysing the role of regional factors in firms' export performance so far are from developing economies. Future studies should investigate whether the response of firm exports to the regional factors is similar in developed countries.

[3] Since the focus of this study is the export performance of firms, and because of the space limitations, we do not intentionally summarize the extensive literature on the determinants of innovation that are internal and external to the firm. We refer the interested reader to the reviews of the literature provided by Audretsch and Feldman (2004) and Carlino and Kerr (2015) and to Czarnitzki and Hottenrott (2009) for an analysis of the relative contribution of firm and regional factors.

[4] Unfortunately, it was not possible to gain access to the ICS micro-data for the most recent years. In any case it is worth noting that the inspection of the aggregated regional data on export and innovation activity reveals quite stable evolution over time and hence persistent differences across the Spanish regions in both magnitudes (see Tables A.1 and A.2 of the Appendix).

[5] 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 they include information on export activity, innovation, and other sources of firm heterogeneity, they do not guarantee representativeness at the regional level and thus are not useful for the study in this paper.

[6] We were not able to compute a measure of total factor productivity because of the lack of the required information (e.g. capital) in the ICS.

[7] Previous studies have 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).

[8] More information about the sector–region distribution of the firms in the sample and the main magnitudes under analysis is provided in Tables A.3 to A.8 of the Appendix.

[9] See for instance Angrist and Pischke (2009) and Cameron and Trivedi (2005).

[10] We also estimated the impact of innovation on export status by IV using a linear probability model. However, we prefer to report the results from the bivariate probit framework given our interest in simulating the margins of exports for the Spanish regions in an alternative scenario for firms' innovation activity. The bivariate probit model guarantees values for the predicted probabilities that are within the logical range, while the linear probability model does not.

[11] Estimates were also computed using a single binary instrument for each type of obstacle, in which the "very important" and "important" responses were grouped into one category and "not very important" and "unimportant" into the other. The results were robust to this alternative definition of the instruments.

[12] A detailed discussion of the appropriateness of the several types of obstacles/impediments as instruments of innovation in a firm-level exports equation can be found in Lachenmaier and Wößmann (2006). We do not reproduce their full arguments here for reasons of space. In any case it needs to be stressed that the lack of own capital will not necessarily be exogenous for absolute exports, as they may serve as a funding scheme for innovation. However, similarly to the case in Lachenmaier and Wößmann (2006), since the focus of the analysis is the propensity to export, it can be argued that this will not affect the innovation possibilities, which can be financed by bigger domestic revenues in firms with a low (or null) propensity to export. In any case it should be mentioned that the results are robust to the exclusion of this variable from the list of instruments.

[13] In addition to the one based on the share of R&D incentives, Altomonte et al. (2013) defined another instrument based on the average industry–country R&D intensity, measured some years previously. To achieve this, they relied on OECD aggregated data on R&D expenditures and value added. Unfortunately, we could not exploit a similar instrument in our analysis given the lack of data on R&D investments at the industry–region level in Spain.

[14] As indicated above, the characteristics of the empirical model used to obtain the results prevent the computation of the standard battery of validity of instruments tests. Hence, we must rely on the arguments discussed above and on some informal evidence to support the validity of the instruments used in this study. In that regard it can be mentioned that a non-significant (direct) effect was obtained for the set of instruments in the reduced-form equation for the export propensity using the sample of firms in an industry in which innovation is a quasi-negligible activity, mining and quarrying. Conversely, as expected given the indirect effect exerted through the influence via innovation, the same exercise in the case of the full set of firms in the Spanish regions revealed a significant joint effect of the instruments on the propensity to export. In a similar vein a linear empirical specification was estimated in which the variable of interest was not the propensity to export but the export intensity (the share of exports in the firm's total sales). The results of the tests clearly indicated that the instruments are not weak and that they are orthogonal to the error term of the export equation. In other words they are valid instruments for the export intensity specification. We assume that this could easily be the case as well when the magnitude under analysis is not the export intensity but the export propensity. These results are available from the authors.

[15] A formal test of equality of the marginal effects in all regions could not be implemented, as they were computed using the particular sample of firms in each region. However, the fact that the likelihood ratio tests that can be computed using the values of the log pseudo-likelihoods reported in Table A.9 in the Appendix lead to the rejection of a common

coefficient for innovation and productivity in all the regions in the biprobit model points to the convenience of not imposing a common marginal effect of innovation in all regions.

[16] It should be noted that this simple counterfactual exercise does not include general equilibrium adjustments that are expected to follow the change in innovation and exports. As already mentioned, it is merely a sort of *what if* exercise, the aim of which is simply to assess the contribution of differences across regions in firms' innovation to the regional disparities in the extensive export margin.

[17] We use the t-statistic to test the significance of the difference between the actual and the counterfactual margin using the sample of firms in each region. The entire set of results (t statistics and p-values) is available on request).

[18] This result is explained by the peculiarities of the Canary Islands, where the main bulk of the economy centres on tourism. The production of the industrial sector accounts for only about 8% and manufacturing for 4%.

Table 1. Extensive margin of exports and share of innovative firms.

	Ext. Margin Exports	Product Innov.	Process Innov.	Innovation (Prod/Proc)	Obs.
Spain	51.24	32.43	38.13	48.20	14078
Andalusia	33.76	24.11	34.12	41.04	1100
Aragon	46.49	29.09	35.82	45.18	685
Asturias	32.76	25.62	31.53	39.90	406
Balearic Isl.	21.00	11.42	21.46	25.11	219
Canary Isl.	9.22	20.28	28.57	33.64	204
Cantabria	33.75	25.70	31.89	39.01	313
Castile Leon	42.50	28.44	34.78	43.89	647
Castile La Mancha	35.56	23.15	30.00	37.04	541
Catalonia	68.41	42.82	46.86	58.98	3118
Valencia	55.90	33.07	38.53	49.11	1796
Extremadura	37.44	15.07	26.48	29.22	219
Galicia	45.84	28.97	32.75	41.94	795
Madrid	51.21	35.81	37.37	50.27	1279
Murcia	44.98	26.39	30.86	40.89	527
Navarra	49.75	34.74	40.98	50.76	593
Basque Country	62.07	35.50	42.71	54.23	1276
La Rioja	55.52	25.77	35.58	45.71	316

Notes: Figures in %, except for the number of observations. The extensive margin of exports was computed as the share of firms in the sample that declared to sell abroad.

Table 2. Extensive margin of exports by innovation status.

	Product Innov.		Process Innov.		Innovation (Prod/Proc)	
	Yes	No	Yes	No	Yes	No
Spain	71.21	41.66	65.78	42.28	66.34	37.20
Andalusia	52.45	27.82	44.53	28.18	44.79	26.08
Aragon	71.36	36.29	62.04	37.81	63.75	32.27
Asturias	52.88	25.83	46.88	26.26	48.15	22.54
Balearic Isl.	36.00	19.07	25.53	19.77	29.09	18.29
Canary Isl.	13.64	8.09	16.13	6.45	16.44	5.56
Cantabria	54.22	26.67	49.51	26.36	48.41	24.37
Castile Leon	61.41	34.99	56.44	35.07	56.69	31.40
Castile La Mancha	60.00	28.19	54.32	27.51	54.00	24.71
Catalonia	82.10	58.16	78.44	59.57	79.12	53.01
Valencia	72.90	47.50	67.77	48.46	68.93	43.33
Extremadura	63.64	32.80	60.34	29.19	60.94	27.74
Galicia	65.65	37.77	63.85	37.08	63.36	33.19
Madrid	69.43	41.05	66.11	42.32	65.79	36.48
Murcia	62.68	38.64	63.25	36.83	60.45	34.28
Navarra	65.53	41.34	60.91	42.00	60.80	38.36
Basque Country	78.59	52.98	73.58	53.49	73.70	48.29
La Rioja	79.76	47.11	66.38	49.52	69.13	44.07

Note: Figures in %.

Table 3. Marginal effects for the extensive margin of exports.

	Product Innov.	Process Innov.	Innovation (Prod/Proc)
Spain	0.351***	0.340***	0.323 ***
Andalusia	0.359***	0.315***	0.286***
Aragon	0.432***	0.390***	0.377***
Asturias	0.317***	0.309***	0.292***
Balearic Isl.	0.300***	0.225***	0.226***
Canary Isl.	0.149***	0.186***	0.162***
Cantabria	0.360***	0.363***	0.330***
Castile Leon	0.370***	0.351***	0.332***
Castile La Mancha	0.380***	0.377***	0.342***
Catalonia	0.346***	0.333***	0.318***
Valencia	0.380***	0.371***	0.352***
Extremadura	0.394***	0.350***	0.339***
Galicia	0.379***	0.381***	0.355***
Madrid	0.373***	0.376***	0.351***
Murcia	0.390***	0.402***	0.362***
Navarra	0.372***	0.347***	0.324***
Basque Country	0.362***	0.349***	0.325***
La Rioja	0.410***	0.366***	0.341***

Notes: *** p<0.01, ** p<0.05, * p<0.1, corresponding to robust standard errors. Marginal effects obtained as the average from the ones for each firm in the sample of each region. Results for Spain correspond to the model with a regionally invariant effect of innovation and productivity. The specification used to compute the marginal effects includes controls for productivity, size, firm group (national or international), industry (NACE 2 digits) and regions.

Table 4. Changes in the extensive margin of exports due to counterfactual innovation.

	Product Innov.	Process Innov.	Innovation (Prod/Proc)
Spain	4.44***	3.49***	4.24***
Andalusia	8.17***	5.20***	5.96***
Aragon	7.85***	5.55***	6.71***
Asturias	6.55***	5.92***	6.42***
Balearic Isl.	11.72***	7.34***	9.30***
Canary Isl.	4.28**	3.97**	4.30**
Cantabria	7.77***	7.06***	7.89***
Castile Leon	6.26***	5.06***	5.71***
Castile La Mancha	9.21***	8.02***	9.01***
Catalonia	– –	– –	– –
Valencia	4.49***	3.55***	4.34***
Extremadura	12.93***	8.94***	12.48***
Galicia	6.35***	6.63***	7.40***
Madrid	3.22**	4.31***	3.78***
Murcia	7.69***	8.03***	8.03***
Navarra	3.72**	2.44	3.14*
Basque Country	3.34***	1.32	2.05*
La Rioja	8.78***	4.62*	5.59**

Notes: Change in percentage points with respect to the actual extensive margin in each region. Figures on the share of innovative firms in Catalonia are used as benchmark. *** $p<0.01$, ** $p<0.05$, * $p<0.1$ of a test of equality of the actual and counterfactual margins of exports.

Appendix

Table A.1. Export activity in the Spanish regions.

	Share of exporting firms (%)			Share of volume of exports (%)			Exports over GDP (%)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2014**
Andalusia	10	11	10	9	10	10	11	13	19
Aragon	2	3	2	5	5	4	25	25	29
Asturias	1	1	1	2	2	1	12	15	18
Balearic Isl.	1	1	1	1	0	0	5	3	4
Canary Isl.	2	5	4	1	1	1	2	5	6
Cantabria	1	1	1	1	1	1	16	18	21
Castile Leon	2	0.3	3	6	6	6	18	19	24
Castile La Mancha	2	3	3	2	2	2	8	9	15
Catalonia	26	31	25	27	26	26	24	24	31
Valencia	12	13	12	11	10	11	19	18	26
Extremadura	1	1	1	1	1	1	7	7	10
Galicia	3	4	3	8	8	8	25	26	33
Madrid	17	16	22	11	11	11	10	11	14
Murcia	2	3	3	3	3	4	17	18	39
Navarra	1	2	1	3	4	3	31	41	46
Basque Country	5	6	8	9	10	9	25	27	35
La Rioja	1	1	1	1	1	1	14	16	21
No regionalised	11		0	2		1			
Spain	100	100	100	100	100	100	17	17	23

Notes: The first two groups of columns refer to the contribution of the region in the total figure for Spain of the number of exporting firms and the volume of exports respectively. The last group of columns is the ratio of exports over the GDP of each region and Spain as a whole. Elaborated from the trade data collected by the customs office of the Spanish Tax Agency and elaborated by ICEX. Ministry of Economics, Industry and Competitiveness of Spain.

Table A.2. Innovation activity in the Spanish regions.

	GERD/GDP (%)			Patent Applications (EPO)		
	2005	**2010**	**2013**	**2005**	**2010**	**2012**
Andalusia	0.81	1.18	1.06	8.2	10.3	10.0
Aragon	0.77	1.09	0.91	40.8	56.8	54.0
Asturias	0.69	1.04	0.89	16.7	13.8	9.2
Balearic Isl.	0.27	0.42	0.34	6.5	11.6	9.2
Canary Isl.	0.58	0.62	0.51	6.2	3.3	5.0
Cantabria	0.46	1.23	0.94	15.0	26.5	16.9
Castile Leon	0.89	1.09	1.02	20.4	10.2	12.3
Castile La Mancha	0.39	0.65	0.55	14.1	9.5	8.1
Catalonia	1.32	1.59	1.52	73.5	64.2	57.0
Valencia	0.96	1.06	1.04	25.2	23.0	21.4
Extremadura	0.68	0.84	0.77	5.1	3.9	1.4
Galicia	0.84	0.93	0.87	11.6	13.3	10.8
Madrid	1.75	1.95	1.77	41.7	49.3	38.3
Murcia	0.71	0.92	0.84	9.4	19.5	20.1
Navarra	1.65	2.00	1.82	104.6	117.5	60.8
Basque Country	1.47	1.99	2.12	64.0	80.4	64.4
La Rioja	0.64	1.06	0.81	17.6	28.7	13.0
Spain	1.10	1.35	1.26	31.4	32.4	27.4

Note: GERD denotes total intramural R&D expenditures and GDP the gross domestic product. Patents refers to the number of patens applications to the European Patent Office per million inhabitants. All data from the Eurostat Database.

Table A.3. Sector distribution of firms in the sample in each Spanish region. (%)

	Sect_1	Sect_2	Sect_3	Sect_4	Sect_5	Sect_6	Sect_7	Sect_8	Sect_9	Sect_10	Sect_11	Sect_12	Total
Andalusia	2.82	21.96	7.71	9.61	4.56	3.56	10.77	12.34	6.79	4.81	4.97	10.11	100
Aragon	2.02	14.40	5.79	6.46	4.98	5.92	6.46	15.48	13.86	9.83	7.81	7.00	100
Asturias	3.70	13.86	3.00	12.47	2.77	2.77	9.01	27.71	8.31	6.93	4.39	5.08	100
Balearic Isl.	1.69	19.41	16.88	17.30	1.69	3.38	10.13	7.59	3.38	2.53	5.91	10.13	100
Canary Isl.	4.74	25.43	3.02	15.52	4.31	3.88	15.52	16.81	0.86	1.72	4.74	3.45	100
Cantabria	1.45	15.07	2.03	8.70	3.77	4.35	11.30	31.30	9.86	4.93	3.77	3.48	100
Castile Leon	4.07	22.30	7.01	11.50	3.37	4.49	10.10	15.85	8.27	2.95	4.77	5.33	100
Castile La Mancha	1.34	15.19	17.53	9.85	4.17	3.34	12.85	13.52	4.67	3.34	4.51	9.68	100
Catalonia	0.85	8.96	12.10	10.02	13.04	6.48	3.87	12.47	12.16	9.98	4.96	5.11	100
Valencia	1.42	8.76	14.47	10.38	7.24	7.03	13.69	10.33	7.24	5.24	2.20	12.01	100
Extremadura	5.86	33.20	3.91	10.55	2.34	1.95	13.67	15.23	2.73	3.52	0.78	6.25	100
Galicia	4.01	15.57	12.26	11.67	2.83	3.30	11.32	13.44	7.67	3.42	8.73	5.78	100
Madrid	1.94	8.93	4.90	15.48	11.30	4.10	5.98	12.17	8.86	15.55	4.54	6.26	100
Murcia	2.03	20.78	5.91	8.11	7.77	5.41	10.14	12.67	8.45	2.53	2.70	13.51	100
Navarra	1.24	18.82	3.42	8.55	3.11	5.29	7.78	21.15	13.06	6.07	6.84	4.67	100
Basque Country	0.91	5.82	1.68	8.20	4.27	6.10	3.29	31.67	16.82	9.95	5.82	5.47	100
La Rioja	0.82	22.53	17.03	7.69	3.30	5.77	8.52	13.74	5.77	2.20	2.20	10.44	100
Total	1.90	13.46	8.92	10.39	7.05	5.22	8.24	15.66	9.72	7.33	4.80	7.30	100

Note: See the corresponding labels of the sectors in Table A.9.

Table A.4. Regional distribution of firms in the sample in each sector. (%)

	Sect_1	Sect_2	Sect_3	Sect_4	Sect_5	Sect_6	Sect_7	Sect_8	Sect_9	Sect_10	Sect_11	Sect_12	Total
Andalusia	11.76	12.91	6.84	7.32	5.12	5.41	10.35	6.24	5.53	5.19	8.20	10.97	7.92
Aragon	5.19	5.21	3.16	3.03	3.44	5.53	3.82	4.82	6.95	6.54	7.92	4.68	4.88
Asturias	5.54	2.92	0.96	3.41	1.12	1.51	3.11	5.03	2.43	2.69	2.60	1.98	2.84
Balearic Isl.	1.38	2.24	2.94	2.59	0.37	1.01	1.91	0.75	0.54	0.54	1.91	2.16	1.56
Canary Isl.	3.81	2.88	0.52	2.27	0.93	1.13	2.87	1.63	0.13	0.36	1.50	0.72	1.52
Cantabria	1.73	2.53	0.52	1.89	1.21	1.89	3.11	4.52	2.29	1.52	1.78	1.08	2.26
Castile Leon	10.03	7.75	3.68	5.18	2.23	4.03	5.73	4.73	3.98	1.88	4.64	3.42	4.68
Castile La Mancha	2.77	4.43	7.73	3.72	2.33	2.52	6.13	3.39	1.89	1.79	3.69	5.22	3.93
Catalonia	9.69	14.42	29.43	20.90	40.09	26.92	10.19	17.26	27.13	29.54	22.40	15.20	21.69
Valencia	9.34	8.14	20.31	12.50	12.84	16.86	20.78	8.25	9.31	8.95	5.74	20.59	12.51
Extremadura	5.19	4.14	0.74	1.70	0.56	0.63	2.79	1.63	0.47	0.81	0.27	1.44	1.68
Galicia	11.76	6.43	7.65	6.25	2.23	3.52	7.64	4.78	4.39	2.60	10.11	4.41	5.56
Madrid	9.34	6.04	5.00	13.57	14.60	7.17	6.61	7.08	8.30	19.34	8.61	7.82	9.11
Murcia	4.15	5.99	2.58	3.03	4.28	4.03	4.78	3.14	3.37	1.34	2.19	7.19	3.88
Navarra	2.77	5.90	1.62	3.47	1.86	4.28	3.98	5.70	5.67	3.49	6.01	2.70	4.22
Basque Country	4.50	4.04	1.77	7.39	5.67	10.94	3.74	18.94	16.19	12.71	11.34	7.01	9.36
La Rioja	1.04	4.00	4.56	1.77	1.12	2.64	2.47	2.09	1.42	0.72	1.09	3.42	2.39
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: See the corresponding labels of the sectors in Table A.9.

Table A.5. Sample share of exporting firms in each region and sector. (%)

	Sect_1	Sect_2	Sect_3	Sect_4	Sect_5	Sect_6	Sect_7	Sect_8	Sect_9	Sect_10	Sect_11	Sect_12	Total
Andalusia	13.33	40.51	33.71	25.00	50.94	65.00	20.18	22.96	48.00	44.44	38.60	23.21	33.73
Aragon	46.67	29.47	39.02	32.61	69.70	64.10	17.78	37.38	61.70	58.21	66.04	48.00	46.42
Asturias	0.00	33.90	38.46	16.98	66.67	62.50	31.43	32.14	34.38	39.29	70.59	22.73	32.76
Balearic Isl.	25.00	19.05	43.24	2.63	33.33	12.50	8.70	5.88	33.33	16.67	33.33	34.78	21.00
Canary Isl.	0.00	16.07	14.29	2.78	12.50	12.50	5.88	2.86	0.00	50.00	27.27	0.00	9.22
Cantabria	40.00	34.69	50.00	17.24	63.64	46.67	18.92	33.01	40.00	28.57	58.33	33.33	33.75
Castile Leon	28.00	50.69	43.48	26.25	72.22	60.71	16.67	43.81	53.85	52.38	55.17	36.36	42.50
Castile La Mancha	28.57	54.22	34.04	33.93	52.17	60.00	14.49	21.92	50.00	58.82	40.00	26.42	35.49
Catalonia	32.00	60.51	62.69	57.86	84.03	81.77	50.85	59.34	77.30	76.55	70.27	63.41	68.41
Valencia	7.69	48.12	57.36	37.43	72.18	75.21	57.85	39.04	64.12	64.52	64.10	63.21	55.90
Extremadura	33.33	45.07	20.00	47.83	83.33	60.00	19.35	22.58	50.00	50.00	50.00	28.57	37.44
Galicia	35.71	46.34	31.37	43.96	77.27	73.08	40.66	40.74	55.74	53.57	61.76	38.30	45.91
Madrid	13.04	41.07	43.75	42.13	70.75	72.55	39.19	38.27	62.39	62.38	70.91	36.14	51.21
Murcia	16.67	58.56	56.67	19.57	67.50	65.52	35.19	19.44	51.06	50.00	30.77	50.00	44.98
Navarra	14.29	62.26	38.10	41.18	66.67	64.71	25.58	36.15	58.75	60.61	66.67	42.86	49.75
Basque Country	15.38	47.89	65.22	54.21	76.47	73.24	37.78	59.85	76.89	59.85	67.57	56.06	62.07
La Rioja	0.00	77.92	72.22	39.13	50.00	66.67	18.52	40.43	70.59	33.33	57.14	39.47	55.52
Total	21.15	48.08	51.09	39.19	74.22	71.23	34.67	42.63	65.26	62.90	61.14	46.58	51.24

Note: See the corresponding labels of the sectors in Table A.9.

Table A.6. Sample share of firms that innovated in product in each region and sector. (%)

	Sect_1	Sect_2	Sect_3	Sect_4	Sect_5	Sect_6	Sect_7	Sect_8	Sect_9	Sect_10	Sect_11	Sect_12	Total
Andalusia	6.67	21.94	10.11	21.15	52.83	35.00	23.68	17.04	40.00	31.48	36.84	18.75	24.18
Aragon	33.33	22.11	14.63	30.43	48.48	35.90	17.78	21.50	36.17	49.25	32.08	16.00	29.05
Asturias	13.33	16.95	30.77	26.42	50.00	25.00	22.86	25.00	21.88	39.29	41.18	22.73	25.62
Balearic Isl.	0.00	16.67	13.51	10.53	0.00	12.50	4.35	0.00	16.67	16.67	16.67	13.04	11.42
Canary Isl.	20.00	19.64	42.86	13.89	50.00	50.00	14.71	20.00	0.00	50.00	9.09	12.50	20.28
Cantabria	40.00	14.29	66.67	20.69	36.36	33.33	16.22	25.24	33.33	28.57	25.00	50.00	25.70
Castile Leon	12.00	34.72	17.39	18.75	50.00	35.71	18.18	28.57	46.15	33.33	27.59	24.24	28.44
Castile La Mancha	14.29	30.12	13.83	10.71	39.13	60.00	23.19	13.70	26.92	58.82	48.00	15.09	23.29
Catalonia	16.00	40.22	37.05	25.79	63.14	38.42	33.90	31.82	55.14	57.98	37.84	34.15	42.82
Valencia	11.54	35.00	26.79	20.86	51.13	33.88	23.97	29.95	51.15	53.76	30.77	34.43	33.07
Extremadura	0.00	14.08	10.00	4.35	50.00	80.00	16.13	12.90	16.67	25.00	0.00	14.29	15.07
Galicia	28.57	34.96	12.75	23.08	68.18	34.62	20.88	25.00	44.26	50.00	36.76	21.28	29.06
Madrid	4.35	32.14	23.44	28.43	55.10	33.33	37.84	20.99	43.12	51.49	43.64	18.07	35.81
Murcia	16.67	32.43	10.00	15.22	45.00	13.79	14.81	25.00	42.55	50.00	7.69	26.39	26.39
Navarra	28.57	36.79	23.81	17.65	44.44	29.41	39.53	27.69	45.00	42.42	42.86	42.86	34.74
Basque Country	0.00	22.54	26.09	18.69	54.90	42.25	31.11	28.57	48.11	52.55	36.49	33.33	35.50
La Rioja	0.00	27.27	31.48	0.00	41.67	40.00	11.11	23.40	47.06	16.67	42.86	23.68	25.77
Total	14.23	29.43	25.31	21.62	56.07	36.03	23.95	25.83	46.30	50.72	35.69	26.81	32.44

Note: See the corresponding labels of the sectors in Table A.9.

Table A.7. Sample share of firms that innovated in process in each region and sector. (%)

	Sect_1	Sect_2	Sect_3	Sect_4	Sect_5	Sect_6	Sect_7	Sect_8	Sect_9	Sect_10	Sect_11	Sect_12	Total
Andalusia	20.00	34.18	17.98	38.46	52.83	45.00	35.96	29.63	40.00	46.30	35.09	26.79	34.09
Aragon	40.00	30.53	24.39	39.13	60.61	53.85	22.22	28.97	38.30	35.82	39.62	38.00	35.77
Asturias	26.67	33.90	30.77	26.42	41.67	50.00	34.29	30.36	21.88	35.71	41.18	31.82	31.53
Balearic Isl.	0.00	11.90	18.92	23.68	33.33	25.00	21.74	29.41	16.67	50.00	16.67	30.43	21.46
Canary Isl.	20.00	32.14	57.14	22.22	75.00	25.00	17.65	28.57	0.00	0.00	27.27	37.50	28.57
Cantabria	40.00	24.49	66.67	34.48	45.45	33.33	40.54	30.10	40.00	28.57	16.67	8.33	31.89
Castile Leon	20.00	43.06	23.91	36.25	55.56	46.43	21.21	38.10	21.15	52.38	37.93	24.24	34.78
Castile La Mancha	42.86	39.76	17.02	35.71	34.78	33.33	28.99	21.92	42.31	41.18	48.00	22.64	30.13
Catalonia	20.00	44.20	39.38	45.28	59.21	49.26	46.61	41.41	47.30	51.47	49.32	43.90	46.86
Valencia	23.08	46.88	35.85	36.90	53.38	35.54	31.82	38.50	41.98	37.63	38.46	37.26	38.53
Extremadura	0.00	30.99	10.00	17.39	50.00	80.00	29.03	22.58	33.33	37.50	0.00	21.43	26.48
Galicia	32.14	39.84	13.73	30.77	59.09	38.46	27.47	34.26	44.26	50.00	27.94	31.91	32.70
Madrid	21.74	36.61	25.00	36.04	51.02	39.22	33.78	38.27	35.78	41.09	47.27	18.07	37.37
Murcia	16.67	39.64	13.33	26.09	42.50	41.38	33.33	23.61	27.66	41.67	15.38	27.78	30.86
Navarra	28.57	42.45	28.57	29.41	55.56	44.12	48.84	36.15	46.25	42.42	47.62	39.29	40.98
Basque Country	23.08	33.80	34.78	34.58	54.90	59.15	35.56	44.09	41.04	38.69	45.95	51.52	42.71
La Rioja	33.33	41.56	20.37	34.78	33.33	46.67	25.93	40.43	41.18	50.00	57.14	34.21	35.58
Spain	23.46	38.14	29.43	36.09	54.66	45.11	32.75	36.43	40.74	43.67	40.81	33.65	38.12

Note: See the corresponding labels of the sectors in Table A.9.

Table A.8. Sample share of firms that innovated in product and/or process in each region and sector. (%)

	Sect_1	Sect_2	Sect_3	Sect_4	Sect_5	Sect_6	Sect_7	Sect_8	Sect_9	Sect_10	Sect_11	Sect_12	Total
Andalusia	23.33	41.35	20.22	41.35	64.15	55.00	42.11	35.56	56.00	55.56	45.61	32.14	41.09
Aragon	53.33	36.84	31.71	50.00	63.64	53.85	26.67	36.45	52.13	53.73	52.83	48.00	45.11
Asturias	33.33	38.98	38.46	39.62	50.00	50.00	40.00	38.39	31.25	50.00	52.94	36.36	39.90
Balearic Isl.	0.00	19.05	21.62	26.32	33.33	25.00	21.74	29.41	16.67	50.00	33.33	34.78	25.11
Canary Isl.	20.00	35.71	57.14	27.78	75.00	50.00	20.59	34.29	0.00	50.00	36.36	37.50	33.64
Cantabria	40.00	28.57	66.67	34.48	54.55	53.33	45.95	36.89	40.00	35.71	33.33	50.00	39.01
Castile Leon	28.00	53.47	26.09	40.00	66.67	60.71	30.30	43.81	50.00	57.14	44.83	30.30	43.89
Castile La Mancha	42.86	46.99	21.28	37.50	52.17	66.67	37.68	26.03	42.31	58.82	64.00	26.42	37.15
Catalonia	24.00	52.54	52.59	48.43	77.40	58.62	53.39	50.51	66.76	69.71	58.11	53.05	58.98
Valencia	30.77	53.12	43.02	41.71	69.17	49.59	40.08	44.92	58.78	65.59	48.72	50.47	49.11
Extremadura	0.00	32.39	10.00	17.39	66.67	80.00	32.26	25.81	33.33	50.00	0.00	28.57	29.22
Galicia	42.86	45.53	22.55	40.66	77.27	50.00	35.16	39.81	62.30	60.71	42.65	36.17	42.01
Madrid	21.74	45.54	35.94	45.69	70.07	49.02	48.65	44.44	48.62	63.37	63.64	26.51	50.27
Murcia	25.00	48.65	13.33	34.78	55.00	41.38	38.89	37.50	53.19	58.33	15.38	37.50	40.89
Navarra	42.86	50.94	42.86	39.22	61.11	52.94	53.49	44.62	58.75	48.48	59.52	60.71	50.76
Basque Country	23.08	40.85	43.48	41.12	72.55	66.20	48.89	50.99	59.91	62.04	54.05	62.12	54.23
La Rioja	33.33	48.05	40.74	34.78	58.33	60.00	25.93	48.94	58.82	50.00	71.43	44.74	45.71
Spain	28.85	45.30	38.28	41.82	70.81	55.17	40.07	43.67	57.56	62.42	51.96	43.20	48.20

Note: See the corresponding labels of the sectors in Table A.9.

Table A.9. Marginal effects and statistics for the propensity to export model.

	Product Inn.	Process Inn.	Prod/Proc Inn.	Product Inn.	Process Inn.	Prod/Proc Inn.
Innovation						
All regions (Spain)	0.351***	0.340***	0.323***			
Andalusia				0.359***	0.315***	0.286***
Aragon				0.432***	0.390***	0.377***
Asturias				0.317***	0.309***	0.292***
Balearic Isl.				0.300***	0.225***	0.226***
Canary Isl.				0.149***	0.186***	0.162***
Cantabria				0.360***	0.363***	0.330***
Castile Leon				0.370***	0.351***	0.332***
Castile La Mancha				0.380***	0.377***	0.342***
Catalonia				0.346***	0.333***	0.318***
Valencia				0.380***	0.371***	0.352***
Extremadura				0.394***	0.350***	0.339***
Galicia				0.379***	0.381***	0.355***
Madrid				0.373***	0.376***	0.351***
Murcia				0.390***	0.402***	0.362***
Navarra				0.372***	0.347***	0.324***
Basque Country				0.362***	0.349***	0.325***
La Rioja				0.410***	0.366***	0.341***
Productivity (log)						
All regions	0.111***	0.105***	0.104***			
Andalusia				0.126***	0.115***	0.123***
Aragon				0.107***	0.117***	0.107***
Asturias				0.149***	0.151***	0.144***
Balearic Isl.				0.119***	0.112***	0.111***
Canary Isl.				0.070***	0.070***	0.070***
Cantabria				0.125***	0.123***	0.130***
Castile Leon				0.104***	0.095***	0.097***
Castile La Mancha				0.121***	0.116***	0.112***
Catalonia				0.108***	0.104***	0.102***
Valencia				0.109***	0.098***	0.097***
Extremadura				0.133***	0.100***	0.108***
Galicia				0.083***	0.077***	0.075***
Madrid				0.086***	0.083***	0.080***

	Product Inn.	Process Inn.	Prod/Proc Inn.	Product Inn.	Process Inn.	Prod/Proc Inn.
Murcia				0.097***	0.066***	0.083***
Navarra				0.121***	0.119***	0.129***
Basque Country				0.107***	0.112***	0.108***
La Rioja				0.144***	0.177***	0.165***
Size Medium	0.136***	0.125***	0.130***	0.133***	0.123***	0.128***
Size Large	0.139***	0.127***	0.141***	0.133***	0.122***	0.139***
Group national	-0.042***	-0.035***	-0.038***	-0.041***	-0.035***	-0.037***
Group international	0.052***	0.056***	0.057***	0.053***	0.056***	0.058***
Food, beverages & tob.	0.129***	0.130***	0.128***	0.123***	0.126***	0.125***
Textile & leather	0.216***	0.229***	0.221***	0.212***	0.227***	0.220***
Wood, cork & paper	0.109***	0.088***	0.091***	0.107***	0.088***	0.091***
Refined petrol. & chem.	0.183***	0.214***	0.193***	0.173***	0.209***	0.189***
Rubber & plastic	0.272***	0.266***	0.262***	0.264***	0.262***	0.260***
Other non-metallic prod.	0.046	0.048	0.044	0.043	0.047	0.043
Basic & fabricated metals	0.114***	0.109***	0.107***	0.111***	0.109***	0.108***
Machinery & equip. n.e.c.	0.210***	0.254***	0.228***	0.202***	0.250***	0.225***
Electrical & optical eq.	0.177***	0.227***	0.193***	0.168***	0.224***	0.191***
Transport equipment	0.196***	0.206***	0.194***	0.188***	0.202***	0.191***
Other manufactures n.e.c	0.182***	0.186***	0.177***	0.177***	0.184***	0.176***
Aragon	0.052***	0.056***	0.054***	0.308	0.032	0.170
Asturias	-0.007	0.009	0.004	-0.310	-0.501	-0.347
Balearic Isl.	-0.020	-0.018	-0.011	-0.062	-0.074	-0.011
Canary Isl.	-0.238***	-0.220***	-0.226***	-0.263	-0.451	-0.409
Cantabria	0.011	0.026	0.025	0.035	-0.125	-0.105
Castile Leon	0.037*	0.050***	0.043**	0.413	0.336	0.366
Castile La Mancha	0.019	0.030	0.028	0.079	-0.054	0.068
Catalonia	0.133***	0.143***	0.138***	0.360*	0.240	0.267
Valencia	0.118***	0.129***	0.123***	0.464*	0.411*	0.456*
Extremadura	0.089***	0.086***	0.097***	0.111	0.236	0.201
Galicia	0.082***	0.101***	0.094***	0.688***	0.556**	0.624***
Madrid	0.020	0.044***	0.030*	0.584**	0.453**	0.525**
Murcia	0.081***	0.098***	0.089***	0.575**	0.700**	0.573**
Navarra	0.047**	0.056***	0.052***	0.243	0.093	0.060
Basque Country	0.131***	0.131***	0.127***	0.469*	0.201	0.287
La Rioja	0.149***	0.145***	0.139***	0.090	-0.437	-0.313

	Product Inn.	Process Inn.	Prod/Proc Inn.	Product Inn.	Process Inn.	Prod/Proc Inn.
ρ (ath)	-0.513***	-0.596***	-0.472***	-0.572***	-0.645***	-0.503***
Wald test –joint significance	6548.4***	6422.1***	6725.3***	7246.0***	7154.2***	7344.0***
log pseudo-L	-15243.7	-16089.0	-15977.6	-15147.3	-15985.5	-15876.8
Wald test (ρ=0)	78.0***	102.3***	72.4***	72.0***	102.2***	70.4***

Notes: A common effect of innovation and productivity is estimated in the first three columns while an independent effect in each region is estimated in the last three columns. Marginal effects obtained as the average from the ones for each firm in the corresponding sample. The number of observations used in each model is 14078. *** p<0.01, ** p<0.05, * p<0.1, corresponding to robust standard errors. ρ (ath) denotes the estimate of (a transformation of) the correlation coefficient between the errors of the export and innovation equations. Excluded categories are small firms, no belonging to a group, in mining and quarrying, located in Andalusia.

Table A.10. Robustness to the inclusion of regional factors, using product innovation.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Innovation						
All regions	0.351***	0.401***	0.388***			
Andalusia				0.359***	0.366***	0.365***
Aragon				0.432***	0.436***	0.432***
Asturias				0.317***	0.339***	0.336***
Balearic Isl.				0.300***	0.311***	0.303***
Canary Isl.				0.149***	0.163***	0.156***
Cantabria				0.360***	0.370***	0.367***
Castile Leon				0.370***	0.370***	0.365***
Castile La Mancha				0.380***	0.388***	0.389***
Catalonia				0.346***	0.348***	0.345***
Valencia				0.380***	0.375***	0.376***
Extremadura				0.394***	0.397***	0.403***
Galicia				0.379***	0.363***	0.363***
Madrid				0.373***	0.370***	0.376***
Murcia				0.390***	0.387***	0.385***
Navarra				0.372***	0.378***	0.372***
Basque Country				0.362***	0.362***	0.360***
La Rioja				0.410***	0.425***	0.418***
Firm controls	YES***	YES***	YES***	YES***	YES***	YES***
Region fixed effects	YES***	NO	NO	YES	NO	NO
GDPpc		0.009***	0.008***		0.018	-0.010
Private Capital		0. 083***	0.085***		-0.117	0.003
LPI		0.014***			-0.047	
Sea Transport.			0.003***			-0.005
Motorways			-0.472			1.290
Railways			1.018***			6.636
ρ (ath)	-0.513***	-0.698***	-0.645***	-0.572***	-0.576***	-0.571***

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Wald test –joint significance	6548.4***	7477.5***	7203.1***	7246.0***	7241.9***	7209.1***
log pseudo-L	-15243.7	-15349.9	-15333.6	-15147.3	-15157.8	-15155.5
Wald test (ρ=0)	78.0***	139.8***	115.0***	72.0***	72.1***	71.6***

Notes: Columns (i) and (iv) reproduce results for product innovation in Table A.9. They are included to facilitate comparisons. Marginal effects obtained as the average from the ones for each firm in the corresponding sample. The number of observations used in each model is 14078. *** p<0.01, ** p<0.05, * p<0.1, corresponding to robust standard errors. GDPpc denotes the value of GDP per capita in the region; Private Capital is the stock of physical private capital over the GDP in the region; LPI is the index of logistic performance in each region from Bensassi, Márquez-Ramos, Martínez-Zarzoso, and Suárez-Burguet (2015); Sea Transport is the percentage of the total sea traffic transportation corresponding to the region; Motorways and Railways refer to the kilometres of the corresponding infrastructure divided by the region's surface in square kilometres. $\boldsymbol{\rho}$ (ath) denotes the estimate of (a transformation of) the correlation coefficient between the errors of the export and innovation equations. All specifications include the full list of firm controls used in the results described in the main text.

Table A.11. Robustness to the inclusion of regional factors, using process innovation.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Innovation						
All regions	0.340***	0.387***	0.377***			
Andalusia				0.315***	0.321***	0.321***
Aragon				0.388***	0.392***	0.389***
Asturias				0.309***	0.331***	0.330***
Balearic Isl.				0.225***	0.232***	0.221***
Canary Isl.				0.186***	0.199***	0.192***
Cantabria				0.363***	0.371***	0.368***
Castile Leon				0.351***	0.347***	0.343***
Castile La Mancha				0.377***	0.386***	0.387***
Catalonia				0.333***	0.332***	0.330***
Valencia				0.371***	0.365***	0.367***
Extremadura				0.350***	0.344***	0.356***
Galicia				0.381***	0.367***	0.369***
Madrid				0.376***	0.369***	0.378***
Murcia				0.402***	0.384***	0.382***
Navarra				0.347***	0.349***	0.344***
Basque Country				0.349***	0.349***	0.348***
La Rioja				0.366***	0.375***	0.372***
Firm controls	YES***	YES***	YES***	YES***	YES***	YES***
Region fixed effects	YES***	NO	NO	YES	NO	NO
GDPpc		0.008***	0.007***		0.001	-0.030
Private Capital		0. 073***	0.080***		-0.687	0.063
LPI		0.011***			-0.011	
Sea Transport.			0.002***			-0.001
Motorways			-0.505*			1.019
Railways			1.325***			9.786
ρ (ath)	-0.596***	-0.793***	-0.747***	-0.645***	-0.640***	-0.640***

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Wald test –joint significance	6422.1***	7494.9***	7252.1***	7154.2***	7049.8***	7062.0***
log pseudo-L	-16089.0	-16195.2	-16178.3	-15985.5	-16000.9	-15996.7
Wald test (ρ=0)	102.3***	169.1***	143.1***	102.2***	96.7***	97.8***

Notes: Columns (i) and (iv) reproduce results for process innovation in Table A.9. They are included to facilitate comparisons. Marginal effects obtained as the average from the ones for each firm in the corresponding sample. The number of observations used in each model is 14078. *** p<0.01, ** p<0.05, * p<0.1, corresponding to robust standard errors. GDPpc denotes the value of GDP per capita in the region; Private Capital is the stock of physical private capital over the GDP in the region; LPI is the index of logistic performance in each region from Bensassi et al. (2015); Sea Transport is the percentage of the total sea traffic transportation corresponding to the region; Motorways and Railways refer to the kilometres of the corresponding infrastructure divided by the region's surface in square kilometres. ρ (ath) denotes the estimate of (a transformation of) the correlation coefficient between the errors of the export and innovation equations. All specifications include the full list of firm controls used in the results described in the main text.

Table A.12. Robustness to the inclusion of regional factors, using product / process innovation.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Innovation						
All regions	0.323***	0.370***	0.360***			
Andalusia				0.286***	0.293***	0.293***
Aragon				0.377***	0.380***	0.377***
Asturias				0.292***	0.314***	0.313***
Balearic Isl.				0.226***	0.233***	0.223***
Canary Isl.				0.162***	0.174***	0.167***
Cantabria				0.330***	0.338***	0.336***
Castile Leon				0.332***	0.329***	0.326***
Castile La Mancha				0.342***	0.348***	0.350***
Catalonia				0.318***	0.318***	0.317***
Valencia				0.352***	0.346***	0.348***
Extremadura				0.339***	0.336***	0.348***
Galicia				0.355***	0.340***	0.343***
Madrid				0.351***	0.345***	0.354***
Murcia				0.362***	0.355***	0.354***
Navarra				0.324***	0.328***	0.325***
Basque Country				0.325***	0.325***	0.324***
La Rioja				0.341***	0.353***	0.350***
Firm controls	YES***	YES***	YES***	YES***	YES***	YES***
Region fixed effects	YES***	NO	NO	YES	NO	NO
GDPpc		0.008***	0.007***		0.003	-0.029
Private Capital		0. 077***	0.082***		-0.079	0.053
LPI		0.012***			-0.018	
Sea Transport.			0.002***			-0.003
Motorways			-0.600*			0.732
Railways			1. 240***			10.240*
ρ (ath)	-0.472***	-0.654***	-0.608***	-0.503***	-0.501***	-0.502***

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Wald test –joint significance	6725.3***	7742.0***	7252.1***	7344.0***	7289.0***	7300.3***
log pseudo-L	-15977.6	-16079.9	-16178.3	-15876.8	-15890.0	-15885.6
Wald test (ρ=0)	72.4***	123.9***	104.3***	70.4***	67.9***	69.1***

Notes: Columns (i) and (iv) reproduce results for innovation, regardless of type, in Table A.9. They are included to facilitate comparisons. Marginal effects obtained as the average from the ones for each firm in the corresponding sample. The number of observations used in each model is 14078. *** p<0.01, ** p<0.05, * p<0.1, corresponding to robust standard errors. ρ (ath) denotes the estimate of (a transformation of) the correlation coefficient between the errors of the export and innovation equations. All specifications include the full list of firm controls used in the results described in the main text.

Table A.13. Marginal effects for the extensive margin of exports to EU and non-EU countries.

	Exports to EU			Exports to non-EU		
	Product Innov.	**Process Innov.**	**Innovation (Prod/Proc)**	**Product Innov.**	**Process Innov.**	**Innovation (Prod/Proc)**
Spain	0.363***	0.351***	0.324***	0.361***	0.347***	0.326***
Andalusia	0.369***	0.334***	0.304***	0.370***	0.324***	0.293***
Aragon	0.400***	0.367***	0.348***	0.434***	0.382***	0.368***
Asturias	0.340***	0.307***	0.286***	0.333***	0.323***	0.300***
Balearic Isl.	0.299***	0.223***	0.217***	0.308***	0.240***	0.235***
Canary Isl.	0.126***	0.181***	0.165***	0.155***	0.188***	0.163***
Cantabria	0.379***	0.368***	0.321***	0.367***	0.365***	0.332***
Castile Leon	0.365***	0.362***	0.327***	0.375***	0.359***	0.336***
Castile La Mancha	0.383***	0.385***	0.341***	0.400***	0.387***	0.349***
Catalonia	0.351***	0.332***	0.313***	0.352***	0.333***	0.318***
Valencia	0.393***	0.381***	0.358***	0.397***	0.381***	0.358***
Extremadura	0.446***	0.359***	0.340***	0.398***	0.350***	0.337***
Galicia	0.425***	0.431***	0.384***	0.388***	0.391***	0.361***
Madrid	0.376***	0.380***	0.346***	0.382***	0.384***	0.355***
Murcia	0.392***	0.398***	0.351***	0.394***	0.407***	0.362***
Navarra	0.373***	0.354***	0.322***	0.374***	0.343***	0.320***
Basque Country	0.360***	0.348***	0.323***	0.361***	0.347***	0.321***
La Rioja	0.433***	0.395***	0.373***	0.437***	0.373***	0.351

Notes: *** p<0.01, ** p<0.05, * p<0.1, corresponding to robust standard errors. Marginal effects obtained as the average from the ones for each firm in the sample of each region. The specification used to compute the marginal effects includes controls for productivity, size, firm group (national or international), industry (NACE 2 digits) and regions.

Table A.14. Changes in the extensive margin of exports to EU and non-EU countries due to counterfactual innovation.

	Exports to EU			Exports to non-EU		
	Product Innov.	**Process Innov.**	**Innovation (Prod/Proc)**	**Product Innov.**	**Process Innov.**	**Innovation (Prod/Proc)**
Spain	5.31***	4.26***	5.05***	5.70***	4.64***	5.44***
Andalusia	8.54***	5.68***	6.62***	8.87***	5.74***	6.53***
Aragon	7.96***	6.17**	7.14***	10.16***	7.72***	8.85***
Asturias	6.64***	5.20**	5.68**	7.69***	6.86**	7.31***
Balearic Isl.	11.97***	7.72**	9.40***	12.83***	8.68***	10.57***
Canary Isl.	3.68**	3.52**	3.68**	4.70**	4.24*	4.55**
Cantabria	7.98***	6.80***	7.24***	8.18***	7.31**	8.13***
Castile Leon	6.53***	5.67**	6.19***	7.19***	6.01**	6.65***
Castile La Mancha	9.69***	8.65***	9.56***	11.42***	9.85***	10.91***
Catalonia	--	--	--	--	--	--
Valencia	5.22***	4.12***	5.07***	5.29***	4.15***	5.04***
Extremadura	14.49***	9.13***	12.38***	15.43***	11.29**	14.73***
Galicia	7.70***	8.19***	8.93***	6.87***	7.16***	7.96***
Madrid	4.24**	5.26***	4.85***	4.73**	5.78***	5.30***
Murcia	7.34***	7.54***	7.35***	8.46***	8.84***	8.73***
Navarra	4.53*	3.20	4.03	5.06*	3.72	4.44
Basque Country	4.02**	2.02	2.88	4.49**	2.46	3.25
La Rioja	11.47***	7.29*	8.94**	12.14***	7.27	8.41**

Notes: Change in percentage points with respect to the actual extensive margin in each region. Figures on the share of innovative firms in Catalonia are used as benchmark. *** p<0.01, ** p<0.05, * p<0.1 of a test of equality of the actual and counterfactual margins of exports.

References

Bensassi, S., Márquez-Ramos, L., Martínez-Zarzoso, I., & Suárez-Burguet, C. (2015). Relationship between logistics infrastructure and trade: Evidence from Spanish regional exports. *Transportation Research Part A*, *72*, 47–61.