Mapping Specialization into Trade Volumes in Spain's Regions

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May 2008

Abstract

In this paper, we explore the mapping between specialization and trade. Does regional specialization in a particular industry translates into a greater level of export? We estimate an equation explaining the determinants of intra-European trade in Spain's Autonomous Communities, focusing specifically on an index of industry specialization. The analysis is done at the industry-region level, using a panel of 18 sectors and 15 Autonomous Communities, from 1988 to 2003. We also discuss the effects of other determinants of trade: relative productivity, economic geography, market size, endowments, etc. The econometric results confirm the existence of a significant mapping between specialization and exports. Market size, geography and productivity are also significant determinants of trade. By comparison, the counterfactual relationship between specialization and imports is negative or not significant. We also obtain that regions exporting relatively more in a given industry also import relatively more in this industry.

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Acknowledgement: The research presented in this paper was done at the Centre for Operation Research and Econometrics (CORE). I would like to thank Jacques Thisse, Pierre-Philippe Combes, Kristian Behrens, Giordano Mion and for helpful comments and suggestions. This text presents research results of the Belgian Program on Interuniversity Poles of Attraction initiated by the Belgian State, Prime Minister's Office, Science Policy Programming. The scientific responsibility is assumed by the author.

1 Introduction

Does regional specialization in a particular industry translate into a relatively greater level of export? In the traditional trade models, the answer is positive. Following the standard theory of international trade, in a world of homogeneous products, the production of a good should concentrate in regions having a comparative advantage in the making of this good. Inversely, they must import the goods in which they do not have a comparative advantage. The direction of trade follows entirely the distribution of comparative advantage. Hence, for a given world demand, the standard models outline a clear relationship between the extent of specialization and the pattern of trade.

But in the light of the “new” trade theories with imperfect competition (Krugman, 1979, 1980; Helpman, 1981; Ethier, 1979, 1982, Helpman and Krugman 1985), the relation between specialization and trade can be much more ambiguous: regions do not need to specialize in order to trade. The first and most obvious reason implies intra-industry trade. Two similar countries can trade because they produce different varieties of a good. Neither is specialized, but there is still trade. There is no mapping between specialization and trade. A crucial assumption here is the absence of non-homothetic demand patterns, which is assumed in many trade models. If this assumption is not satisfied, a greater relative level of specialization could then simply express a higher local absorption of the good in the region. In this case, specialization does not lead to greater trade flows.

Moreover, the New Economic Geography (NEG) suggests that inter-sectoral trade is the outcome of the agglomeration of industries in space (Krugman 1991; Fujita *et al.*, 1999). In NEG models, interactions between economies of scale, market size and trade costs affect the location of industry. The regions where a given industry tends to agglomerate will appear as being relatively more specialized, hosting a larger share of world production, and will export relatively more. Hence, we recover a mapping between specialization and trade. Yet, in NEG, the mapping does not follow a linear clear-cut relationship as in the standard comparative advantage model. The intensity of the mapping will rather evolve according to a multi-dimensional set of factors: market size, trade costs, geography, economies of scale, degree of product differentiation, etc. And the model still allows for intra-industry trade with no specialization whatsoever. The volume of trade will also depend on geography, notwithstanding the level of specialization. Distance between trading partners can represent a big impediment for trade. Notably, regions close to big markets will have a greater propensity to trade than peripheral countries.

Therefore, the objective of this paper is to test empirically the mapping between specialization and trade in Spain’s Autonomous Communities (AC) at the industry level. Specifically, we estimate a trade equation mixing comparative advantage, economic geography and monopolistic competition. The analysis will be done in the industry-region dimension, using a panel of 18 sectors, 15 ACs, from 1988 to 2003. To the best of our knowledge, this is the first time that such a relationship is investigated at the industry-region level.

To evaluate the strength of the mapping between specialization and trade, we focus mainly on the relationship between specialization (at the industry-region level) and the level of trade, but we also discuss the effects of other determinants of trade: relative productivity, market potential, geography, market size, endowments, etc. As a counterfactual benchmark, we also examine the mapping between imports and specialization. We concentrate on intra-European trade, e.g. trade between Spain’s Autonomous Communities and the other Member-States of the European Union (EU15). Spain has joined the European Community in 1986, two years before our time sample (1988 to 2003). Therefore, the integration of Spain into the European market represents an excellent study-case to understand the effects of trade liberalization on trade and specialization.

Overall, the econometric analysis confirms the existence of a mapping between specialization and exports. In comparison, the counterfactual relationship between specialization and imports is negative or not significant, but only when we condition on the level of exports in the industry-region. Otherwise, we obtain a positive relationship between specialization and imports. This is because the regions exporting relatively more in a given industry – implying a higher specialization in this industry - also import relatively more in this industry.

The organization of the paper is as follows. First, in section 2, we present a small trade model mixing monopolistic competition, comparative advantage, trade costs and heterogeneous demand patterns across regions. Then, we discuss the theoretical foundations justifying the existence or absence of a mapping between specialization and trade. In section 3, we introduce the empirical methodology. We show that, by exploiting the industry-dimension of our data, we are able to devise a simple regression strategy that allows us to focus only on the mapping between specialization and the volume of trade. The fourth section presents the estimation results, starting with the regressions in levels. Then, the model is estimated in first-difference. Finally, we show the results for the counterfactual relationship between imports and specialization.

2 Conceptual framework

To begin with, it is important to clarify the definition given to the concept of "specialization" throughout this paper: a region is said to be specialized in a given industry if the share of this industry in the region's total production (or employment) is relatively higher than in other regions.

2.1 The trade equation

We present a simple model of trade that follows closely Deardorff (2004), mixing comparative advantage, product differentiation and trade costs. Suppose there are C regions trading in the world. In what follows, *r* denotes the region of provenance, and *c* the region of destination, for *r,c* = 1,…,C. We assume that all consumers within a region *r* are identical and their preferences can be represented by a Cobb-Douglas utility function:

$$(1) \qquad U_r = K^{\beta_r} A^{1-\beta_r} \qquad \text{where} \quad 0 < \beta_r < 1$$

where K is a differentiated good and A is a numéraire good. Here, we depart slightly for Deardorff (2004) by allowing heterogeneous utility functions across regions. Using the Dixit & Stiglitz (1977) model of monopolistic competition, we can define K as:

$$(2) \qquad K = \left[\sum_{n=1}^{N} (q_n)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \qquad \sigma > 1$$

where q_n is the quantity consumed of variety *n* of good K, N is the total number of varieties existing in the world and σ is the elasticity of substitution between varieties, which is assumed to be constant and equal across regions. The price of the numéraire is normalized to 1. In this type of model, the utility maximization problem is solved in two steps. First, the consumer decides to spend an amount $E_r^k = \beta_r E_r$ on good K, where E_r^k is the expenditure on good K in region *r*. Then, she allocates this expenditure E_r^k over N differentiated varieties.

All firms in region *r* face a unit cost of production a_r. As usual in the Dixit & Stiglitz setting, each firm chooses to produce a distinct variety, but in the same quantity and at the same price, which is just a constant markup over unit cost:

$$(3) \qquad p_{rc} = \rho(a_r + \tau_{rc}^k) \qquad \text{where} \quad a_r = \frac{w_r}{\gamma_r}, \quad \rho = \left[\frac{\sigma}{\sigma-1}\right] \quad \text{and} \quad \tau_{rc}^k = \phi d_{rc} + \tau^k$$

where p_{rc} is the price charged in region *r* for varieties delivered to region *c*, w_r is an index of input unit costs and γ_r is a productivity parameter. In addition, firms must incur a unit trade cost τ^k_{rc} to ship product K from region *r* to *c*, where d_{rc} is the distance between *r* and *c*, ϕ is the transport cost per unit of distance and τ^k is a measure of tariffs and non-tariffs barriers imposed on good K. In fact, we can interpret the parameter (a_r) as an average unit cost in region *r* which might depend on several regional characteristics (wages, subsidies, some particular regional know-how, natural endowments, productivity spillovers, etc.). But it might also reflect the actual distribution of productivity across heterogeneous firms in the region, independently on regional characteristics[1] (Bernard *et al*., 2000; Melitz, 2003; Melitz and Ottaviano, 2005).

Assume that N_r is the given number of firms producing good K in region *r*. Since each firm specializes in the production of a single variety, N_r is also the number of varieties. Then, the total quantity of good K purchased by region *c* from region *r* is:

(4) $$x_{rc} = N_r q_{rc}$$

where x_{rc} measures total exports of good K from region *r* to region *c* and q_{rc} is the quantity of each variety purchased by region *c* from region *r*. Using (2) and inserting (4), we can define the following CES sub-utility function:

(5) $$U_c = \left[\sum_{r=1}^{C}\sum_{n=1}^{N_r}(q_{rc})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = \left[\sum_{r=1}^{C}N_r(q_{rc})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = \left[\sum_{r=1}^{C}(N_r)^{\frac{1}{\sigma}}(x_{rc})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

Total exports of good K delivered to *c* are found by maximizing (5) subject to $\sum_{r=1}^{c} p_{rc}x_{rc} = \beta_c E_c$.
This maximization problem yields the usual solution:

(6) $$x_{rc} = \frac{1}{p_{rc}}\beta_c E_c N_r\left(\frac{p_{rc}}{\tilde{p}_c}\right)^{1-\sigma} \quad \text{where} \quad \tilde{p}_c = \left[\sum_r N_r(p_{rc})^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

where $\tilde{p}_c$ is a sort of CES weighted index of world prices facing consumers in region *c*. Substituting the price equation (3) in (6), we get a solution for trade:

(7) $$x_{rc} = \frac{1}{\rho(a_r + \tau^k_{rc})}\beta_c E_c N_r\left(\frac{a_r + \tau^k_{rc}}{I_c}\right)^{1-\sigma} \quad \text{where} \quad I_c = \left[\sum_r N_r(a_r + \tau^k_{rc})^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

We can express (7) in term of c.i.f. value, noting that $v_{rc} = p_{rc}x_{rc} = [\rho(a_r + \tau^k_{rc})]x_{rc}$:

(8) $$v_{rc} = \beta_c E_c N_r\left(\frac{a_r + \tau^k_{rc}}{I_c}\right)^{1-\sigma}$$

[1] For example, it may be that, in a region having no particular comparative advantage, there exists a particularly clever, inventive or efficient entrepreneur capable of creating a firm that will be very competitive on world markets.

Following a common hypothesis made in trade models with monopolistic competition, we further assume that the number of firms in region *r* depends on the size of the domestic market for good K relatively to world demand:

$$(9) \qquad N_r = \frac{E_r^k}{E^k} = \frac{\beta_r E_r}{E^k}$$

where E^k corresponds to world expenditure on good K. Given the level of fixed costs in producing good K and the demand size, firms will enter the market until the zero-profit condition is attained. Using this assumption and the trade cost equation defined in (3), we get an equation explaining the volume of exports between two regions for good K:

$$(10) \qquad \nu_{rc} = \frac{\beta_c E_c \beta_r E_r}{E^k}\left(\frac{a_r + \left(\phi d_{rc} + \tau^k\right)}{I_c}\right)^{1-\sigma}$$

Equation (10) will be used to define the regression equation in the empirical analysis. It corresponds to a gravity equation of trade, since exports between *r* and *c* depend on the product of their respective economic size, given the distance separating them. Equation (10) also includes standard comparative advantages, expressed here by relative unit costs. Note that exports from *r* to *c* do not directly depend on the relative cost between *r* and *c*, but to *r*'s unit cost relative to a weighted average of costs in the world (I_c). This is because firms in region *r* are not only competing with firms in *c* to supply consumers in *c*, but with all firms in the world that also produce varieties of good K.

Differences in the demand pattern across regions also play a role for trade (Markusen, 1986). To see this, suppose that:

$$\beta_r > \beta_c \ \text{ and } \ \beta_c = \beta_c \qquad \text{for all } c, c' \neq r$$

Here, region *r* as a higher preference for good K than all other regions relatively to the numéraire. Total production in region *r* is given by the summation of its domestic production and its total exports in the world. From (10), and normalizing the value of production by the size of the region, we have:

$$(11) \qquad \frac{\nu_r^k}{E_r} = \left[\frac{\beta_r E_r \beta_r}{E^k}\hat{P}_{rr}\right] + \left[\sum_{c\neq r}^{C}\frac{\beta_c E_c \beta_r}{E^k}\hat{P}_{rc}\right] \quad \text{where} \quad \hat{P}_{jj} = \left(\frac{a_j + \tau_{jj}}{I_j}\right)^{1-\sigma}$$

where the first term in brackets is the value of production in region *r* delivered to itself (local absorption of the good) and ν_r^k is total production of good K in region *r*. To concentrate on comparative advantages and on preferences, assume no trade costs. Then, every country faces the same index of costs I. Since $E^k = \sum_c \beta_c E_c$, and with some manipulations, the share of production of good K in region *r* with respect to its economic size is then given by:

$$(12) \qquad \frac{\nu_r^k}{E_r} = \beta_r\left[\frac{a_r}{I}\right]^{1-\sigma}$$

If we compare this share with region *c*, we get that:

(13) $$\frac{\nu_r^k / E_r}{\nu_c^k / E_c} = \frac{\beta_r}{\beta_j}\left[\frac{a_r}{a_c}\right]^{1-\sigma}$$

Notice that equation (13) is a kind of specialization index: it measure the share of industry *k* in total production of region *r* relatively to the share of industry *k* in region *c*. Then, relative specialization depends directly on comparative advantages, as usual. But suppose that there is no comparative advantage (a_r=a_c). If two regions are similar in every aspect but their preferences for good K relatively to the numéraire, the region that allocates a greater share of expenditure for good K will be relatively more specialized than the other region. This will have two opposing effects on trade. First, a higher number of varieties (firms) can be sustained in the larger market of region *r*. Thus, region *r* gets also a larger share of world exports. But, the region *r* also absorbs a greater share of production for domestic use. An increase in β_r will have a greater effect on domestic production than on exports. The partial derivative of domestic production with respect to β_r is given by:

(14) $$\frac{\partial\left(\nu_{rr}^k / E_r\right)}{\partial \beta_r} = 2\beta_r \hat{P} \frac{E_r}{E^k} \qquad \text{where } \hat{P} = \left(\frac{a_r}{I}\right)^{1-\sigma} = \left(\frac{ac}{I}\right)^{1-\sigma}$$ with no comparative advantage.

while the partial derivative of export from region *r* to region *c* with respect to β_r is given by:

(16) $$\frac{\partial\left(\nu_{rc}^k / E_r\right)}{\partial \beta_r} = \beta_c \hat{P} \frac{Ec}{E^k}$$

Take two regions having the same economic weight (E_r=E_c). Since $2\beta_r > \beta_c$, the impact of the higher preference for good K in region *r* has a much greater effect on the domestic absorption of the good than on exports. Hence, a region could show up as being statistically more specialized without having a direct mapping with the volume of exports, simply because it consumes domestically a bigger share of its total production of the good[2].

To examine the mapping between trade and specialization using equation (10), it is convenient to decompose trade into two familiar components. The **direction of trade** indicates which regions are net exporters and which ones are net importers in a given industry. This is closely related to specialization, since being a net exporter usually means producing relatively more than other regions. The **volume of trade** is then the total amount of trade realized by a region in that industry, as defined by equation (10).

In the standard Ricardian model, with homogeneous products and no trade costs, the *direction of trade* follows entirely the distribution of comparative advantages. Regions reallocate production factors to the production of the goods for which they have a comparative advantage. Hence, the level of specialization of a region in a given industry reveals completely the region's comparative advantage. Then, given this specialization, the *volume of trade* depends on world demand for the good. In equation (10), because of the structure of the utility function in the Dixit & Stiglitz model of monopolistic competition, we have incomplete specialization: all regions produce good K. But the volume of trade still increases monotonically with the level of comparative advantage (lower marginal cost a_r). Assuming that regions specialize according to their comparative advantage, we obtain a mapping between specialization and trade. Not also that, even in a pure comparative advantage models, trade costs and geography can also determine the volume of trade (Rauch, 1991). In equation (10), given the extent of comparative advantages, the volume of trade depends also on the distance between the trading partners.

[2] Belgium produces much more beer than France, but consumes also much more beer than France. Moreover, Belgian consumers tend to drink preponderantly their own beer. See alos Rivera-Batiz (1988).

However, in trade models with imperfect markets, the *direction of trade* can be ambiguous. We have assumed that the number of firms in a region depends on its domestic market size. With no trade costs, a firm can choose to locate in any region of its preference. If regions are similar in every way (no comparative advantage and homothetic demand) but the set of varieties they produce, it is impossible to determine the unique direction of trade (Ruffin, 1999) and equation (13) will equal 1 (no specialization). But there will still be trade. With no comparative advantage across regions and no trade costs, then the expression in brackets in equation (10) equals 1 and the *volume of trade* is wholly dependent on the product of the regions' market size for good K. In this case, we would obtain a high volume of trade, but absolutely no specialization: the mapping between specialization and trade might be very imperfect. In addition, contrary to standard trade models, regions must not necessarily be dissimilar for trade to occur. This is coming from the fact that, with monopolistic competition, consumers are given a taste for diversity and they will prefer to access to the largest array of product varieties, including the foreign ones (Krugman, 1979, 1980; Helpman, 1981; Ethier, 1979, 1982). Therefore, this taste for variety is the cause of international exchanges, even if all regions are similar.

If market sizes are initially unequal between regions, then the regions with the larger home market will be able to sustain the production of a higher number of differentiated products. Hence, a region could appear as more specialized in a given industry if its relative economic size is larger than in other regions and will export relatively more. We thus recover a mapping between specialization and trade. More generally, with trade costs, the volume of exports of a region depends essentially on its "market potential". The "market potential" characterizes the degree of geographical proximity to the largest markets. A region will tend to trade more with close regions because of trade costs, but also with the regions having the largest demand for its products.

With the existence of trade costs, the NEG models bring forth further insights about the location of firms across regions (Krugman 1991; Fujita, Krugman & Venables, 1999). With intermediate trade costs, the firm will choose to concentrate production in the location where it will find the higher demand for its product. This process could lead to the so-called "home-market" effect (Helpman & Krugman, 1985; Krugman, 1991). Forward (cost) and backward (demand) linkages between vertically linked firms can also trigger the agglomeration process (Venables, 1996; Puga, 1999)[3]. Against these agglomeration forces, the location of industry is also determined by some dispersion forces: high wages or input costs, strong local market competition, etc. Therefore, in NEG, the *direction of trade* follows the location of firms and workers according to the agglomeration/dispersion forces. The regions where industry locates will appear as being relatively more specialized, hosting a larger share of world production, and will export relatively more. Hence, we obtain again a mapping between specialization and trade. Yet, in NEG, the mapping does not follow a linear clear-cut relationship as in the standard comparative advantage model. Assuming monopolistic competition, the intensity of the mapping will rather evolve according to a multi-dimensional set of factors: the level of trade costs, the absolute and relative market size, geography, fixed costs, etc.

In short, the level of specialization of a region in a given industry reveals the reallocation of resources within the regions (following comparative advantages or the H-O-S model based on factor abundance), the level of local absorption of the good and the location of firms across regions. More generally, specialization may depend on all sorts of local advantages (natural advantages, wages, local subsidies, education, "marshallian" local scale economies[4], etc.) which will define the comparative advantage, but that will also attract relatively more firms. Then, the *volume of trade* will depend on the extent of this specialization, but also on industry characteristics (trade costs applicable to the industry τ^k, degree of product differentiation σ, world demand in

[3] To save on trade costs, producers will choose to locate close to their suppliers (forward linkages). Similarly, firms/suppleirs will choose to locate close to their customers/final product firms (backward linkages).
[4] Marshall (1890, 1892).

the industry E^k, etc.) and on the region's economic geography in terms of market potential, reflecting the interactions between spatial trade costs (ϕd_{rc}), the region's own absolute demand E_r and the partner's demand $(\beta_c E_c)$ for good K. Table 1 synthesizes the different determinants of the direction and of the volume of trade.

Table 1: Determinants of trade in a given industry-region

Determinants of specialization (Direction of trade)	**Determinants of volume of trade**
Industry-region characteristics ▪ Productivity level ▪ Factor abundance & endowments (labor, capital, etc.) ▪ Wages ▪ Intra-industrial marshallian externalities ▪ Forward / Backward linkages ▪ Local absorption **Regional characteristics** ▪ Natural advantages (access to water, natural resources, etc.) ▪ Local factor prices (inputs, intermediates goods, etc.) ▪ Inter-industrial marshallian externalities ▪ Education and innovation level ▪ Local development policies (structural funds, subsidies, etc.) ▪ Relative market size (relative set of varieties) ▪ Home market effect	**Industry-region characteristics** → ▪ SPECIALIZATION **Industry characteristics** ▪ Trade costs (transport costs, quotas and tariffs, language, etc.) ▪ Economies of scale (fixed costs) ▪ Rate of substitution (product differentiation) ▪ World demand in the industry **Regional characteristics** ▪ Absolute market size ▪ Market potential ▪ Geography ▪ Supply potential

2.2 The mapping

In Table 2, we identify four "extreme" cases in the mapping of specialization into trade. The *first case* in the upper left panel (low trade, low specialization) is trivial. In the absence of comparative advantage and with homogeneous goods, there is no motive for trade. Also, very high trade costs will discourage trade: firms will prefer to supply markets from local facilities only.

The *second case* (low trade, high specialization) refers from non-homothetic demand patterns across regions: the specialized regions have a relatively higher absorption of their own production. This case can also be related to the NEG models in the situation where regions have very different market sizes, with high trade costs. Because of the home-market effect, firms will concentrate in the high market region, which will appear as being specialized. However, trade with the small market region will be low precisely because the demand in this region is small and also because of intermediate/high trade costs that discourage trade flows.

Table 2: The mapping between specialization and world trade

	Low world trade	**High world trade**
Low specialization	- Competitive markets - No comparative advantages - Homothetic demand - High trade costs	**Intra-industrial trade** - Monopolistic competition - Medium/low trade costs - Similar market size - No comparative advantages
High specialization	- No comparative advantages + Non-homothetic demand, different local absorption. - **NEG**: imperfect competition + Significant differences in market size + high trade costs	**Inter-industrial trade** - Comparative advantages **Intra-industrial trade (NEG)** - Monopolistic competition - Agglomeration of economic activities - Medium/low trade costs - Differences in market potential

The *third case* (high trade, low specialization) corresponds to intra-industry trade between similar regions in terms of market size, and low trade costs. There is no comparative advantage, which would have led to inter-industry trade, hence specialization. The *fourth case* (high trade, high specialization) is consistent with standard trade models (comparative advantages). But this case may also relate to the NEG models, where the pattern of trade follows the agglomeration of economic activities (for medium or low trade costs).

2.3 Empirical literature

To our knowledge, this is the first paper exploring the mapping between exports and specialization at the industry-region level. Beine & Coulombe (2007) and Crabbé, Beine & Vandenbussche (2006) study the relationship between trade integration and the degree of industrial specialization, but at the aggregate regional level. Using the same database as in this paper, Paluzie & Lafourcade (2005) try to identify the determinants of bilateral trade flows between the regions of Spain and France. They show that neighboring regions trade much more between them than with other regions. Rice, Stewart & Venables (2003) explore the geography of intra-industry trade between OECD countries. They show that distance is not the primary determinant of intra-industry trade, but rather the similarities in the countries' economic structures (supply and demand characteristics). Redding & Venables (2003) also examine the determinants of export performance for a sample of 101 countries. They estimate for each country a foreign market access component, which depends on the trading partners' total expenditure on differentiated products, weighted by distance. Their results indicate that this foreign market access component as a positive and significant effect on export performance.

3 Empirical methodology

In order to evaluate the strength of the mapping between trade and specialization, we will estimate a trade equation based on equation (10). We choose to concentrate only on intra-EU trade[5], e.g. Spanish trade going to or coming from the other EU 14 countries[6]. The Autonomous Communities export in average about 75% of total exports to the European Union and this average share is more or less stable since 1991. Hence, indexing equation (10) to allow for *k* industries and t time periods, and taking total volume of trade by industry-region going to the rest of the EU14, we have:

$$(10') \quad \nu_{i(kr)t-EU} = \frac{\beta^k_{EUt} E_{EUt} \beta^k_{tr} E_{tr}}{E^k_t} \left(\frac{a_{i(kr)t} + \left(\phi d_{rt-EU} + \tau^k\right)}{I^k_{tEU}} \right)^{1-\sigma}$$

Here, the industry-region unit *i*(*kr*) is composed of two dimensions: an industry (index *k*) and a region (index *r*), for a sample of 18 sectors and 15 Autonomous Communities. However, we will estimate a reduced version of equation (10'). Indeed, Table 1 reveals one interesting feature for the empirical methodology. Except for specialization, the determinants of the volume of trade (second column) depend mainly on industry effects constant to all regions and on regional effects constant to all industries. These industry and region effects can be efficiently estimated by fixed effects or withdrawn by demeaning the data in the industry and in the region dimension.

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[5] Unfortunately, intra-Spanish trade data between ACs themselves are not available.

[6] For our time sample (1988-2003), the EU15 (pre-accession Member-States before 2004) represents the appropriate level of economic integration.

Once these effects are taken into account, the only remaining component of trade in Table 1 is the specialization level (direction of trade). To characterize the specialization level in the industry-region, we compute the following specialization index (SPEC):

$$SPEC_{i(kr)t} = \frac{\left(EMPi(kr)t / EMP_{rTOT} \right)_t}{\left(EMP_{EUkt} / EMP_{EUTOT} \right)_t} = \frac{\left(share_{i(kr)} \right)_t}{\left(share_{kEU} \right)_t}$$

where the share of employment of industry-region *i*(*kr*) in the region *r* is divided by the share of the industry *k* in total EU employment. An index higher than 1 indicates that the region is more specialized in this industry relatively to the EU15 and inversely if the index is smaller than 1. Since we are working with intra-EU trade, we always use the European Union (EU15) as the benchmark.

This specialization index is similar to the Balassa index of revealed comparative advantage (Balassa, 1965). Since specialization reflects any kind of industry-region advantage (first column of Table 1), the direction of trade should be well approximated by SPEC alone. With the fixed industry and region effects already controlling for the volume of trade, there should be no need in providing any other determinants in the regression but specialization. Indeed, closer inspection of equation (10) indicates that, allowing for industry and region effects, we are left with the terms β_r^k and $\left[a_r^k / I_c^k \right]$ that are the only variables indexed in both the industry (*k)* and the region (*r)* dimensions. Yet, these terms are also the determinants of equation (13) which is very similar to the definition of SPEC above. Hence, for given industry and regional characteristics, we should clearly be able to identify the mapping between trade and specialization.

Hence, we rely on a very basic estimation methodology to identify the strength of the mapping between exports and specialization. Specifically, we estimate the following regression equation:

$$(11) \qquad EXCAP_{i(kr)t} = \beta_1 SPEC_{i(kr)t} + u_k + u_r + e_{i(kr)t}$$

where EXCAP is the per capita value of intra-EU exports in the industry-region *i*, u_k is an industry effect, u_r is an effect specific to the region *r* and e_{it} is an i.i.d. error term. To take into account the size of each AC, we choose to divide the trade values by total population in the AC. The independent variable is thus the level of intra-EU export per capita (EXCAP) in real values.

We are interested in the mapping between specialization and trade, focusing on the sign and significance of coefficient β_1. Specifically, the mapping indicates if, at time *t*, a region relatively more specialized in a given industry is relatively exporting more than other regions, whatever the channels explaining this relationship. Estimating equation (11) in a cross-section fashion does exactly that. The panel dimension will then be used to obtain more robust results and to estimate fixed industry and regional effects, but not to study any dynamic interactions; we do not wish to infer any causal relations.

Indeed, from the theoretical point of view, trade is not necessarily "caused" by specialization. Once the volume of trade has been controlled for, exports and specialization should be the expression of the same process: the extent of economic integration. It follows that the variable SPEC could be endogenous in equation (11) since specialization might be simultaneously determined with exports. But this is precisely the idea behind the concept of a mapping between specialization and trade. In any event, to avoid bias results, endogeneity can be dealt with using the Instrumental Variable (IV) estimator and the General Methods of Moment (GMM) developed by Arellano & Bond (1991).

Moreover, the variables in equation (11) might also be characterized by a unit root process, raising the potential problem of spurious regressions (Granger & Newbold, 1974). This issue will not be discussed here for conciseness. However, in Laurin (2007), we show that our regression results are not driven by a spurious relationship. We also provide in Laurin (2007) some useful indications for detecting spurious results in a panel setting such as ours, based on the insights of a small Monte Carlo exercise. Essentially, the advantage of panel data is that the cross-section dimension can overweight the spurious effect of the time dimension as the number of cross-units increases (Banerjee, 1999).

3.1 Control variables

If one believes that the SPEC index reveals only very imperfectly the comparative advantage, other cost/efficiency variables can be included in equation (11) as a robustness check. To measure productivity, we use value added divided by employment in the industry-region[7]. This variable is a proxy for average productivity in the industry-region ($a_{i(kr)}$). Then, we construct a relative measure of productivity (PRODR), taking the ratio of the average productivity in the industry-region over the EU15's value added by employment in the respective industry[8]. The ratio PRODR is akin to the expression $\left(a_{i(kr)}/I^{K}_{EU}\right)$ in equation (10'), where the index of production costs I^{K}_{EU} is given by the average EU15 level. To be competitive on world markets, it is also important to fully exploit economies of scale. We measure the scale of production (SCALE) taking employment divided by the number of firms in the industry-region. We expect PRODR and SCALE to have a positive effect on exports.

To measure factor abundance and regional endowments, we could use several variables. Total employment in the industry-region (EMP) expresses labor abundance. Total population in the region would also be an important local endowment, but we have already deflated the trade values by population. The number of firms located in the industry-region (FIRM) can encourage intra-industry externalities (technological spillovers and forward/backward linkages). However, EMP, FIRM and SCALE might be correlated with SPEC, particularly since EMP and SCALE all also computed using employment data. In Table 3, we show the variables' correlation matrix. High levels of correlation are shown in bold. Both EMP and FIRM are absolute measures of specialization. Since we prefer working with a relative specialization measure, we choose to use only SPEC in the regressions and discard the two others. SCALE has a completely different interpretation, and is not much correlated with other variables, except obviously with FIRM. So, SCALE will be kept as a control.

Some regional natural endowments are also provided in the regression: the share of employment in agriculture relatively to total regional employment (AGRI), the total agricultural area actually used in percentage of total regional area (AGRIUSE) and a dummy for regions having a direct access to sea (SEA). As an aside issue, we also include the amount of European Structural Funds received by the AC (FUND), in order to see if the European regional policy is a discriminating element in the ranking of ACs in terms of trade.

Unfortunately, we do not have adequate data on capital by industry-region in Spain. Capital accumulation, notably through FDI, may be one of the most important factors explaining the growth of trade in Spain between 1988 and 2003 (see Alguacil & Orts, 2002). However, FIRM or SCALE may represent good proxies for the capital level in the industry-region.

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[7] We have also used a variable measuring average wage costs. This variable was highly correlated to our productivity index PRODR, and regression results using wages instead of value added – available upon request - were very similar.

[8] Since both the numerator and the denominator are in nominal values, the resulting index is comparable in time. From the viewpoint of firms, investment decisions are taken considering the inflation differentials across the EU.

Table 3: Correlation matrix (variables in log)

	SPEC				
PRODR	0,221	**PRODR**			
SCALE	0,155	0,240	**SCALE**		
EMP	**0,583**	0,123	0,211	**EMP**	
FIRM	**0,489**	-0,011	**-0,306**	**0,854**	**FIRM**
GDP	-0,008	0,124	0,120	**0,427**	**0,336**
GDPCAP	0,148	**0,330**	0,035	0,108	0,075
GRAVITY	0,142	0,277	0,009	-0,019	-0,029
FUND	-0,044	-0,091	0,019	0,234	0,211
AGRI	-0,031	-0,266	-0,060	-0,194	-0,142
AGRIUSE	-0,026	-0,062	-0,110	-0,113	-0,049
FRANCE	0,131	0,262	0,067	0,088	0,046
PORTUGAL	-0.118	-0.203	-0.043	0.0273	0.0456
SEA	0,024	-0,005	0,096	0,174	0,119

Finally, instead of computing region fixed effects, the gravity component of trade can be estimated separately. From the gravity equation (10), the combination of distance and the partners' respective market size has an important effect on the volume of trade. To measure own demand (E_r), we take the regional GDP (GDP) or GDP per capita (GDPCAP). Based on Harris (1954), we also construct the following gravity index (GRAVITY):

$$\mathrm{GRAVITY}_{rt} = \sum_{c \neq r}^{C} \frac{\mathrm{GDP}_{ct}}{(d_{rc})^2} \qquad \text{for } r = 1,\ldots,15, \quad \text{and} \quad c = 1, \ldots, 76.$$

where *c* are trade partners within the EU15 and d_{rc} is the distance between the Spanish AC *r* and the trade partner *c*. As trade partners, we have defined 76 geographic units covering all the EU15 territory: all NUTS2 regions of the biggest or closest countries (Portugal, France, Germany, Italy and the UK) and the whole national area for the others countries (Belgium, Denmark, Greece, Ireland, Luxemburg, the Netherlands, Austria, Finland and Sweden)[9]. Distance is defined as the amount of road kilometers needed to join the capital cities of the AC and the trade partner, as obtained from the Internet Route Planer *Via Michelin*[10]. This gravity index can be understood as a sort of market potential index[11]. Note that the value of the gravity index changes in time, following the growth of GDP in nearby EU regions. We expect a positive effect of gravity on the volume of exports. We also use two geographical dummy variables for ACs sharing a border with France (FRANCE) or with Portugal (PORTUGAL). These regional characteristics will be inserted sequentially in the regression equations. Other trade costs that are particular to the industry (τ^k) are captured in the industry effects.

3.2 Data

Data are classified in the NACE Rev. 1 industrial classification at the 2-digit level, composed of 22 sectors, including 6 service sectors. But we reduce our investigation to 18 NACE Rev.1 sectors (see Appendix 2), because of data problems with the other sectors. We focus on 15 Autonomous

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[9] Since Spain's regions are geographically situated in a compact "rectangle" at the south end of the EU, taking the smaller and farther countries as a whole does not really affect the gravity index.

[10] http://www.viamichelin.com. The road distance is a good approximation of freight transportation costs, being a much more refined distance measure than the simple straight-line geodesic distance between two points

[11] It would have been interesting to also provide an index for proximity to inputs (backward linkages) or to costumers (forward linkages), but the lack of comparable regional data across the EU prevents us from constructing such an index.

Communities (see Appendix 2)[12]. In total, we get 270 industry-region units (18 sectors in 15 ACs) over 16 periods (1988-2003), for a total of 4320 observations. The panel is balanced, except that for FIRM and SCALE, statistics on the number of firms are not available for year 2003.

For trade data (imports and exports), we exploit a very extensive database, obtained from the *Agencia Estatal de Administración Tributaria* (Spanish custom authorities), that compiles all monthly international transactions in good and services, coming from or going to each Spanish provinces, by products (at the 8-digit TARIC classification[13]) and by country of origin or destination. Using a correspondence matrix, the trade data at the TARIC 8-digit product level can be straightforwardly aggregated to obtain trade values at the 2-digit NACE Rev. 1 classification by Autonomous Communities. The trade values are deflated using INE's (*Instituto Nacional de Estadística*) national price index for exports and imports. Hence, the obtained trade series correspond to the real annual value of intra-EU exports or imports by industry (at the 2-digit NACE classification) by Autonomous Communities.

Almost all other statistics on Spain's ACs are provided by INE, and particularly the *Regional Accounts Statistics* and the *Industrial Companies Survey*. The regional land use statistics (agricultural area, arable land) can be found in *Eurostat*'s Regional statistics. The EU15 values are taken from *Eurostat*'s national accounts and from a special database constructed by the *Groningen Growth and Development Centre* (60-Industry Database)[14]. The total EU15 intra-trade values are available in *Eurostat*'s Comext database (Intra – and Extra-EU trade, Annual data, combined Nomenclature). The exact source of data for each variable is detailed in Appendix 1.

The INE's *Regional Accounts Statistics* suffers from a change in the industrial classification in 1995. The 1986-1995 series do not quite follow the NACE Rev.1 industrial classification. Therefore, the series had to be re-constructed or interpolated based on two other databases: Eurostat's Regional statistics (*Structural business statistics*) and INE's *Industrial Companies Survey,* which both are compatible with the NACE Rev.1 classification. The obtained series become comparable throughout the whole period. The exact interpolation technique used to construct the series and to estimate missing values are described in Appendix 1.

All variables are taken in log. To avoid losing zero-value observations, we just rescale the variables by adding 1 to all values before applying the log transformation.

4 Results

In Table 4, we first present the simple OLS regression of EXCAP on SPEC (specification 1) in levels. The coefficient is positive and highly significant. The variable SPEC alone explains about 17% of exports per capita.

In specification 2, we implement our reduced regression strategy assuming that SPEC is a fairly good proxy of the whole specialization process (direction of trade component) when other components of the volume of trade are estimated by industry and regional fixed effects. The coefficient of SPEC remains positive and significant; specialization with industry and regional fixed effects are sufficient to explain about 84% of exports per capita in the industry-regions, as conjectured in our empirical hypothesis.

[12] Spain is composed of 17 Autonomous Communities. But we exclude two Autonomous Community, the Islands of Canarias and Baleares because of data unavailability.
[13] TARIC is the industrial classification used for trade data in Spain.
[14] http://www.ggdc.net.

Table 4: Panel results - Determinants of export

Independent variable: log(EXCAP)	Comparative advantage		+ Gravity		Demeaning by		
	OLS	Fixed-effects	OLS	Fixed-effects	Industry	Region	Industry & region
	1	2	3	4	5	6	7
log(SPEC)	3.659*** (31.45)	2.943*** (41.91)	3.499*** (29.86)	2.852*** (42.32)	3.044*** (46.36)	3.524*** (29.19)	9.713*** (163.93)
log(GDP)	-	-	0.517*** (11.90)	0.521*** (24.87)	-	-	-
log(GRAVITY)	-	-	1.299*** (9.65)	1.406*** (23.17)	-	-	-
constant	4.493*** (52.52)	-	-5.461*** (-7.29)	-	-	-	-
F-test for fixed effects (*p*-value)							
Industry effects	-	891.98*** (0.000)	-	957.29*** (0.000)	-	-	-
Region effects	-	63.89*** (0.000)	-	-	-	-	-
Adj. R2	0.1742	0.8378	0.2102	0.8445	0.3321	0.1645	0.8615
Nb of obs.	4320	4320	4320	4320	4320	4320	4320

OLS using White heteroscedasticity robust standard errors. Constant excluded with fixed effects. In parentheses below coefficient: *t*-statistics. * = significant at 10%; **=significant at 5%; ***= significant at 1%.

Then, in specification 3 and 4, we add the two gravity variables, GDP and GRAVITY, in place of region-fixed effects. GDP has a positive and significant coefficient[15], in spite of the fact that the export value has been deflated by population. Regions having a larger market size tend to export more than smaller regions. The regions' market potential (GRAVITY) has also a positive and significant coefficient, as expected: regions closer to the EU economic core tend to have a higher export intensity. With the addition of industry fixed effect (specification 4), we are again able to explain about 84% of per capita exports.

However, industry or regional effects are not necessarily constant through time. For example, the evolution of industry might follow its product life-cycle. Industries are also affected differently by trade costs that are known to decrease in time within the EU. At the regional level, the value of the gravity index changes in time. Portugal, on Spain's western border, has enjoyed strong economic growth in the period 1988-2003. The same for some regions in the southern part of France (for example, the area of Toulouse and its aeronautic industry). Hence, these effects should improve the market potential for ACs close to Portugal or France. To take into account common industry or regional evolutions, we demean the variables in both dimensions[16]. In this way, the variables are whitened from the common industrial and regional trends. The demeaned regressions are presented in specifications 5, 6 and 7 in Table 4. The coefficient of SPEC remains positive and significant. When the data are demeaned in both dimensions (specification 7), SPEC now explains 86% of exports. The value and significance of the SPEC coefficient are much higher than in the previous regressions. This confirms our hypothesis: when the volume of trade is controlled for industry or regional effects, there is a strong relation between trade and specialization.

[15] The GDP variable might be highly endogeneous. But it measures total regional GDP. The industry's own exports affect only partialy total GDP. The endogeneity problem might be not too severe, depending on the size of the industry-region, and keeping in mind that this variable is used only as a control.
[16] Specifically, we substract from each variable the industry annual mean and the region annual mean.

These OLS results might not be consistent if SPEC is endogenous in the equation regression. The endogeneity of SPEC can be solved using the Instrumental Variable (IV) estimator. We must first devise some appropriate instruments. We know from the NEG models and the endogenous growth models (Grossman & Helpman, 1995) that specialization can be a cumulative process. Thus, the initial level of specialization in 1986 might represent a good instrument. With low trade costs (which is the case within the EU), economic geography predicts that economic activities should concentrate closer to the "core". Hence, the market potential of a region should affect the specialization level. By construction, the gravity index is exogenous. Also, the specialization process is an important aspect of industrial structural change. Structural transformation should imply the passage from an economy based on traditional low-productivity sectors to more advanced value-added sectors. Balaguer and Cantavella-Jorda (2004) and Laurin (2008) show that economic development in Spain is related to the extent of structural change. The regional GDP per capita reflects in part the process (or absence) of structural change. Since the GDP series are available from 1980, we take the sixth-period lagged value of GDP per capita. We thus have three instruments for SPEC: the initial value of SPEC in 1986 (SPEC86), the market potential (GRAVITY) and the sixth-period lagged value of GDP per capita (LAGGDP). SCALE is also provided in the IV regressions to insure that SPEC, which must be instrumented, is not the only variable evolving in the industry-region dimension.

Results of the IV regressions are presented in Table 5, specification 10. The IV estimates appear to be close to the OLS estimates. SPEC is still positive and significant. But the high value of Hausman *t*-statistic (-14.39), shown in specification 10, still indicates a significant difference between the OLS and IV estimators. The endogeneity of SPEC is indeed affecting the consistency of the OLS estimates.

In Table 5, we also verify the robustness of the previous results by adding other determinants of exports as controls. In all specifications, the coefficient of SPEC remains highly significant and positive. Specification 11 includes two complement productivity measures: the average productivity level in the industry-region relatively to the EU (PRODR) and the average number of employees by firms in the industry-region (SCALE). Specialization might not reveal perfectly the distribution of comparative advantages across regions. Hence, the industry-region's productivity level is a direct measure identifying the comparative advantage. Both PRODR and SCALE have a positive and significant effect on exports, even when taking into account fixed industry and regional effects.

In the next specifications of Table 5, we insert sequentially regional determinants measuring other local advantages. Here, with regional variables, we need to omit region fixed-effects. The two variables measuring agricultural endowments AGRI (share of agriculture in total regional employment) and AGRIUSE (percentage of land used for agricultural activities) have a negative and significant coefficient. These variables should not really have an effect on industries other than the agricultural or perhaps the food and beverage sector. But the largest agricultural regions happen to coincide with regions that are lagging in terms of growth or structural change. In fact, the importance of regional agriculture seems to be a good measure of structural change in Spain (Balaguer & Cantavella-Jorda, 2004; Laurin, 2008). At the beginning of the sample period, Spain in general was highly specialized in agricultural activities. While the importance of agriculture has substantially declined in most ACs, some are still highly specialized in this sector. Industrial development usually implies the transformation of the region's industrial structure from agriculture towards more advanced sectors. Thus, the ACs that are still too dependent on agriculture tend to export relatively less, since they generally coincide with the less-developed regions in Spain.

Table 5: Panel results - Determinants of export

Independent variable: log(EXCAP)

	IV	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**
	10	**11**	**12**	**13**	**14**	**15**	**16**
log(SPEC)	3.245*** (25.30)	2.396*** (35.44)	2.235*** (33.08)	2.346*** (32.54)	2.358*** (35.57)	2.327*** (33.78)	2.255*** (32.51)
log(PRODR)	-	1.146*** (14.62)	1.193*** (14.97)	1.543*** (20.17)	1.183*** (15.66)	1.471*** (20.47)	1.313*** (20.01)
log(SCALE)	0.138*** (4.19)	0.202*** (7.38)	0.243*** (8.66)	0.212*** (7.13)	0.221*** (8.10)	0.219*** (7.68)	0.228*** (11.21)
log(GDPCAP)	-	-	0.978*** (9.33)	-	-	-	-
log(FUND)	-	-	-	0.072*** (4.04)	-	-	-
log(AGRI)	-	-	-	-	-0.332*** (-13.20)	-	-
Log(AGRIUSE)	-	-	-	-	-	-0.376*** (-5.34)	-
FRANCE	-	-	-	-	-	-	0.482*** (10.35)
PORTUGAL	-	-	-	-	-	-	0.126** (2.77)
SEA	-	-	-	-	-	-	0.191*** (5.15)
constant	4.527** (38.37)	-	-	-	-	-	-
F-test for fixed effects (*p*-value)							
Industry effects	-	885.1*** (0.000)	821.3*** (0.000)	841.8*** (0.000)	899.7*** (0.000)	980.1*** (0.000)	1206.0*** (0.000)
Time effects	-	42.8*** (0.000)	21.8*** (0.000)	24.7*** (0.000)	30.8*** (0.000)	36.6*** (0.000)	40.12*** (0.000)
Region effects	-	37.1*** (0.000)	-	-	-	-	-
Hausman *t*-stat (*p*-value)	-14.39*** (0.000)	-	-	-	-	-	-
Adj. R2	0.1918	0.8653	0.8528	0.8514	0.8564	0.8506	0.8527
Nb of obs.	4155	4155	4155	3900	4155	4155	4155

OLS using White heteroscedasticity robust standard errors. Constant excluded with fixed effects. In parentheses below coefficient: *t*-statistics. * = significant at 10%; **=significant at 5%; ***= significant at 1%.

Closeness to France (FRANCE) has positive and significant coefficient: regions closer to the EU economic core tend to have a higher export intensity. The regions close to Portugal (PORTUGAL) also tend to export relatively more, but the coefficient is smaller and less significant than for FRANCE. The coefficient is also positive and significant for access to sea (SEA). The results for these two variables indicate the importance of geography in explaining trade. Finally, regions that are recipients of European structural Funds (FUND) tend to export relatively more.

4.1 Results in first-difference

The variables used in the regression model might not be stationary. Thus, for a robustness check, we estimate the export equation in log annual deviations[17]. The results are presented in Table 6.

[17] We can show that the variables are stationary in first-difference. See Laurin (2007).

Table 6: First-difference estimations

Independent variable: Δlog(EXCAP)	OLS	OLS	GLS	GLS	Arellano-Bond	Arellano-Bond[1]
	D1	**D 2**	**D 3**	**D 4**	**D 5**	**D 6**
Δlog(SPEC)	0.673*** (3.11)	0.661*** (2.99)	0.578*** (3.26)	0.558*** (3.05)	1.297*** (2.36)	1.299*** (2.37)
Log(EXCAP) $_{t-1}$	-0.012*** (-2.52)	-0.063*** (-5.27)	-	-	-	-
Δlog (EXCAP) $_{t-1}$	-0.329*** (-6.31)	-0.313*** (-6.05)	-	-	0.268*** (3.46)	0.272*** (3.48)
Δlog (EXCAP) $_{t-2}$	-0.202*** (-4.38)	-0.198*** (-4.30)	-	-	-	-
constant	0.236*** (5.74)	-	0.088*** (9.84)	-	-	-
F-test for fixed effects (*p*-value)						
Regional fixed effect	-	1.69** (0.051)	-	8.07 (0.921)	-	-
Industry fixed effect	-	5.45 (0.000)	-	22.37 (0.131)	-	-
Time fixed effect	-	3.17*** (0.000)	-	28.51*** (0.004)	178.9*** (0.000)	177.0*** (0.000)
R2	0.1213	0.1533	-	-	-	-
Log likelihood	-	-	-3842.9	-3816.9	-	-
Nb of obs.	3510	3510	4050	4050	3780	3780

Constant excluded with fixed effects. OLS: using White heteroscedasticity robust standard errors. GLS estimation corrects for autocorrelation providing an AR(1) process for each unit. Arellano-Bond (1991) GMM estimator, correcting for autocorrelation (one lag deviation) and using White heteroscedasticity robust standard errors. In parentheses below coefficient: *t*-statistics. * = significant at 10%; **=significant at 5%; ***= significant at 1%.
1. Added instruments: log(INISPEC), log(LAGPIBCAP), log(GRAVITY).

In specifications D1 and D2, we correct for autocorrelation parametrically by including the lagged level of EXCAP and two lags of its first-difference. We also use the Generalized Least Square (GLS) estimation method in specifications D3 and D4. Similarly to the level regressions, the coefficient of SPEC remains positive and significant in all specifications. In the GLS estimations, the industry and region fixed-effects (specification D4) are not significant. In fact, the first-difference operator removes any fixed components in time. However, the time fixed-effects are still significant.

As explained previously, SPEC might be endogenous in the ECXAP equation. Hence, we implement the Arellano & Bond (1991) General Methods of Moments (GMM) in specifications D5 and D6 of Table 6. This estimator uses as set of instruments composed of a series of lags in level and in first-difference of the endogenous variables. In specification D6, we include in addition to the Arellano & Bond instruments the three instruments used previously for the IV regression (Table 5): the initial level of specialization, the lagged GDP per capita and the gravity index. In all specifications, SPEC has still a positive and significant coefficient, but the GMM coefficient value is much higher than the OLS and GLS estimations.

Again, this difference suggests that the OLS and GLS point estimates of Table 6 might be seriously biased, confirming the endogeneity of SPEC. This difference could be driven by the quality of the instruments, particularly since the set of instruments of the Arellano-Bond estimator might have a low efficiency in a short time sample. Yet, in light of your objective, the endogeneity problem is not too worrying. The very existence of endogeneity confirms that the variables are simultaneously determined, bringing further evidence of a significant mapping. Both sets of biased and unbiased coefficients are positive and significant, which is sufficient to establish our case.

In Table 7, we insert the control variables in the first-difference regressions. Total intra-EU exports per capita in the industry (EU-EXCAP) are also included to captures the industry's common evolution in the EU. Hence, we must omit the industry and time fixed-effects when using EU-EXCAP. Since we are working in first-differences, value added per employee (PROD) in absolute terms is preferred to the relative index (PRODR): export growth is caused as much by the evolution of comparative advantage as by the own absolute productivity growth. The variables AGRIUSE and FOREST are not estimated because there is very little annual variability.

Table 7: First-difference estimations with controls

Ind. variable: Δlog(EXCAP)	**GLS D7**	**GLS D 8**	**GLS D 9**	**GLS D 10**	**GLS D 11**	**GLS D 12**	**GLS D 13**	**GLS D 14**	**GLS D 15**
Δlog(SPEC)	0.579***	0.648***	0.582***	0.584***	0.585***	0.528***	0.644***	0.617***	0.550***
	(3.12)	(3.44)	(3.14)	(3.15)	(3.15)	(2.74)	(3.54)	(3.42)	(2.98)
Δlog(PROD)	0.062	0.055	0.059	0.068	0.066	0.056	0.103	0.096	0.062
	(0.67)	(0.60)	(0.64)	(0.73)	(0.71)	(0.56)	(1.18)	(1.10)	(0.67)
Δlog(SCALE)	-	-0.044	-	-	-	-	-	-	-
		(-1.57)							
Δlog(AGRI)	-	-	-0.493***	-	-	-	-	-	-
			(-3.17)						
Δlog(GRAVITY)	-	-	-	-1.64	-	-	-	-	-
				(-0.32)					
Δlog(GDP)	-	-	-	-	0.168	-	-	-	-
					(0.26)				
Δlog(FUND)	-	-	-	-	-	0.001	-	-	-
						(0.10)			
Δlog(EU-EXCAP)	-	-	-	-	-	-	0.154***	0.117*	-
							(2.34)	(1.76)	
Δlog(IMCAP)	-	-	-	-	-	-	-	0.140***	0.138***
								(8.26)	(8.11)
constant	-	-	-	-	-	-	-	-	-
F-test fixed effects (*p*-value)									
Region fixed effect	7.99	9.72	-	-	-	-	63.65***	49.75***	12.81
	(0.924)	(0.836)					(0.000)	(0.000)	(0.616)
Industry fixed effect	21.45	12.71	13.08	12.22	13.47	14.96	-	-	10.76
	(0.161)	(0.693)	(0.667)	(0.728)	(0.638)	(0.527)			(0.769)
Time fixed effect	32.95***	28.98**	36.59***	32.41***	33.06***	30.81***	-	-	29.54***
	(0.002)	(0.011)	(0.001)	(0.003)	(0.002)	(0.004)			(0.008)
Log likelihood	-3816.6	-3538.8	-3815.3	-3819.8	-3819.8	-3606.4	-3840.2	-3806.0	-3786.2
Nb of obs.	4050	3885	4050	4050	4050	3780	4050	4050	4050

GLS estimation correct for autocorrelation providing an AR(1) process for each unit. Constant excluded with fixed effects. In parentheses below coefficient: *t*-statistics. * = significant at 10%; **=significant at 5%; ***= significant at 1%.

Again, the coefficient of SPEC is always positive and significant. Productivity growth (PROD) has a positive coefficient, but is insignificant in all specifications. SCALE is negative, but also insignificant. Akin to the level estimations, AGRI has a negative and significant effect on export growth. However, all the other regional variables are non significant, in part because the first-difference operator singles out the individual effect. As expected, the export growth in each industry-region tends to follow the European evolution in this industry: the variable UE-EXCAP, which captures an industry and time effect, is positive and significant.

We also provide in the regressions the first-difference of the value of imports per capita in the industry-region (IMCAP). Interestingly, the coefficient of IMCAP is positive and highly significant. It seems that the evolution of exports tends to follow the evolution of imports in time. To investigate more extensively this result, we now discuss the relationship between specialization, imports and exports.

4.2 A counterfactual: the case of imports

If there exist a significant and positive mapping between specialization and exports, the counterfactual would be to have a negative or insignificant mapping between specialization and imports. In particular, the mapping should be negative in the standard Ricardian trade model: regions reallocate resources out of the production of the goods for which they do not have a comparative advantage. Hence, they must import the goods in which they do not specialize. Since imports of a region are exactly equal to the exports of the provenance region, the equation of imports is similar to equation (10), but with the trade partner index reversed. Hence, we see that the comparative advantage of the importing region does not have a direct effect on the volume of imports: its costs level (a_r) affect imports only through the cost weighted average index (I). Similarly to exports, imports will be determined by market size. Because consumers have a preference for diversity, a region must import the varieties it does not produce, whether or not this region is specialized in this industry. Geography plays also a role: a region geographically close to important foreign markets (in terms of demand and market size) will show a greater propensity to import from these markets.

Table 8: Panel results: imports and trade balance

	Equation for:	
	log(EXCAP)	**Trade balance**
	1	**2**
log(SPEC)	2.017***	1.354***
	(26.33)	(14.84)
log(PRODR)	0.993***	0.725***
	(12.78)	(8.06)
log(SCALE)	0.195***	0.182***
	(7.19)	(5.36)
log(IMCAP)	0.363***	-
	(12.75)	
F-test for fixed effects (*p*-value)		
Industry effects	80.61***	40.68***
	(0.000)	(0.000)
Region effects	35.70***	29.30***
	(0.000)	(0.000)
Time effects	19.05***	2.51***
	(0.000)	(0.001)
Adj. R2	0.8793	0.4470
Nb of obs.	4155	4155

OLS using White heteroscedasticity robust standard errors. Constant excluded with fixed effects. In parentheses below coefficient: *t*-statistics.
* = significant at 10%; **=significant at 5%; ***= significant at 1%.

Therefore, we now investigate briefly the mapping between imports and specialization. As a first step, in Table 8, imports per capita (IMCAP) are added as a determinant in the EXCAP equation regression (specification 1). The coefficient of IMCAP is positive and significant. Note that the two trade variables are taken in per capita accounts, so that this positive relationship is not driven by the size of the region[18]. Hence, a region exporting relatively more in an industry tends to also import more in this industry.

How can this positive relationship be explained at the regional level? From equation (10), both exports and imports are driven by common components: respective market size, trade costs, the preference for the good and the elasticity of substitution. Hence, we expect a positive relationship between both trade variables. This relationship can be equally justified by the existence of vertical linkages between firms. In this case, we can interpret the CES sub-utility function of equation (2) as the demand of final good firms for differentiated intermediate inputs, and equation (1) as a production function of a representative firm in region *r*, where A would be a CRS input good.

[18] The result is similar if we use exports and imports in share of the regional GDP.

Using this setting, the trade model would then follow exactly as derived in section 2. However, we would have another justification for approximating the number of firms N_r by the market size. In fact, the higher the number of firms in the region, the greater the demand for intermediate inputs. Since the specialization index captures also the concentration of firms in an industry-region, we obtain a positive relation between specialization and imports.

We can further develop the links between exports and imports using the vertical linkages model. To be successful on world markets, a firm needs to be competitive. The firm must use the lowest-price or best-quality inputs possible. The region where the firm is located cannot produce every product with the lowest price or the best quality. This necessarily means importing parts of the inputs or intermediate goods abroad. It follows that the more the firm produces to sell abroad (higher exports), the more it is using foreign inputs (higher imports). In other words, the capacity to export depends on access to imports[19].

Finally, there is the "aptitude for trade" argument: regions that export the most demonstrate a greater "aptitude" for international trade, and consequently import more (and vice-versa). When a firm starts to export, it interacts with foreign firms and agents. This firm becomes more aware of the qualities, prices and technologies of foreign product, which then favors imports. In turn, foreign firms exporting to Spain will be in contact with local producers and might become interested in purchasing their products, creating a new export market for Spain's firms. Integrating the world economy gradually unfolds all kinds of opportunities for trade.

Therefore, in order to remove the import component, we test the mapping between specialization and net export (per capita) in specification 2 of Table 8. We define net export as the trade balance in log: log(trade balance) = log(EXCAP) - log(IMCAP). As expected, the mapping between specialization and net trade is positive and significant, but the fit of the regression is much lower (0.45).

In a second step, Table 9 considers the mapping between imports per capita and specialization. When IMCAP is simply regressed on specialization (specification 3), SPEC has a positive and significant coefficient, but the R^2 is then very low (0.05). The interesting feature in Table 9 is that, when EXCAP is added to the regression (specifications 4 to 6), specialization becomes negative and significant. Since the export level tends to follow the import level, part of the relation between import and specialization is explained by components that are common with exports. But once exports are taken into account, we uncover a negative mapping between import and specialization. As expected, own market size (GDP) and GRAVITY have a positive and significant coefficient (specification 5). If we instead estimate the gravity component by region effects (specification 6), SPEC keeps its negative coefficient.

These results about imports are very interesting. For exports, by construction of the SPEC index, we expected unambiguously a positive coefficient for specialization. Then, the empirical issue is more about the intensity of this mapping between specialization and exports and the significance of other determinants of trade, rather than the sign of the coefficient. But, to get further insights about the determinants of trade, the regression results for imports are equally relevant. The expected negative relationship between comparative advantages and imports can be identified only when the common components with exports are taken into account, by introducing the level of exports in the regression or by using fixed industry and region effects. Otherwise, both exports and imports tend to express the overall "openness to trade" of the industry-region.

[19] See for example Amiti & Konings (2005). They show that a reduction of import tariffs on inputs has a positive and significant effect on firm productivity in the Indonesian manufacturing sector.

Table 9: Panel results for imports

Independent variable: log(IMCAP)	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**
	3	**4**	**5**	**6**	**7**
log(SPEC)	1.696*** (18.43)	-1.131*** (-15.95)	-1.163*** (-16.44)	-1.218*** (-17.49)	0.351*** (4.37)
log(EXCAP)	-	0.772*** (77.61)	0.753*** (73.26)	0.753*** (73.59)	0.282*** (15.14)
log(GDP)	-	-	0.169*** (7.80)	-	-
log(GRAVITY)	-	-	0.844*** (12.91)	-	-
constant	6.157*** (86.96)	2.684*** (36.10)	-0.908** (-2.47)	-	-
F-test for fixed effects (*p*-value)					
Industry fixed effect	-	-	-	-	128.9*** (0.000)
Region fixed effect	-	-	-	33.63*** (0.000)	165.5*** (0.000)
Time fixed effect	-	-	-	0.90 (0.554)	18.8*** (0.000)
Adj. R2	0.0524	0.7429	0.7543	0.7671	0.8732
Nb of obs.	4320	4320	4320	4320	4320

OLS using White heteroscedasticity robust standard errors. Constant excluded with fixed effects. In parentheses below coefficient: *t*-statistics. * = significant at 10%; **=significant at 5%; ***= significant at 1%.

5 Conclusion

In this study, we have shown that there is a significant and positive mapping between specialization and exports in Spain's Autonomous Communities. In a given industry, specialized regions tend to export relatively more. This result is robust to many different econometric specifications. In comparison, the counterfactual relationship between specialization and imports is negative or not significant, when exports are taken into account.

Specialization explains about 17% of the volume of exports per capita. This outcome is robust and is not driven by a spurious regression. It follows that about 83% of trade volume is determined by other factors than standard Ricardian comparative advantage and the agglomeration of firms. Especially, economic geography represents an important determinant of trade.

While this relation between specialization and exports may seem trivial, it is the first time, to the best of your knowledge, that it is tested at the industry-region level. In fact, by exploiting the panel dimensions of our data, we have showed a convenient way of estimating a trade equation. Some components of trade are essentially determined by regional characteristics (most notably economic geography) and industry characteristics that can be easily estimated through industry and region effects or by demeaning the data in both dimensions. Indeed, with the demeaned variables, specialization alone now explains about 86% of the volume of exports per capita.

Beside this growth investigation, the richness of the *Agencia Estatal de Administración Tributaria*'s trade data opens up all sorts of further empirical research areas. In this paper, we have aggregated the data at the AC regional level and the 2-digit NACE industrial level. But data are available at the province level, at the 8-digit industry classification and for all countries of destination or of origin. One interesting avenue would be to analyze the links between diversity of exports (in terms of the number of products traded) and economic development. Moreover, it should be noted that we have focused on intra-EU trade only. The intensity of the mapping between specialization and trade might be very different if we take into account total world trade - and, in the case of Spain, especially with Latin America. We might expect differences - in resources endowments and productivity levels for instance - to be wider between extra-EU countries and Spain than between European countries. Provided that we have sufficient data on extra-European countries, this issue could also be investigated.

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Appendix 1: Source of data and construction

Table A1: Source of data

Statistics by industry and Autonomous communities	
Trade data (Export and Import)	Agencia Estatal de Administración Tributaria
Employment	INE: Spanish Regional Accounts; INE: Industrial Companies Survey; Eurostat: Regional statistics, Structural business statistics
Value added	INE: Spanish Regional Accounts; INE: Industrial Companies Survey
Number of firms & Salaries and wage payments	INE: Industrial Companies Survey; Eurostat: Regional statistics, Structural business statistics
Statistics by Autonomous communities	
GDP	INE: Spanish Regional Accounts
Deflators (GDP, export and import)	INE: Spanish Regional Accounts; INE: National Accounts
Population	INE: Population figures
Total area (Km^2)	INE: Territory, Physical variables
Total area used for agriculture (Km^2) & Arable land (Km^2)	Eurostat: Regional statistics, Agriculture, Land use
Total internal expenditure in R&D activities	INE, la estadística de I+D en España
European statistics	
Employment & Value added	Groningen Growth and Development Centre, 60-Industry Database, October 2004; Eurostat, national accounts, Breakdown by 31 branches
Salaries and wage payments	Eurostat, national accounts, Breakdown by 31 branches
EU15 GDP and GDP per capita	Eurostat, national accounts, GDP and main components
EU regional NUTS2 GDP	Eurostat, regional statistics, European System of Accounts
Deflators (GDP, Value added export and import)	Groningen Growth and Development Centre, 60-Industry Database, October 2004; Eurostat, national accounts
Intra EU-trade	Eurostat, Comext, Intra – and Extra-EU trade, Annual data, combined Nomenclature

Construction of data

For employment, value added and the number of firms by industry-region, we use a mix of three databases for the employment statistics: INE's *Spanish Regional Accounts*, INE's *Industrial Companies Survey* and Eurostat's *Regional statistics* (*Structural business statistics*). The INE's *Regional Accounts Statistics* suffers from a change in industrial classification in 1995. The 1986-1995 series do not quite follow the NACE Rev.1 classification. Some industries are not really affected by this change, and both series (1986-1995 and 1995-2004) could be simply joined together. But for others, the 1986-1995 series had to be re-constructed or interpolated based on the two other databases which are both compatible with the NACE Rev.1 classification. INE's

Industrial Companies Survey statistics are available at a more refined level of the NACE Rev.1 classification. Taking a conversion table, it is possible to reconstruct the data for the years prior to 1995. However, the conversion is not always perfect. To avoid a level effect in 1995, we interpolate backwards the data prior to 1995, e.g. we take the ratio of the 1995 value over the 1994 value in the actual data and apply this ratio to the 1995 level in the re-constructed series, and so forth for the previous years. The obtained series become comparable throughout the whole period and follow the evolution of the actual data. Unfortunately, it was impossible to reconstruct the data for the Manufacture of wood and wood products, which is excluded from the sample.

Appendix 2: List of sectors and Autonomous Communities

Table A2: List of sectors in the data sample: classification of economic activities

NACE Rev.1.1 (CNAE in Spain)	
A+B	Agriculture, hunting and forestry
CA	Mining and quarrying of energy producing materials
CB	Mining and quarrying, except of energy producing materials
DA	Manufacture of food products, beverages and tobacco
DB+DC	Manufacture of textiles and textile products + Manufacture of leather and leather products
DE	Manufacture of pulp, paper and paper products; publishing and printing
DF	Manufacture of coke, refined petroleum products and nuclear fuel
DG	Manufacture of chemicals, chemical products and man-made fibres
DH	Manufacture of rubber and plastic products
DI	Manufacture of other non-metallic mineral products
DJ	Manufacture of basic metals and fabricated metal products
DK	Manufacture of machinery and equipment n.e.c.
DL	Manufacture of electrical and optical equipment
DM34	Manufacture of motor vehicles, trailers and semi-trailers
DM35	Manufacture of other transport equipment
DN	Manufacturing n.e.c.
E	E Electricity, gas and water supply
K	Real estate, renting and business activities
Sector excluded from the sample:	
DD	Manufacture of wood and wood products

Table A3: List of Autonomous Communities (and abbreviations)

Andalusia	Galicia
Aragon	Madrid
Asturias	Region of Murcia (Murcia)
Cantabria	Comunidad Floral de Navarra (Navarra)
Catalonia	Basque country (P.Vasco)
Castilla y Leon (C.Leon)	La Rioja (Rioja)
Castilla y Mancha (C.Mancha)	Comunidad Valenciana (Valenciana)
Extremadura	