The granular and fundamental components of export specialization*

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Abstract

Firms do not play any role in shaping countries' export specialization in neoclassical models of trade. However, the evidence shows that in some industries few firms dominate exports, suggesting that they might also contribute to export specialization. In this paper we propose an easy-to-implement methodology to decompose export specialization into a country-specific component, fundamental comparative advantage, and a firm-specific component, granular comparative advantage. We implement this methodology on Spanish regional exports in 2014. We find that, on average, only in 9 out of the 96 analyzed industries granular comparative advantage is larger than fundamental comparative advantage; however, these industries account for 37% of regional exports. We also show that variation in export specialization across industries and regions is mostly explained by granular comparative advantage.

JEL: F1, F10, F23

Keywords: exports, fundamental comparative advantage, granular comparative advantage, Spain, regions, export superstars, firm-level data.

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1 Introduction

Why some countries export some goods and import others is a central question of positive trade theory (Jones and Neary, 1984). The Ricardian and Heckscher-Ohlin models of trade contend that countries export the goods in which they have a comparative advantage and import the goods in which they have a comparative disadvantage. In these models, comparative advantage emerges from differences in technology and factor endowments. Since these variables are determined at the country level, firms do not play any role in shaping countries' export specialization.

However, this argument seems difficult to reconcile with the fact that in many countries industry-level exports are dominated by few firms (Freund and Pierola, 2015). For example, in 2014, the share of apparel in Spanish exports was 60% higher than the share of apparel in world exports.[1] However, only three firms accounted for 51% of all Spanish exports in this industry. Was Spanish export specialization in apparel explained by neoclassical comparative advantage or by three outstanding firms?

In this paper, we propose an easy-to-implement methodology to decompose export specialization into a country-level, or fundamental, comparative advantage, and a firm-level, or granular, comparative advantage. This methodology allow us to identify industries in which export specialization is explained mostly by granular comparative advantage; and, investigate the contribution of fundamental and granular comparative advantage to the variation in export specialization across countries and industries.

We implement our methodology on Spanish regional exports for the year 2014. On average, granular comparative advantage dominates in 9 out of 96 industries. Although this number is small, granular industries account, on average, for 37% of regional exports. Granular comparative advantage becomes more important when we analyze the variation in export specialization across industries and regions. We find that granular comparative advantage explains 70% of the variation in export specialization across industries and regions, while fundamental comparative advantage explains the remaining 30% of the variation.

We define export specialization as country i exports in industry k relative to a reference industry k', divided by the same ratio in a reference country i'. We decompose export specialization into fundamental comparative advantage and granular comparative advantage. Researchers can observe countries' export specialization. However, they cannot observe the fundamental comparative advantage component or the granular comparative advantage component of export specialization. We develop a methodology to estimate fundamental comparative advantage and, then, calculate granular comparative

[1] Authors calculations using the Comtrade database (available at `http://comtrade.un.org`). To measure apparel exports we add-up the HS chapters 61 and 62.

advantage as the difference between export specialization and fundamental comparative advantage.

To estimate fundamental comparative advantage, we frame our methodology in an environment where firms are heterogeneous in productivity. If the pool of potential entrants was large, firms would occupy all the available productivity levels and with the densities predicted by the productivity distribution function. In this setting, differences in export specialization, once size and trade costs were controlled for, would be determined by variations in fundamental comparative advantage only. Granular comparative advantage only emerges when the potential number of entrants is small. In this situation, which productivity levels are occupied and which are not, the so-called luck-at-draw, begins to influence export specialization.

Our methodology rests on two assumptions. First, firms' productivity is distributed Pareto. Second, the fixed, and variable, cost of exporting in industry k relative to industry k' is the same across countries. Although, at first sight, this assumption might not seem realistic, as explained later, for our empirical analyses we will use a database where this assumption is met. If the number of potential entrants was large, fundamental comparative advantage would equal the ratio of relative exporters: country i exporters in industry k relative to the number of exporters in k' divided by the same ratio in country i'. We argue that even in a small number of entrants scenario, the ratio of the relative number of exporters still provides a valid approximation of fundamental comparative advantage. Although the realized productivities might depart from the densities predicted by the distribution function in a continuity scenario, the division of firms between exporters and non-exporters should not differ significantly from the distribution we would observe in a large number of draws scenario. Based on this argument, we use the ratio of the relative number of exporters as an approximation of fundamental comparative advantage, and calculate granular comparative advantage as the difference between export specialization and fundamental comparative advantage.

In the empirical section, we implement our methodology using regional exports data. We use these data, because it is safe to assume that within a country regions face similar relative fixed and variable exports costs. In particular, we will use information of regular Spanish exporting firms operating from the peninsular territory in 2014.

Our paper is related with the literature that analyzes the contribution of granular and fundamental comparative advantage to trade specialization. A first attempt to estimate the contribution of these components is provided by Freund and Pierola (2015). They analyze whether countries' revealed comparative advantage in an industry would alter if top exporters disappeared.[2] Granular comparative advantage dominates if revealed comparative advantage disappears; in contrast, fundamental comparative advantage dominates

[2] De Lucio et al. (2017) also apply this methodology on Spanish exports.

if revealed comparative advantage remains. The limitation of this methodology is that the behavior of the rest of exporters, once the top firms disappear, is not known. Besides, it only identifies whether an industry is granular or fundamental. It does not have a measure of fundamental and granular comparative advantage for each industry and, hence, cannot estimate the contribution of these components to the variation in export specialization across countries and industries. To overcome these limitations, Gaubert and Itskhoki (2016) develop a general equilibrium model with a finite number of firms. They apply a simulated method of moments to estimate the parameters of the model; then, they use these parameters to estimate the contribution of granular and fundamental comparative advantage to the variation in exports across French industries. Our paper, while keeping the features of a general equilibrium model, contributes to this literature offering an alternative, and easy-to-implement, methodology to identify granular industries, and measure the contribution of granular and fundamental comparative advantage to the variation in export specialization across industries and countries. Because of data limitations, we apply our methodology to regional exports. However, if data were available, it could also be applied on country-level data, as long as the countries included in the sample had similar relative fixed and variable export costs across industries.[3]

Our paper is also related with the literature that has analyzed export specialization at the regional level (Courant and Deardorff, 1992; Coşar and Fajgelbaum, 2016). As far as we know, for the first time in the literature, we present data on the concentration of exports by firm at the regional level. We show that in some regions the top exporter might account for almost 50% of exports. Another novelty is that we estimate the contribution of granular and fundamental comparative advantage to differences in export specialization across regions and industries. We show that, within an industry, differences in export specialization across regions are mostly explained by granular comparative advantage; within a region, granular comparative advantage also explains most of the differences in export specialization across industries.

The paper is organized as follows. Next, we explain our methodology to estimate fundamental and granular comparative advantage. Section 3 presents the database and analyzes the concentration of exports by firm in Spanish regions. Section 4 carries out the empirical analyses. In this section, we identify the granular industries and measure the contribution of fundamental and granular comparative advantage to the variation in export specialization across regions and industries. We also provide some robustness checks. Section 5 concludes.

[3]For example, Head and Mayer (2014) introduce similarity in export costs selecting a distant destination for the same sample of exporters (see Figure 3.1).

2 A methodology to estimate the fundamental and granular components of export specialization

In this section, we explain our methodology to calculate the fundamental and granular components of export specialization. We begin decomposing export specialization into fundamental comparative advantage (FCA) and granular comparative advantage (GCA).

$$\frac{X_{ik}/X_{ik'}}{X_{i'k}/X_{i'k'}} = FCA_{ik} + GCA_{ik} \quad (1)$$

where X_{ik} are industry k exports by country i; i' is the reference country and k' is the reference industry.

As explained in the introduction, researchers only observe export specialization. They do not observe neither the fundamental nor the granular component of export specialization. A strategy to estimate these components is to develop a general equilibrium model with a finite number of firms, and simulate the model until the differences between the moments generated by the model and actual moments are minimized. The parameters obtained after the minimization process are then used to calculate fundamental and granular comparative advantage. This is the strategy followed by Gaubert and Itskhoki (2016) to estimate the fundamental and granular components in French industries' exports.[4] However, these authors use moments that demand information on domestic sales that we do not have.

As an alternative to the simulated method of moments, we propose an easy-to-implement methodology to estimate fundamental and granular comparative advantage. First, we estimate fundamental comparative advantage and, then, we calculate granular comparative advantage as the difference between export specialization and fundamental comparative advantage.

To estimate fundamental comparative advantage, we decompose exports into the number of exporters, the extensive margin, and the average exports per firm, the intensive margin:

$$X_{ik} = N_{ik} x_{ik} \quad (2)$$

where N_{ik} is the number of firms located in country i that export industry k products, and x_{ik} is the average exports per firm in industry k.

To investigate the determinants of the extensive and intensive margins of trade, we frame our analysis in a Melitz-type heterogeneous firms' trade model (Melitz, 2003).

[4] Minondo (2017) also uses a simulated method of moments to estimate the contribution of fundamental and granular components to the variation of expert chess players across countries.

Firms produce horizontally-differentiated varieties within an industry with monopolistic competition, labor is the only factor of production, and preferences of a representative consumer are given by a constant elasticity of substitution (CES) utility function. Firms are heterogeneous in productivity and face fixed and variable export costs. Following Chaney (2008), the potential number of entrants is fixed, but large enough, so there is a continuity of firms.

If productivity is distributed Pareto, the intensive margin of exports is determined by (Fernandes et al., 2015):

$$x_{ik} = \Big(\frac{\theta\sigma}{\theta - (\sigma - 1)}\Big) F_{ik} \tag{3}$$

where σ is the elasticity of substitution and F_{ik} is the fixed cost of exporting. The shape parameter θ measures the heterogeneity in the distribution of productivity, with higher values meaning less heterogeneity. For stability, it is assumed that $\theta > \sigma - 1$.

If we substitute (2) and (3) in the left-hand side of (1),

$$\frac{X_{ik}/X_{ik'}}{X_{i'k}/X_{i'k'}} = \Big(\frac{N_{ik}/N_{ik'}}{N_{i'k}/N_{i'k'}}\Big)\Big(\frac{F_{ik}/F_{ik'}}{F_{i'k}/F_{i'k'}}\Big) \tag{4}$$

Based on the properties of the Pareto distribution, we can express the number of exporters of country i in industry k by the following expression:

$$N_{ik} = M_i \Big(\frac{\underline{z}_{ik}}{\varphi_{ik}}\Big)^{-\theta} \tag{5}$$

where M_i is the exogenous mass of firms that can potentially enter any industry in country i; $\underline{z}_{ik}$ is the threshold productivity firms should reach to obtain profits from exports; φ_i^k is the minimum productivity firms can draw in country i and industry k. Following Costinot et al. (2012), we denote this parameter as the fundamental productivity of country i in industry k. According to (5), the number of exporters will be larger the lower the threshold productivity to export, and the larger the fundamental productivity and the heterogeneity in the distribution of productivity.

If we substitute (5) in (4),

$$\frac{X_{ik}/X_{ik'}}{X_{i'k}/X_{i'k'}} = \Big(\frac{\varphi_{ik}/\varphi_{ik'}}{\varphi_{i'k}/\varphi_{i'k'}}\Big)^{\theta}\Big(\frac{\underline{z}_{ik}/\underline{z}_{ik'}}{\underline{z}_{i'k}/\underline{z}_{i'k'}}\Big)^{-\theta}\Big(\frac{F_{ik}/F_{ik'}}{F_{i'k}/F_{i'k'}}\Big) \tag{6}$$

Note that, the first ratio in the right-hand side of (6) is country i's fundamental comparative advantage in industry k. According to (6), export specialization is the product of fundamental comparative advantage, the ratio of relative export-threshold productivities and the ratio of relative fixed exports costs.

The export-threshold is determined by the following expression:

$$\underline{z}_{ik} = \Big(\frac{F_{ik}}{\mu\beta_k Y}\Big)^{(1/\sigma-1)}\Big(\frac{w_i\tau_{ik}}{P_k}\Big) \tag{7}$$

where $\mu = (\sigma - 1)^{\sigma-1}\sigma^{-\sigma}$.

$\beta_k Y$ is the share of income that the foreign destination devotes to consume industry k varieties; w_i is the wage in country i; τ_i is an iceberg-type trade cost, denoting the units of a variety that should be sent to the foreign destination to ensure that one unit arrives; finally, P_k is the price index of industry k varieties in the foreign destination.

At this point, we assume that fixed exports costs in industry k relative to industry k' in country i are the same as in country i'

$$\frac{F_{ik}}{F_{ik'}} = \frac{F_{i'k}}{F_{i'k'}} \tag{8}$$

and variable export costs in industry k relative to industry k' in country i are the same as in country i'

$$\frac{\tau_{ik}}{\tau_{ik'}} = \frac{\tau_{i'k}}{\tau_{i'k'}} \tag{9}$$

Although, at first sight, this assumption might not seem realistic, as explained later, for our empirical analyses we will use a database where this assumption is met. With this assumption, we can simplify (6), which becomes

$$\frac{X_{ik}/X_{ik'}}{X_{i'k}/X_{i'k'}} = \Big(\frac{\varphi_{ik}/\varphi_{ik'}}{\varphi_{i'k}/\varphi_{i'k'}}\Big)^{\theta} \tag{10}$$

Note that the ratio-of-ratios structure of (10), which follows the spirit of Head et al. (2010) tetrax methodology, leads to the canceling of some unobserved variables, such as $\mu, \beta_k Y, w_i, w_{i'}$, and P_k.

According to (10), if relative export costs are similar across countries, productivity is distributed Pareto, and there is a large number of potential entrants, export specialization is determined by fundamental comparative advantage only.

With these assumptions, we can simplify (4) and calculate fundamental comparative advantage using the ratio of the relative number of exporters:

$$\frac{X_{ik}/X_{ik'}}{X_{i'k}/X_{i'k'}} = \frac{N_{ik}/N_{ik'}}{N_{i'k}/N_{i'k'}} \tag{11}$$

Therefore, in a continuity of firms scenario, we can use the ratio of the relative number of exporters to calculate fundamental comparative advantage. Our main argument is that even when the number of draws is small, the ratio of the relative number of exporters still provides an accurate estimate of fundamental comparative advantage. When the number of draws is small, the distribution of productivities might differ from the one predicted by the density function with a continuity of firms. However, we need to know the number of exporters and non-exporters only. This is equivalent to reduce the productivity levels firms might draw to two: a productivity below the export-threshold, and a productivity above the export-threshold. In this case, even with a small number of draws, the distribution of firms between exporters and non-exporters would be very similar to the distribution we would have if the number of draws were large. Hence, the realized number of exporters will provide an accurate approximation of the number of exporters we would expect in the continuous case.

To support our argument, we draw on Eaton et al. (2012). These authors explain that if the number of draws is small, the number of industry k exporters in country i is the realization of a random variable that follows a Poisson distribution, with parameter $\lambda = M_i(\underline{z}_{ik}/\varphi_{ik})^{-\theta}$. Note that in a Poisson distribution the expected value of the random variable is λ. Hence, the expected number of exporters in a small number of draws scenario is the same as the number of exporters in a large number of draws scenario. In a Poisson distribution the standard deviation of the random variable is $\sqrt{\lambda}$. To measure the extent to which a realization might differ from the expected value in each of the four elements that compose the ratio of the relative number of exporters, we calculate the number of exporters' coefficient of variation:

$$cvN_{ik} = \frac{(\underline{z}_{ik}/\varphi_{ik})^{\theta/2}}{\sqrt{M_i}} \tag{12}$$

We can give values to the variables in (12) to measure the coefficient of variation. The ratio in the numerator measures the minimum productivity that firms in country i need to reach to export industry k varieties, relative to the fundamental productivity of firms in country i and industry k. We can approximate this ratio with the exporters' labor productivity premium estimated by the empirical literature. For example, Bernard et al. (2007) report that value-added per worker is 11 percent larger in exporters than non-exporters in the US, once industry effects are controlled for. Following Eaton et al. (2012), we take $\theta = 5$. Even for a very small number of draws[5], $M_i = 100$, the coefficient of variation is very low, $cvN_{ik} = 0.13$.[6] This conclusion is in line with Minondo (2017), who compares the number of expert chess players across countries predicted by a model with a continuity of players and a model with a finite number of players. Using a simulated method of moments, he shows that, for moderate levels of expertise, equivalent to a low $\underline{z}^k_{ij}/\varphi^k_i$ ratio, the continuous and discrete models predict very similar numbers.

[5] For example, Gaubert and Itskhoki (2016) use 8,000 draws for small French sectors.

[6] A distribution with a coefficient of variation lower than 1 is considered a low-variance distribution.

As shown in Appendix (A), the coefficient of variation of the ratio of the relative number of exporters is determined by a more complex expression than (12). We use random numbers generated by a Poisson distribution with different λ parameters to measure the coefficient of variation in alternative scenarios. As shown in Table A1, even in the more stringent scenarios, the coefficient of variation remains low.

Our methodology rests on the assumption that industry k fixed and variable export costs in industry k relative to industry k' are the same in country i and country i'. To abide by this assumption we use Spanish regional trade data. As argued by Helpman et al. (2008), export fixed costs combine the costs exporters face in their country (e.g. the costs of drafting a contract for a foreign delegate) and in the destination country (e.g. the legal costs of opening a delegation). Since regulatory and legal costs are similar within Spain, it is reasonable to assume a similarity in relative fixed costs across Spanish regions. Variable export costs combine transport and other barriers to trade, such as communication costs and tariffs. We argue that it is also reasonable to assume that relative variable trade costs are similar across Spanish regions.

To sum up, assuming productivity is distributed Pareto and similarity in relative fixed and variable export costs, we argue that the ratio of relative number of exporters provides a valid approximation of fundamental comparative advantage. Although our methodology is easy to implement, it also entails some limitations that we should highlight. First, our methodology rests on the assumption that productivity is distributed Pareto. As explained by Arkolakis et al. (2012) this assumption is standard in the literature.[7] They provide three reasons to explain the popularity of this distribution function. First, it is easy to treat analytically. Second, it provides a reasonable approximation for the distribution of firm sales and exports.[8] Finally, from the theoretical point of view, the Pareto distribution can be the outcome of simple stochastic processes of firm-level growth, entry and exit. Notwithstanding these arguments, some papers have begun to explore whether other functions approximate the distribution of productivity across firms more accurately (Head et al., 2014; Hanson et al., 2015; Fernandes et al., 2015). Second, we provide arguments to support that even in a small number of entrants scenario, the ratio of the relative number of exporters can provide a good approximation of fundamental comparative advantage. However, our approximation has a margin of error. Hence, we should consider our methodology a fairly correct approximation to identify granular industries and measure the contribution of granular and fundamental comparative advantage to variation in export specialization across industries and regions.

[7] See the list of references in footnote 22 in that paper.

[8] For example, De Lucio et al. (2017) show that a Pareto distribution fits very well the distribution of exports across firms in Spain.

3 Data

Our data are obtained from the Customs Database, elaborated by the Customs and Excise Department of the Spanish Tax Agency, which covers the universe of exports transactions in Spain. For each transaction, we know the firm's pseudo-identification code, the product at the 8-digit Combined Nomenclature (CN) classification, the destination of the export transaction, the free-on-board (FOB) value in euros of the transaction, and the exported quantity (in weight metric and/or units). The database also reports the fiscal address, at regional level, of the exporter. We use data for the year 2014.

Map 1: NUTS II Regions of Spain

Spain is divided into 17 regions (Eurostat's NUTS II classification), which are shown in Map 1. Due to their special geographic features, for the empirical analyses, we remove from the sample the two regions located in Africa (Ceuta and Melilla), and the two island regions (Balearic Islands and Canary Islands). To perform the empirical calculations we collapse exports at the HS 2-digit level, which distinguishes 96 different products, which are denoted as chapters.[9]

Columns 1 and 2 in Table 1 provide information on Spanish regions' share in total exports and number of exporters.[10] We can see that 52% of Spanish exporters are located in Catalonia and Madrid. The next regions in the ranking of exporters are Valencia, 12%, and Andalusia, 11%. The region with the highest amount of exports is Madrid, with 29%

[9]There is not chapter 77, and there are no data for chapters 98 and 99.

[10]The shares are calculated over the total number of exporters and the value of exports of the regions included in the sample.

Table 1: Distribution of exporters, export values and share of top exporters in Spanish regions, 2014

Region	Exporters as % of number of exporters in the sample	Exports as % of total exports in the sample	Share top 1 firm in regional exports	Share top 5 firms in regional exports
Andalusia	11	6	6	21
Aragon	3	3	35	46
Asturias	1	1	27	43
Basque Country	4	8	11	22
Cantabria	1	1	28	53
Castile and León	3	4	48	68
Castile-La Mancha	3	1	6	15
Catalonia	26	23	10	17
Extremadura	1	1	10	29
Galicia	4	7	23	54
Madrid	26	29	9	23
Murcia	3	3	10	21
Navarre	1	4	31	50
Rioja	1	1	6	22
Valencia	12	9	10	23
Spain (total)			2	10

Source: Authors estimations using the Customs database. Note: The regional number of exporters and exports shares are calculated over the total number of exporters and the value of exports of the regions included in the sample. The top1 and top 5 figures for Spain are calculated using data from all regions.

of the total, followed by Catalonia, 23%, Valencia, 9% and Basque Country, 8%. The correlation between the share in the number of exporters and the share in total exports is 0.95.

Following Gaubert and Itskhoki (2016), as a first proxy of granular comparative advantage, Table 1 also presents the share of the top 1 exporter and the share of the top 5 exporters in regional exports. There is a large variation in the share of the top 1 exporter across regions. For example, in Castile and León the top exporter represents almost half of regional exports, whereas in Andalusia, Castile-La Mancha and Rioja the top exporter only explains 6% of all exports. The average is 18%, with a standard deviation of 13%. At the bottom of the table, we also present the share of the top 1 exporter for Spain: 2%.[11] At the regional level, the correlation between the amount of exports and the share of the top exporter is -0.28. The differences across regions are still sizable for the share of the top 5 exporters. The average is 34%, with a standard deviation of 17%. The regions with the highest shares are Castile and León, 68%, and Galicia, 54%. The lowest

[11] The Spanish figure is calculated with data from all regions.

percentages are found in Castile-La Mancha, 15% and Catalonia, 17%. The share of the top 5 exporters in Spanish exports is 10%. These figures point out that in some regions, few firms dominate exports. In the next section, we apply our methodology to identify whether this dominance is associated with granular comparative advantage.

4 Empirical analyses

We use (11) to calculate fundamental comparative advantage. For our baseline analysis, we select the world as the destination of Spanish regional exports. To reduce noise in the number of exporters, we remove small and occasional exporters. First, we exclude exporters whose total annual export operations in a HS 2-digit chapter are below 6,000 euros.[12] Next, we select firms that export a chapter during three consecutive years. Since our reference year is 2014, for each chapter, we select firms that export in 2013, 2014 and 2015.

Granular comparative advantage is calculated as the difference between export specialization and fundamental comparative advantage. It is important to stress that granular comparative advantage can take positive and negative values. For example, in the small number of entrants scenario, if a firm draws an outstanding productivity, it will become a very large exporter and lead the country to an export specialization above the level predicted by fundamental comparative advantage. In this case, granular comparative advantage will be positive. In contrast, if firms draw productivities below expected values, export specialization will be lower than predicted by fundamental comparative advantage. In this case, granular comparative advantage will be negative. Since granular comparative advantage can take positive and negative values, and both are equally likely, the expectation of granular comparative advantage is zero.

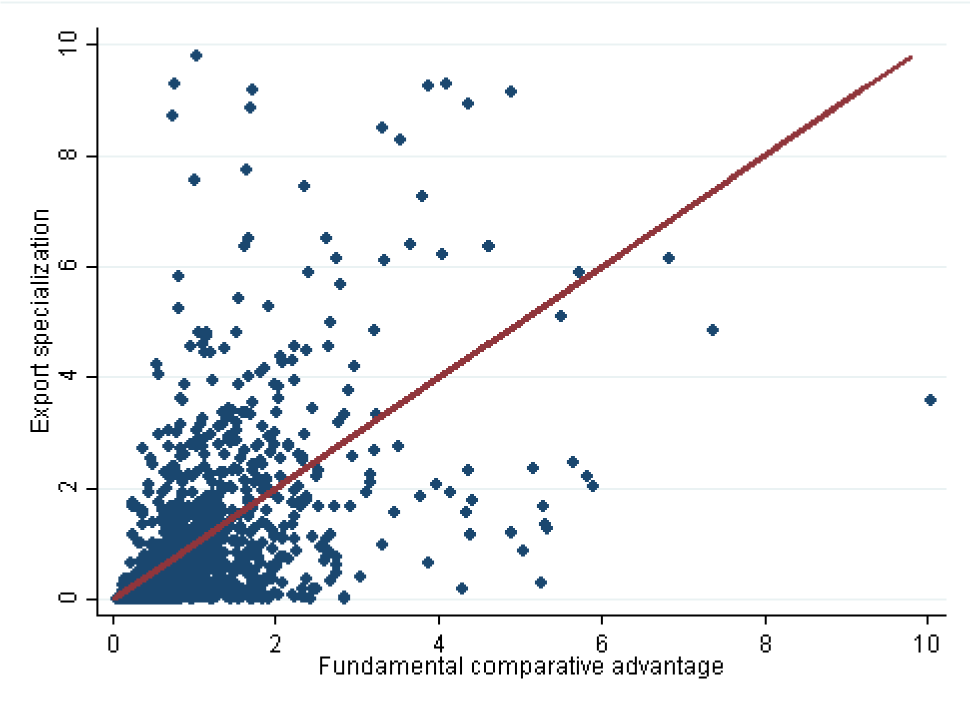
To identify granular comparative advantage at the regional level we need to use a reference country and a reference industry where granular comparative advantage is small. As explained in the methodology section, granular comparative advantage tends to disappear as we increase the number of draws. If there is a large number of draws, firms will occupy all the productivity levels and with the densities predicted by the Pareto distribution. Hence, as reference country we select the aggregation of all regions, Spain, and as reference industry, we select the aggregation of all industries. Choosing these references, export specialization becomes Balassa's revealed comparative advantage index (Balassa, 1965). It is important to stress that selecting these references, we measure Spanish regions' export specialization relative to Spain as a whole.

Using Spain, instead of an specific region, as the reference country, and the sum

[12] Up to this value European Union (EU) exporters do not have to certify that the product meets EU's rules of origin http://madb.europa.eu/madb/rulesoforigin_preferential.htm

of industries, instead of an specific industry, as the reference industry, we smooth the effects that a particular reference region or industry might have on the identification of granular industries at the regional level. In the robustness analysis, we will illustrate this effect selecting Catalonia and mechanical appliances as the reference region and industry, respectively. However, the limitation of using the whole of Spain as the reference country is that granular comparative advantage might be attenuated in large exporting regions, such as Catalonia and Madrid in Spain.[13]

Figure 1: Export specialization vs. fundamental comparative advantage, 2014



Source: Authors calculations using the Customs database.

Figure 1 presents a scatter diagram of export specialization and fundamental comparative advantage.[14] We find a positive correlation between both variables: the larger the ratio of the relative number of exporters, the larger the export specialization. If there were no granular effects all the dots would lie on the 45°line. However, we can observe that dots scatter around the 45°line, denoting the presence of granular comparative advantage. The dots above the 45°line are region+industry combinations where granular comparative advantage is positive, whereas the dots below the 45°line are region+industry combinations where granular comparative advantage is negative.

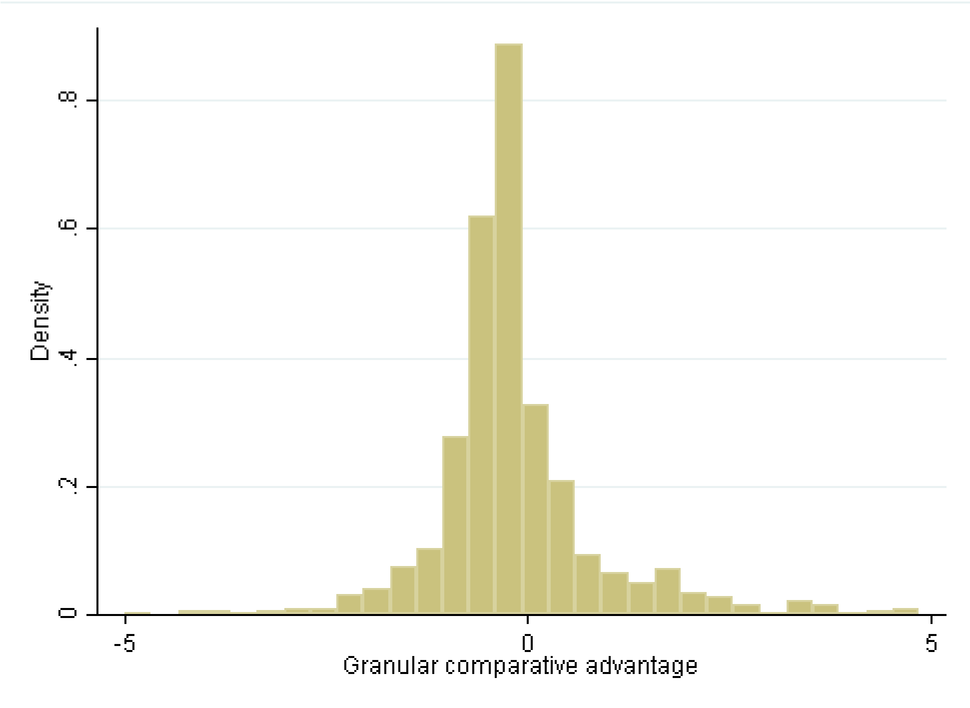
Figure 2 presents the histogram of granular comparative advantage. As expected,

[13]In addition to that, we cannot longer assume full independence across the random variables in the simulations carried out in Table A1.

[14]We have 96 chapters x 15 regions = 1,440 potential observations. There are 187 chapter-region combinations were exports are zero, so the number of observations is 1,253.

average granular comparative advantage is very close to zero: 0.06, with a median of -0.27 and a standard deviation of 2.29. Most observations are around zero, although the mode is slightly lower than zero.[15]

Figure 2: Histogram of granular comparative advantage, 2014



Source: Authors calculations using the Customs database.

Once we have calculated the granular and fundamental components of export specialization, we investigate, first, the presence of granularity on regional exports. Following Gaubert and Itskhoki (2016), we define a chapter as granular when granular comparative advantage is higher than fundamental comparative advantage. For each region, we calculate the number of granular chapters and their share in regional exports. Table 2 presents these calculations for the 15 Spanish regions included in our sample.

The number of granular chapters ranges from 3 in Navarre to 15 in Rioja. As expected, since we take Spain as the reference country, the large exporting regions, Catalonia and Madrid, have few granular chapters. However, we also find a low numbers of granular chapters in small exporting regions, such as Navarre, Castile and León and Cantabria. On average, a Spanish region has 9 granular chapters. There are much larger differences across regions in the share of exports generated by granular chapters. The largest percentage of exports in granular chapters is in Castile and León. Note that this region

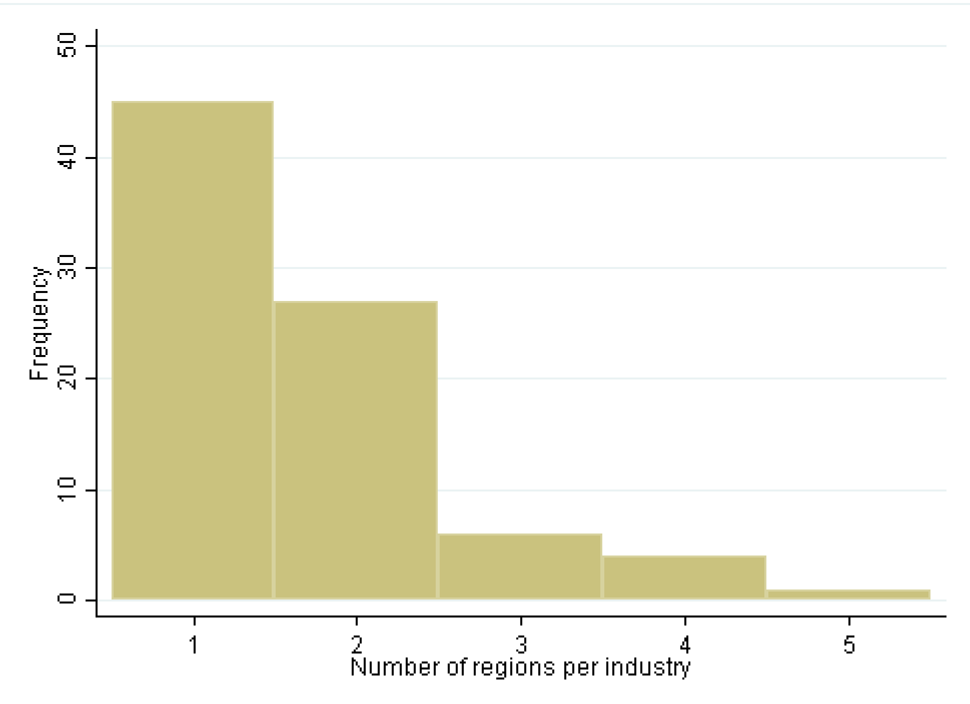
[15]Since the reference country is the aggregation of regions and the reference industry is the aggregation of industries, by construction, a positive granular comparative advantage in a region leads to a negative granular comparative advantage in another region. Notwithstanding this compensation effect, if granular comparative advantage is not random the mean will not be zero.

has a small number of granular chapters.[16] It is followed by Asturias, Extremadura and Cantabria. The regions with the lowest percentage of exports in granular chapters are Madrid, Catalonia, Aragon and Navarre. As average, a Spanish region generates 37% of its exports in granular chapters.

The last two columns identify the granular chapters in each Spanish region. We have divided the granular chapters between those with an export specialization > 1, and those with an export specialization < 1. The first conclusion is that in the majority of cases granularity happens in chapters in which the region reveals a comparative advantage (export specialization > 1). Only in 5% of chapters, granularity is not associated with a revealed comparative advantage.

We also analyze whether regions develop a revealed comparative advantage due to granular comparative advantage, or granular comparative advantage reinforces a revealed comparative advantage the region already had. We find than in 47% of cases granular comparative advantage leads the region to develop a revealed comparative advantage in the chapter; and, in 53% of cases, the region already had a revealed comparative advantage comparative in the chapter.

Figure 3: Distribution of the number of regions across granular industries, 2014



Source: Authors calculations using the Customs database.

The second conclusion is that regions have different granular chapters. Figure 3

[16]As shown later, this difference is explained by vehicles, which is a granular chapter in this region, and accounts for a very high share of regional exports.

Table 2: Granular chapters by region, 2014

Region	Number of granular chapters	% of exports in granular chapters	Granular chapters - XS $>$ 1	Granular chapters - XS $<$ 1
Andalusia	10	43	Animal and vegetable oils, articles of stone, copper, cotton, iron and steel, ores, preparations of vegetables and fruits, products of animals, soap.	Umbrellas.
Aragon	10	16	Carpets, fur, glues, inorganic chemicals, lead, man-made filaments, meat, milling, paper, umbrellas.	
Asturias	8	63	Articles of iron or steel, dairy, iron and steel, organic chemicals, precious stones, salts, ships, zinc.	
Basque Country	10	15	Aluminum, cocoa, glass, lead, other base metals, other metal articles, railway, ships, tools.	Clock.
Cantabria	6	55	Cotton, iron and steel, man-made staple fibers, other metal articles, rubber.	Edible fruits.
Castile and León	5	72	Automobiles, mechanical appliances, misc. manuf. articles, other metal articles, textile.	
Castile-La Mancha	15	54	Aluminum, articles of stone, beverages, dairy, electrical equipment, fur, furniture, glass, lead, meat, nickel, printing, sugar, tools.	Fish.
Catalonia	7	6	Arms, cordage, fertilizers, meat, photo, seeds, vegetable products.	
Extremadura	12	60	Aluminum, clock, cork, glass, iron and steel, precious stones, preparations of vegetables and fruits, rubber, tobacco, wool.	Mechanical appliances, optical.
Galicia	11	43	Apparel-knitted or crocheted, apparel-not knitted or crocheted, cotton, footwear, leather, man-made filaments, man-made staple fibers, other made-up textile articles, silk, vegetable extracts, wood.	
Madrid	6	4	Cereals, ores, pulp of wood, salts, tin, zinc.	
Murcia	11	29	Arms, articles of iron or steel, beverages, coffee, tea, headgear, live animals, meat, other metal articles, plastics, preparations of meat and fish, sugar.	
Navarre	3	16	Electrical equipment, products of animals.	Copper.
Rioja	14	54	Aircraft, aluminum, articles of iron or steel, articles of stone, cereals, footwear, glass, knitted or crocheted fabrics, other metal articles, other vegetable textile, preparations of meat and fish, rubber, textile, wood.	
Valencia	10	32	Ceramic, edible fruits, fur, milling, musical instruments, railway, special woven fabrics, tannins, toys, vegetable extracts.	
Average region	9	37		

Source: Authors calculations using the Customs database. Note: Granular industries are defined as those where granular comparative advantage is larger than fundamental comparative advantage. XS=Export specialization.

presents the distribution of the number of regions in industries where granular comparative advantage dominates fundamental comparative advantage. In most of cases an industry is granular in one or two regions only. This result confirms that granularity emerges randomly across regions and industries. If granularity were not random, we would observe the granular effect concentrated in few industries.

Finally, the existence of a large firm does not necessarily imply that the chapter in which the large firm operates will be granular. The automobile industry illustrates this point. For example, Castile and León has a revealed comparative advantage in automobiles and has a major car assembler. In this region automobiles is a granular chapter. Other regions, such as Aragon, Galicia and Navarre also have a strong revealed comparative advantage in automobiles, and they also have a major car assembler. However, although these regions have a granular comparative advantage in the automobile chapter, it is smaller than fundamental comparative advantage.

To end-up this first analysis, we look to changes in the granular and fundamental chapters over the period 1998-2006. To perform this analysis, we select data for the year 1998 and 2006.[17] Tables A2 and A3 in the Appendix present the granular chapters by region for 2006 and 1998 respectively. On average, the number of granular chapters in 1998 was the same as in 2014, nine; in 2006 the number of granular chapters was 8. The % of exports in granular chapters was the same in 2006 and 2014, 37%; in 1998, the percentage was lower, 28.

On average, there is overlapping between years, although differences across regions are sizable. To get a more accurate assessment of the degree of similarity in the fundamental and granular chapters across years, we calculate the Adjusted Rand Index. This index, ranging between -1 and 1, calculates the fraction of chapter pairs that belong to the same classification (granular or fundamental) in two different years. The index calculates the fraction of correctly classified (respectively, misclassified) pairs over all pairs. The index is adjusted to ensure that the expected value of the index for two random partitions is zero (Hubert and Arabie, 1985).

Table 3 presents the adjusted Rand indexes. When we compare the classification of chapters in 2006 with the classification in 2014 the adjusted rand index is, on average, 0.45. Since the index moves between -1 and 1, we can consider that there is a mild persistence in the classification of chapters between 2006 and 2014. The adjusted Rand index drops to 0.30 when we compare 1998 with 2014, suggesting that persistence declines as we enlarge the period of analysis. The table also shows that there are sizable differences across regions. For example, there are some regions, such as Cantabria, Castile and León, Galicia and Valencia that show a fairly high persistence, with adjusted Rand indexes close or above 0.5 in both periods. In contrast, there are regions that experiment large changes

[17] For both years, we carry out the data-cleaning steps described at the beginning of this section.

Table 3: Fundamental and granular chapters. Similarities over time (Adjusted Rand Indexes)

Region	2006-2014	1998-2014
Andalusia	.38	.16
Aragon	.39	.34
Asturias	.10	.32
Basque Country	.14	.23
Cantabria	.49	.49
Castile and León	.62	.53
Castile-La Mancha	.28	.16
Catalonia	.30	.30
Extremadura	.64	.08
Galicia	.68	.52
Madrid	.49	.55
Murcia	.64	.33
Navarre	.44	-.04
Rioja	.25	.05
Valencia	.66	.48
Average	.45	.30

Source: Authors calculations using the Customs database.

in the classification of chapters, such as Navarre, Extremadura or Rioja.

In our second empirical analysis, we investigate the variables that are positively correlated with granular comparative advantage. We analyze whether, as suggested by Gaubert and Itskhoki (2016), the share of the top exporter within an industry is a good predictor of granular comparative advantage. We also investigate whether granular comparative advantage is more likely to emerge when regions have a large fundamental comparative advantage.

We estimate the following regression equation:

$$GCA_{ik} = \alpha ShareTop1_{ik} + \beta FCA_{ik} + \mu_i + \mu_k + \epsilon_{ik} \quad (13)$$

where μ_i and μ_k are region and chapter fixed effects respectively, and ϵ_{ik} is the disturbance term.

Table 4 presents the results of the regression analyses. In columns (1) to (3), we pool all observations and estimate regressions without origin and chapter fixed effects. In the first regression, we only introduce the share of the top exporter as independent variable. The coefficient is positive, denoting that the share of the top exporter can be a proxy to identify chapters with a large granular comparative advantage. However, the coefficient is not statistically significant. Column (2) reports a positive and statistically significant coefficient for fundamental comparative advantage. This result points out that it is more likely to find a large granular comparative advantage in chapters where fundamental comparative advantage is also large. When we combine both independent variables in column (3), the share of the top exporter and fundamental comparative advantage are positive and statistically significant. This result points out that the share of the top exporter becomes a better proxy for granular comparative advantage once we control for fundamental comparative advantage. Columns (4) to (6) present the results of estimating (13) with region and chapter fixed effects. The only difference is that the coefficient for the share of top exporter becomes much larger.

Table 4: Covariates of granular comparative advantage

	(1)	(2)	(3)	(4)	(5)	(6)
Share top exporter	0.305		1.047***	0.782		3.528***
	(0.242)		(0.404)	(0.486)		(0.772)
Fundamental comparative advantage		0.782*	0.831**		0.821**	1.093***
		(0.409)	(0.411)		(0.386)	(0.371)
Chapter and region FE	No	No	No	Yes	Yes	Yes
N.observ	1253	1253	1253	1253	1253	1253
R squared	0.001	0.178	0.195	0.097	0.260	0.336

Note: ***, **, * statistically significant at 1%. 5% and 10% respectively. Robust standard errors in parentheses.

Next, we investigate the contribution of fundamental and granular comparative advantage to the variation in export specialization across regions and industries. To perform this analysis, we use a regression-based decomposition. We regress each component on export specialization (XS_k) and a constant. Specifically,

$$\begin{aligned} FCA_k &= \alpha + \beta_1 XS_k \\ GCA_k &= \alpha + \beta_2 XS_k \end{aligned} \tag{14}$$

Table 5 presents the results of the regression-based decomposition. We carry out our baseline analysis using 2014 year data. First, we perform the decomposition pooling all observations; next, we carry out region-specific decompositions. When we pool all observations, variations in export specialization across chapters and regions are explained 70% by granular comparative advantage and 30% by fundamental comparative advantage. These results point out that differences in export specialization across industries and regions are explained mostly by granular comparative advantage. Since our methodology to estimate granular comparative advantage controls for region-specific and product-specific effects, we can conclude that differences in export specialization within an industry across regions are explained mostly by variations in granular comparative advantage; and differences in export specialization within a region across industries are also explained mostly by granular comparative advantage.[18]

Table 5: Contribution of granular and fundamental comparative advantage to the variation in export specialization, 1998-2014. Regression-based decomposition (%)

Region	2014		2006		1998	
	Granular	Fundamental	Granular	Fundamental	Granular	Fundamental
All regions	.70	.30	.69	.31	.78	.22
Andalusia	.71	.29	.78	.22	.62	.38
Aragon	.76	.24	.57	.43	.38	.62
Asturias	.68	.32	.79	.21	.83	.17
Basque Country	.59	.41	.38	.62	.42	.58
Cantabria	.93	.07	.94	.06	.91	.09
Castile and León	.23	.77	.38	.62	.05	.95
Castile-La Mancha	.82	.18	.72	.28	.42	.58
Catalonia	.69	.31	.63	.37	.61	.39
Extremadura	.70	.30	.66	.34	.62	.38
Galicia	.68	.32	.72	.28	.60	.40
Madrid	.64	.36	.53	.47	.49	.51
Murcia	.60	.40	.60	.40	.54	.46
Navarre	.62	.38	.48	.52	.55	.45
Rioja	.71	.29	.71	.29	.83	.17
Valencia	.61	.39	.59	.41	.54	.46

Source: Authors estimations using the Customs database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on relative exports. To calculate the contribution of fundamental comparative advantage we regress fundamental comparative advantage on relative exports. All regions' regression pools all observations.

Next, we estimate the contribution of fundamental and granular comparative advantage to the variation in export specialization within each region. We estimate a separate regression for each region. The highest contribution of granular comparative advantage happens in Cantabria (93%) and the lowest in Castile-León (23%). In the large exporting regions, Catalonia and Madrid, the contribution of granular comparative advantage is 69% and 64% respectively.

The contribution of granular comparative advantage to the variation in export specialization across industries and regions in Spain is much higher that the one found by Gaubert and Itskhoki (2016) for French exports. These authors conclude that granular comparative advantage explained 30% of the variation of French industries' share in the world market. These differences might be explained by the fact that we measure regional specialization relative to the country they belong, whereas Gaubert and Itskhoki (2016) measure export specialization of France relative to the world. Since differences in fundamental comparative advantage are smaller within countries than across countries, it is reasonable to expect granular comparative advantage to contribute more to differences in export specialization in the former than in the latter.

[18] When we estimate (14) with product fixed effects or region fixed effects, results are similar to those in Table 5.

We also carry out the decomposition using data from 2006 and 1998. The decomposition for all regions in 2006 yields coefficients that are very similar to those in 2014. However, there are significant differences for individual regions, such as Aragon, Basque Country, Castile and León and Navarre. In 1998, the contribution of granular comparative advantage rises to 78%, and the contribution of fundamental comparative advantage drops to 22%. These figures point out that the contribution of granular comparative advantage has declined between 1998 and 2014.

Robustness analyses

In this subsection we carry out different analyses to test the robustness of our results. First, we re-calculate the fundamental and granular components of export specialization using Catalonia as the reference region and mechanical appliances as the reference industry. We select Catalonia because it is the region with the highest number of exporters, and mechanical appliances because it is the chapter with the highest median number of exporters by region. As explained before, a large number of exporters at the regional and chapter level reduce the granularity effects in the numeraires.

Now, regional export specialization is measured relative to Catalonia and mechanical appliances' exports. Table A4 in the Appendix presents the number of granular chapters and granular exports in each region. Note that in this table Catalonia is not included because it is the reference region. On average, regions have 12 granular chapters, and they account for 42% of exports. These numbers are similar to those reported in Table 2. However, there are large differences in the number of granular chapters and the percentage of exports accounted by these chapters in each region. Now Castile and León does not have any granular chapter, and Andalusia raises the number of granular chapters to 34. In Castile-León, the number of mechanical appliances' exporters, relative to Catalonia, is particularly low. Hence, the rest of chapters have a high ratio of relative exporters, leading to negative or small granular effects. In contrast, the number of exporters of mechanical appliances in Andalusia, relative to Catalonia, is particularly high, and the rest of chapters have a low ratio of relative exporters, leading to strong granular effects. These results highlight the sensitivity of regions' granular chapters to the selected reference industry and region. For that reason, in our baseline analysis we use the aggregate of regions as the reference region, and the aggregate of industries as the reference industry.

Table A5 analyzes the covariates of granular comparative advantage. As in the baseline analysis, we find that both the share of the top exporter and fundamental comparative advantage are positively correlated with granular comparative advantage, and statistically significant. Finally, Table A6 presents the contribution of granular and fundamental comparative advantage to the variation in export specialization across regions and industries. Granular comparative advantage explains 75% of the differences and fundamental comparative advantage 25% of the differences. These percentages are similar to those reported in Table 5.[19]

In the second robustness test, we analyze whether results are altered if we remove some destinations from the analysis. In particular, we remove from the sample the countries that have a land border with the Spanish regions included in the sample (Andorre, France, Gibraltar and Portugal), or are very close by sea to some regions included in the sample (Morocco). We repeat all the empirical analyses. The results are presented in Tables A7 to A9 in the Appendix. They are very similar to those reported in the baseline analysis.

5 Conclusions

We analyze whether country-level factors or outstanding firms determine a country's export specialization. We propose an easy-to-implement methodology to measure the granular and fundamental components of export specialization. Our methodology assumes that productivity is distributed Pareto across firms, and, countries face similar relative fixed and variable export costs. If these assumptions are met, we argue that fundamental comparative advantage can be approximated by the ratio of the relative number of exporters.

To abide by our assumptions, we apply our methodology on Spanish regional exports. Bearing in mind the limitations of our methodology, we find that granular industries are not common, but they might represent a sizable share of regional exports. However, granular comparative advantage plays a very import role explaining the variation in export specialization across industries and regions. Within an industry, most of the differences in export specialization across regions are explained by granular comparative advantage; and, within a region, most of the differences in export specialization across industries are explained by granular comparative advantage.

Our results highlight that regions' export specialization is not determined solely by variables that change slowly over time, but also by outstanding firms. They suggest that regions seeking to alter their export specialization should aim to create an environment for new firms to emerge or to attract outstanding firms from other regions or countries.

Due to the assumptions of our methodology, and data availability, we have carried out the empirical analyses using regional exports. However, if data were available it could also be applied on country-level data, as long as differences in relative fixed and variable export costs were similar across countries.

[19]For the analyses in Table A5 and A6, due to presence of strong outliers, we remove from the sample the observations with a fundamental or granular comparative advantage below the 5% percentile and above the 95% percentile.

Appendix A Coefficient of variation of the ratio of relative exporters

We estimate fundamental comparative advantage using the ratio of the relative number of exporters:

$$\frac{N_{ik}/N_{ik'}}{N_{i'k}/N_{i'k'}} \tag{A1}$$

To facilitate the analysis, we express this ratio as follows:

$$\frac{N_{ik}/N_{ik'}}{N_{i'k}/N_{i'k'}} = (N_{ik}N_{i'k'})\Big(\frac{1}{N_{ik'}N_{i'k}}\Big) = (a_1a_2)\Big(\frac{1}{b_1b_2}\Big) = AB \tag{A2}$$

where $A = a_1a_2$ and $B = \frac{1}{b_1b_2}$

To express the coefficient of variation of [AB] we need the expectation of [AB] and the variance of [AB].

If A and B are independent, the expectation of (A1) is:

$$E[AB] = E[A]E[B] = E[a_1a_2]E\Big[\frac{1}{b_1b_2}\Big] = E[a_1]E[a_2]E\Big[\frac{1}{b_1}\Big]E\Big[\frac{1}{b_2}\Big] \tag{A3}$$

And the variance,

$$\begin{aligned} Var[AB] = E[A^2]E[B^2] - (E[A])^2(E[B])^2 = E[(a_1a_2)^2]E[\Big(\frac{1}{b_1b_2}\Big)^2] \\ -(E[a_1])^2(E[a_2])^2\Big(E\Big[\frac{1}{b_1}\Big]\Big)^2\Big(E\Big[\frac{1}{b_2}\Big]\Big)^2 \end{aligned} \tag{A4}$$

The coefficient of variation can be expressed as:

$$cv[AB] = \frac{\sqrt{E[(a_1a_2)^2]E\Big[\Big(\frac{1}{b_1b_2}\Big)^2\Big] - (E[a_1])^2(E[a_2])^2\Big(E\Big[\frac{1}{b_1}\Big]\Big)^2\Big(E\Big[\frac{1}{b_2}\Big]\Big)^2}}{E[a_1]E[a_2]E\Big[\frac{1}{b_1}\Big]E\Big[\frac{1}{b_2}\Big]} \tag{A5}$$

To gauge the range of values the coefficient of variation may take in (A5), we use numerical simulations with random numbers generated from a Poisson distribution using different λ parameters. For each λ parameter, we calculate the variation coefficient over a sample of 1,000 random numbers. Then, we repeat the simulation 1,000 times and calculate an average variation coefficient. Table A1 presents the results of these

Table A1: Numerical simulations on the ratio of relative exporters coefficient of variation

Simulation	M_i	$M_{i'}$	θ	$\underline{z}_{ik}/\varphi_{ik}$	$\underline{z}_{ik'}/\varphi_{ik'}$	$\underline{z}_{i'k}/\varphi_{i'k}$	$\underline{z}_{i'k'}/\varphi_{i'k'}$	Coefficient of variation (mean)
1	100	100	5	1.11	1.11	1.11	1.11	0.268
2	1,000	1,000	5	1.11	1.11	1.11	1.11	0.087
3	100	1,000	5	1.11	1.11	1.11	1.11	0.197
4	100	100	4	1.11	1.11	1.11	1.11	0.253
5	100	100	5	1.50	1.50	1.50	1.50	0.668
6	100	100	5	1.50	1.11	1.50	1.11	0.496

Note: In each simulation, we calculate the variation coefficient over a sample of 1,000 random numbers generated by the Poisson distribution. The coefficient of variation presented in the table is the average of 1,000 simulations.

simulations.

In Simulation 1 the number of draws is very low (M_i=100), the baseline shape parameter, $\theta = 5$, and the baseline $\underline{z}_{ik}/\varphi_{ik}$ value, 1.11, which is common to both industries. We assume that the number of draws within a country is the same for the analyzed industry k and the reference industry k'. In addition, the analyzed country i and the reference country i' have the same number of draws ($M_i = M_{i'}$). Simulation 1 yields a 0.268 variation coefficient. Since distributions with a variation coefficient less than one are considered as low-variance, we can qualify this value as very low. Simulation 2 raises the number of draws to 1,000 in both countries. With a less restrictive number of draws, the variation coefficient drops to 0.087. In simulation 3 we combine a restrictive number of draws in i and a less restrictive of draws in i'. The coefficient of variation remains very low. In Simulation 4 we analyze whether results are sensible to the shape parameter θ. We reduce the value of the parameter to 4. This yields a coefficient of variation slighltly lower than the one obtained in Simulation 1. In Simulation 5 we raise the threshold productivity to export/fundamental productivity ratio to 50%. The variation coefficient rises to 0.668, but still is below the benchmark value of 1. When we combine a higher threshold/fundamental productivity ratio in one industry with a lower ratio in the other, the coefficient of variation drops to 0.496.

These simulations show that even if we consider scenarios with a low number of draws and large differences between threshold and fundamental productivities, the coefficient of variation remains small.

Table A2: Granular chapters by region, 2006

Region	Number of granular chapters	% of exports in granular chapters	Granular chapters - XS > 1	Granular chapters - XS < 1
Andalusia	13	55	Animal and vegetable oils, articles of stone, beverages, copper, edible vegetables, misc. manuf. articles, optical, ores, preparations of vegetables and fruits, products of animals, straw, tannins, vegetable products.	
Aragon	6	4	Carpets, man-made filaments, paper, straw, umbrellas.	Man-made staple fibers.
Asturias	3	27	Copper, hides, zinc.	
Basque Country	6	3	Cocoa, explosives, glass, misc. edible preparations, photo.	Man-made staple fibers.
Cantabria	8	45	Cotton, glues, man-made staple fibers, other metal articles, other vegetable textile, rubber, special woven fabrics.	Paper.
Castile and León	4	75	Automobiles, coffee, tea, mechanical appliances, textile.	
Castile-La Mancha	19	61	Aluminum, beverages, coffee, tea, cosmetic, electrical equipment, footwear, glass, man-made filaments, man-made staple fibers, meat, musical instruments, photo, preparations of vegetables and fruits, printing, salts, sugar, tannins, textile, tools.	
Catalonia	4	1	Cordage, milling.	Arms, lead.
Extremadura	11	61	Cork, glass, mechanical appliances, misc. edible preparations, optical, precious stones, preparations of vegetables and fruits, printing, rubber, tobacco, wool.	
Galicia	10	70	Apparel-knitted or crocheted, apparel-not knitted or crocheted, automobiles, cotton, footwear, leather, silk, umbrellas, vegetable extracts, wood.	
Madrid	5	8	Cereals, fertilizers, pulp of wood, ships.	Salts.
Murcia	8	26	Articles of iron or steel, headgear, lead, meat, other metal articles, plastics, preparations of meat and fish, sugar.	
Navarre	5	43	Cereals, electrical equipment, fertilizers, mechanical appliances, products of animals.	
Rioja	10	57	Beverages, coffee, tea, furniture, glass, preparations of meat and fish, products of animals, rubber, seeds , textile, wood.	
Valencia	9	31	Carpets, ceramic, edible fruits, fur, milling, musical instruments, seeds , tannins, vegetable extracts.	
Average region	8	37		

Source: Authors calculations using the Customs database. Note: Granular industries are defined as those where granular comparative advantage is larger than fundamental comparative advantage. XS=Export specialization.

Table A3: Granular chapters by region, 1998

Region	Number of granular chapters	% of exports in granular chapters	Granular chapters - XS > 1	Granular chapters - XS < 1
Andalusia	11	20	Copper, cotton, live plants, optical, ores, organic chemicals, other made-up textile articles, ships, straw, tannins.	Electrical equipment.
Aragon	2	3	Meat.	Man-made filaments.
Asturias	8	64	Cocoa, copper, iron and steel, pharmaceutical, pulp of wood, ships, sugar, zinc.	
Basque Country	8	3	Fertilizers, glass, headgear, other base metals.	Antiques, cocoa, cotton, prepared animal fodder.
Cantabria	8	50	Articles of iron or steel, cotton, inorganic chemicals, iron and steel, man-made staple fibers, other metal articles, other vegetable textile, tools.	
Castile and León	2	16	Mechanical appliances, other metal articles.	
Castile-La Mancha	17	57	Aluminum, beverages, cocoa, electrical equipment, furniture, glass, inorganic chemicals, milling, misc. manuf. articles, musical instruments, other made-up textile articles, preparations of vegetables and fruits, printing, salts, tannins.	Man-made staple fibers, prepared animal fodder.
Catalonia	4	1	Cordage, nickel, products of animals.	Arms.
Extremadura	15	53	Articles of iron or steel, articles of stone, beverages, cork, fish, leather, misc. edible preparations, optical, photo, precious stones, preparations of vegetables and fruits, seeds , wood.	Apparel-not knitted or crocheted, man-made filaments.
Galicia	9	24	Apparel-knitted or crocheted, apparel-not knitted or crocheted, articles of stone, leather, preparations of meat and fish, umbrellas, vegetable extracts, wood.	Footwear.
Madrid	7	5	Aluminum, cereals, fertilizers, headgear, pulp of wood, salts, tin.	
Murcia	12	42	Articles of iron or steel, edible vegetables, fertilizers, fish, headgear, lead, meat, pharmaceutical, plastics, sugar.	Other metal articles, printing.
Navarre	4	34	Mechanical appliances, paper, umbrellas.	Cotton.
Rioja	13	32	Apparel-knitted or crocheted, apparel-not knitted or crocheted, coffee, tea, cork, furniture, glass, live animals, man-made staple fibers, other metal articles, products of animals, textile, wood, wool.	
Valencia	13	21	Ceramic, cereals, fur, musical instruments, railway, tannins, vegetable extracts, vegetable products.	Beverages, meat, milling, organic chemicals, pharmaceutical.
Average region	9	28		

Source: Authors calculations using the Customs database. Note: Granular industries are defined as those where granular comparative advantage is larger than the fundamental comparative advantage. XS=Export specialization.

Table A4: Robustness. Granular chapters by region, 2014 (Catalonia as reference region and mechanical appliances as reference industry)

Region	Number of granular chapters	% of exports in granular chapters	Granular chapters - XS > 1	Granular chapters - XS < 1
Andalusia	34	87	Aircraft, animal and vegetable oils, apparel-knitted or crocheted, articles of stone, beverages, cereals, clock, copper, cotton, dairy, edible fruits, edible vegetables, electrical equipment, feathers, fish, fuels, headgear, iron and steel, live plants, ores, other metal articles, precious stones, preparations of vegetables and fruits, products of animals, pulp of wood, salts, soap, straw, tannins, tin, tobacco, umbrellas, wood.	Organic chemicals
Aragon	9	10	Aircraft, carpets, explosives, inorganic chemicals, lead, milling, paper, railway, umbrellas.	
Asturias	7	66	Articles of iron or steel, dairy, iron and steel, ores, salts, ships, zinc.	
Basque Country	9	32	Aircraft, aluminum, fuels, glass, other base metals, other metal articles, railway, ships, tin.	
Cantabria	13	71	Articles of iron or steel, articles of stone, cotton, edible fruits, footwear, fuels, inorganic chemicals, iron and steel, man-made staple fibres, other metal articles, rubber, ships, wood.	
Castile and León	0	0		
Castile-La Mancha	13	26	Aircraft, aluminum, articles of stone, dairy, edible vegetables, fish, footwear, glass, lead, nickel, other metal articles, sugar.	Apparel-knitted or crocheted
Extremadura	6	26	Glass, iron and steel, precious stones, rubber, tobacco, wool.	
Galicia	25	80	Aluminum, apparel-knitted or crocheted, apparel-not knitted or crocheted, articles of stone, automobiles, cereals, cotton, dairy, footwear, furniture, leather, live animals, man-made filaments, man-made staple fibres, other made-up textile articles, other vegetable textile, preparations of meat, fish, ships, silk, straw, tin, umbrellas, vegetable extracts, wood, wool.	
Madrid	19	43	Aircraft, articles of stone, cereals, clock, edible vegetables, explosives, fuels, inorganic chemicals, ores, prepared animal fodder, pulp of wood, railway, rubber, salts, tin, tobacco, umbrellas, wood, zinc.	
Murcia	18	83	Articles of iron or steel, beverages, edible fruits, edible vegetables, fish, footwear, fuels, headgear, iron and steel, live animals, live plants, meat, organic chemicals, other metal articles, plastics, preparations of meat, fish, preparations of vegetables and fruits, sugar.	
Navarre	3	4	Edible vegetables, products of animals.	Copper
Rioja	15	63	Aircraft, aluminum, articles of iron or steel, articles of stone, cereals, footwear, glass, knitted or crocheted fabrics, other metal articles, other vegetable textile, preparations of meat, fish, preparations of vegetables and fruits, rubber, textile, wood.	
Valencia	7	22	Aircraft, ceramic, edible vegetables, explosives, milling, railway, tannins.	
Average region	12	42		

Source: Authors calculations using the Customs database. Note: Granular industries are defined as those where granular comparative advantage is larger than the fundamental comparative advantage. XS=Export specialization.

Table A5: Robustness. Covariates of granular comparative advantage (Catalonia as reference region and mechanical appliances as reference industry)

	(1)	(2)	(3)	(4)	(5)	(6)
Share top exporter	0.423**		0.643***	1.350***		2.344***
	(0.208)		(0.206)	(0.270)		(0.291)
Fundamental comparative advantage		0.324***	0.362***		0.307***	0.576***
		(0.099)	(0.099)		(0.108)	(0.114)
Chapter and region FE	No	No	No	Yes	Yes	Yes
N.observ	963	963	963	963	963	963
R squared	0.005	0.030	0.040	0.227	0.222	0.275

Note: Standard deviation in parentheses. ***, **, * statistically significant at 1%. 5% and 10% respectively. Robust standard errors in parentheses.

Table A6: Robustness. Contribution of granular and fundamental comparative advantage to the variation in export specialization, 2014. Regression-based decomposition (%; Catalonia as reference region and mechanical appliances as reference industry)

Region	Granular	Fundamental
All regions	.75	.25
Andalusia	.70	.30
Aragon	.82	.18
Asturias	.69	.31
Basque Country	.79	.21
Cantabria	.77	.23
Castile and León	.46	.54
Castile-La Mancha	.64	.36
Extremadura	.82	.18
Galicia	.80	.20
Madrid	.79	.21
Murcia	.78	.22
Navarre	.53	.47
Rioja	.85	.15
Valencia	.66	.34

Source: Authors estimations using the Customs database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on relative exports. To calculate the contribution of fundamental comparative advantage we regress fundamental comparative advantage on relative exports. All regions' regression pools all observations.

Table A7: Robustness. Granular chapters by region, 2014 (Neighbor destinations excluded)

Region	Number of granular chapters	% of exports in granular chapters	Granular chapters - XS > 1	Granular chapters - XS < 1
Andalusia	8	30	Articles of stone, copper, cotton, iron and steel, ores, preparations of vegetables and fruits.	Other vegetable textile, umbrellas.
Aragon	7	14	Fur, inorganic chemicals, lead, man-made filaments, meat, paper, seeds .	
Asturias	7	51	Articles of iron or steel, dairy, fertilizers, iron and steel, precious stones, salts, ships.	
Basque Country	5	12	Aluminum, cocoa, other metal articles, railway, ships.	
Cantabria	5	39	Cotton, man-made staple fibers, other metal articles, rubber.	Edible fruits.
Castile and León	9	75	Automobiles, carpets, furniture, glass, mechanical appliances, misc. manuf. articles, other metal articles, textile.	Organic chemicals.
Castile-La Mancha	21	60	Aluminum, beverages, dairy, electrical equipment, footwear, fur, furniture, glass, lead, meat, misc. manuf. articles, nickel, other metal articles, sugar, tools, vegetable products.	Apparel-knitted or crocheted, articles of stone, cotton, edible fruits, salts.
Catalonia	8	8	Arms, cordage, fertilizers, meat, misc. chemical, photo, seeds , vegetable products.	
Extremadura	10	61	Aluminum, clock, iron and steel, mechanical appliances, precious stones, preparations of vegetables and fruits, rubber, tobacco, wool.	Optical.
Galicia	7	55	Apparel-knitted or crocheted, apparel-not knitted or crocheted, footwear, leather, other made-up textile articles, vegetable extracts, wood.	
Madrid	6	5	Cereals, feathers, ores, salts, tin, zinc.	
Murcia	9	25	Arms, beverages, live animals, live plants, meat, other metal articles, plastics, preparations of meat and fish, sugar.	
Navarre	4	19	Electrical equipment, hides, products of animals, salts.	
Rioja	17	75	Aircraft, aluminum, articles of stone, beverages, cereals, footwear, furniture, glass, hides, knitted or crocheted fabrics, misc. chemical, paper, preparations of meat and fish, rubber, textile, wood.	Prepared animal fodder.
Valencia	11	19	Carpets, ceramic, fur, milling, musical instruments, railway, special woven fabrics, tannins, toys, vegetable extracts, wool.	
Average region	9	35		

Source: Authors calculations using the Customs database. Note: Granular industries are defined as those where the granular component is larger than the fundamental component. XS=Export specialization.

Table A8: Robustness. Covariates of granular comparative advantage (Neighbor destinations excluded)

	(1)	(2)	(3)	(4)	(5)	(6)
Share top exporter	0.419		0.846**	0.682**		2.658***
	(0.262)		(0.343)	(0.347)		(0.415)
Fundamental comparative advantage		0.512***	0.541***		0.531***	0.715***
		(0.196)	(0.197)		(0.171)	(0.161)
Chapter and region FE	No	No	No	Yes	Yes	Yes
N.observ	1180	1180	1180	1180	1180	1180
R squared	0.002	0.087	0.097	0.102	0.174	0.213

Note: Standard deviation in parentheses. ***, **, * statistically significant at 1%. 5% and 10% respectively. Robust standard errors in parentheses.

Table A9: Robustness. Contribution of granular and fundamental comparative advantage to the variation in export specialization, 2014. Regression-based decomposition (%; Neighbor destinations excluded)

Region	Granular	Fundamental
All regions	.70	.30
Andalusia	.70	.30
Aragon	.69	.31
Asturias	.65	.35
Basque Country	.46	.54
Cantabria	.92	.08
Castile and León	.35	.65
Castile-La Mancha	.85	.15
Catalonia	.65	.35
Extremadura	.67	.33
Galicia	.68	.32
Madrid	.59	.41
Murcia	.63	.37
Navarre	.78	.22
Rioja	.79	.21
Valencia	.56	.44

Source: Authors estimations using the Customs database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on relative exports. To calculate the contribution of fundamental comparative advantage we regress fundamental comparative advantage on relative exports. All regions' regression pools all observations.

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