Trade, Growth and Structural Change in Spain's Autonomous Communities

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June 2007

Abstract

In this paper, we examine how the relationship between per capita GDP and trade may depend on the level of specialization or on the extent of structural change undertaken between 1988 and 2003 in Spain's Autonomous Communities. The present study is an extension of Laurin (2007a) where we have tested cointegration between GDP per capital and trade. We follow three empirical strategies. First, we present an in-depth statistical analysis of structural change and industrial specialization in Spain's ACs. The second strategy implies verifying the correlation between the extent of structural change – as defined in the previous analysis- and the strength of the cointegration relationship between growth and trade. Third, we investigate the pattern of cross-correlation between regions emerging from their relationship GDP-Trade. More precisely, the bilateral elements of the variance-covariance matrix estimated by the SURE cointegration tests are regressed on variables expressing economic geography, specialization and the evolution of structural change. This original regression exercise brings further evidence of the links between trade, growth and industrial structure. Overall, this study compiles converging evidence on the importance of structural change for Spain's regional development.

JEL classification: C22-Time-Series Models; C23-Models with Panel Data; F14-Country and Industry Studies of Trade; R11-Regional Economic Activity: Growth, Development, and Changes; O18-Regional, Urban, and Rural Analyses; R12-Size and Spatial Distributions of Regional Economic Activity.

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Aknowledgement: The research presented in this paper was done at the Center for Operation Research and Econometrics (CORE). I would like to thank Jacques Thisse, Dominique Peeters, Pierre-Philippe Combes and Hylke Vandenbussche 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.

What are the effects of international trade and specialization on economic growth? The channels linking trade and economic growth may be numerous: optimal reallocation of factors, economies of scale, greater physical or human capital accumulation, foreign direct investment, increased productivity from foreign competitive pressure, access to cheaper or higher-quality inputs, international transmission of ideas, learning-on-imports, etc. This issue has been the focus of a large corpus of theoretical and empirical investigations. In this paper, we concentrate on the particular role of the specialization process as an essential channel linking trade and growth.

Indeed, in standard trade models, trade is welfare-enhancing through the efficiency gains resulting from specialization, based on comparative advantage or factor abundance. This is however a static welfare gains. The more recent literature on endogenous growth and the "new trade" models emphasize the role of specialization and local external economies (technological externalities, forward and backward industrial linkages, etc.) for increased productivity and growth. Trade liberalization induce and define regional specialization, but then, the specialization process itself can affect economic growth, since firms find a productivity advantage in locating near other producers because of these local external economies. Moreover, a region facing the challenge of globalization must usually sustain major industrial transformations to be able to gain from economic integration, either through the standard process of specialization or, more generally, by enhancing the productivity level of its industrial structure. Only the most productive firms will be capable of being competitive on world markets. Thus, a region must have the economic strength to absorb the shocks of trade liberalization and to develop the capacity to take advantage of world integration. Hence, the relationship between trade and growth may be conditioned by the type and the evolution of the regional industrial structure.

The objective of this paper is to show that the extent of structural transformation in Spain's Autonomous Communities – in term of change in regional industrial specialization – may be related to the strength of the relationship between trade and growth. We focus on the 15 Autonomous Communities (AC) for the period 1988-2004. This period is very important for Spain because it covers a phase of important industrial structural changes which have followed the country's accession to the European Community, especially after the establishment of the European Single Market program in 1992.

To this end, we follow three empirical strategies. First, we undertake an in-depth statistical analysis of structural change and industrial specialization in Spain's ACs. From this analysis, we will be able to define a typology of ACs according to their structural evolution that will show to be very convenient for discussing the links between specialization, trade and growth. The two next strategies build on the results of Laurin (2007a) where we have tested the existence of a relationship between GDP per capital and Exports using several cointegration tests. Building on these panel cointegration results, we want to examine how the relationship between GDP per capita and trade may be conditioned on the level of specialization or on the extent of structural change. Hence, the second strategy implies verifying the correlation between the extent of structural change and the cointegration results. The hypothesis is that the lack of structural change may prevent a given region from fully extracting the expected gains of trade. Indeed, from our illustrative correlation analysis, we do observe that *regions experiencing deeper structural changes tend to display a stronger relation between GDP and trade*.

Third, we also investigate the pattern of cross-correlation between regions emerging from their relationship between GDP per capital and Exports. More precisely, taking the variance-covariance matrix estimated by a SURE cointegration test developed in Laurin (2007a), we examine the determinants of bilateral correlations between ACs. Hence, the cross-correlation elements of the SURE matrix are regressed on variables expressing economic geography, specialization and the evolution of structural change. *Regression results show that economic proximity, similarity in the structural change process and common sectoral specializations are significant determinants of the bilateral correlation between ACs*. Since the correlations are taken from the cointegration estimations between GDP per capita and Exports, this original regression exercise sheds again more light on the links between trade, growth and structural change.

Some empirical papers have already considered the extent of industrial transformation in their study of the effects of trade on growth (Fujita & Hu, 2001; Sun & Parikh, 2003; Balaguer & Cantavella-Jorda, 2004; Weinhold & Rauch, 1997). But the usual measure of structural change is essentially based on the intensity of the manufacturing sector in the economy. In our case, we construct a more refined specialization index - based on regional industrial specialization relatively to the EU - encompassing 17 different sectors, including 5 service sectors (NACE 2-digit industrial classification). In particular, we devise a weighted specialization index taking into account the intensity in value added per worker relatively to the EU level. This is important since structural change should especially imply a shift from the traditional low value added sectors to more advanced high value added sectors. Indeed, the statistical evidence indicates that this is the case for most ACs in Spain.

The paper is organized as follows. First, we discuss the theoretical foundations of the study. We will aim at showing that the specialization process is an important channel linking trade and growth. In section 2, we introduce our regional specialization index which will be used to describe the process of structural change and specialization in Spain's regions. Then, equipped with this specialization index, we can proceed with the implementation of the other two empirical strategies: examining the correlation between the extent of structural change and the cointegration results (Section 3) and explaining the determinants of the cross-correlation pattern between ACs estimated from the cointegration relationship (Section 4). Overall, this paper compiles converging evidence on the importance of structural change for Spain's economic integration into the European market.

1. Conceptual framework

The channels linking trade and economic growth are various and well documented: optimal reallocation of factors, economies of scale, access to cheaper (or higher-quality) inputs, international transmission of ideas, etc. In this section, we focus more particularly on the specialization process, showing that it is one of the main channel linking trade and economic growth. Trade liberalization shapes the regional pattern of specialization, which then induces an effect on the productivity and the competitiveness of the local firms. But in addition to the effects induced by trade flows, the specialization process itself can affect economic growth. To be clear throughout this paper, we define the concept of "specialization" in the following way: 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.

In standard trade models, regions specialize according to comparative advantages in terms of relative productivity levels (Ricardo) or factor abundance (H-O-S), inducing an optimal reallocation of factors across industries. These efficiency gains lead to a decrease in prices and an increase in welfare. Here, the gains from trade are directly and necessarily linked to industrial specialization. However, this process leads to a *level effect* on welfare, but there is usually no effect on the *growth rate* in such trade models.

But, notwithstanding the direct effect of trade, the clustering of firms in a single area can affect economic growth by itself. Marshall (1890, 1892) was one of the first economists to address this question, by observing that firms find an advantage in locating near other producers within the same industry. Two main types of external scale economies can be highlighted:

(1) Technological externalities, e.g. the dissemination of knowledge between the firms in the same area;
(2) Economies linked to the proximity of a great number of specialized suppliers (intermediate goods and services).

The effects of the first type of external scale economies - **technological externalities** - have been developed notably by the endogenous growth models (Romer 1986, 1990). Because of its public good attributes, knowledge undertaken by one firm can flow to other firms in its vicinity. The higher the total level of R&D activities undertaken by firms in a region, the larger the scope for technological spillovers between firms. Hence, the regional stock of "knowledge" can have an effect on a firm's productivity. With trade liberalization, the standard specialization process may alter the inter-sectoral allocation of production factors in a way that could affect the technological intensity of the economy (Rivera-Batiz & Romer, 1991a, 1991b; Grossman & Helpman, 1991, 1995). Assume that the economy of a region is composed of two sectors: a technological-intensive industry and a low-tech traditional sector. If the region happens to specialize in the technological-intensive industry, it will need to extract resources out of the traditional sector. This reallocation of resources stimulates the innovation rate since R&D efforts are undertaken mostly in the technological-intensive industry, increasing the stock of knowledge and the regional growth rate. Therefore, the standard specialization process has also an impact on innovation and on the growth dynamic. Learning-by-doing can have a similar impact on the stock of knowledge (Young, 1991). If the region initially specializes in high and sophisticated technological goods, this will spur more learning-by-doing than for low-tech goods or for goods in which learning-by-doing has exhausted. Unfortunately, the outcome is exactly the opposite for regions specializing in low technological goods. In this respect, contrary to standard models, regions do not necessarily gain unambiguously from trade. Growth rates can diverge between regions and this gap could increase with trade liberalization.

The effects of the second type of external economies (**proximity of a great number of specialized suppliers**) have been developed using the monopolistic competition framework (Dixit & Stiglitz 1977). With monopolistic competition, entry of new firms induces greater product differentiation. Taking the input or intermediate good market, the products become more specialized or more innovative so as to respond more adequately or efficiently to the requirements and needs of end-users (Ethier, 1979, 1982; Rivera-Batiz & Romer, 1991a, 1991b). Therefore, the proximity of a great number of specialized suppliers can enhance the productivity of local firms. These sorts of local economies of scale constitute powerful agglomeration forces that may attract new firms. Specialization of a region into a given sector increases and this dynamic feeds itself into a cumulative causation process that can explain the divergence in growth rates between regions. Note that the region where industry locates will appear as being more specialized for each sectors affected by this agglomeration process. Hence, we get a relationship between specialization and growth.

The New Economic Geography (NEG) models investigate further the links between trade liberalization (decreasing trade costs) and the location of industry (Krugman, 1991; Fujita, Krugman & Venables, 1999). For example, the input-output structure of vertically linked firms in a region can trigger the agglomeration process (Venables, 1996). Because of transport costs and economies of scale, intermediate good producers will seek to locate where there is the largest market for their goods. This should obviously coincide spatially with regions specialized in this sector. This effect is called the *backward linkage* (or demand linkage). Similarly, firms in the final good sector will have a lower cost if they locate where there are relatively many upstream firms, since, by doing do, they minimize trade costs on inputs or intermediate purchases and they also benefit from the richer productive environment created by the proximity of numerous specialized intermediate goods. Final good producers will thus seek to locate where they will find the largest pool of intermediate goods, e.g. again in regions specialized in this sector. This is the *forward linkag*e (or cost linkage). For this paper, the insights of the NEG are threefold. First, it introduces another specialization process (shaped by agglomeration or dispersion forces) which can modify the reallocation of resources between innovative and traditional sectors, or affect growth through local spillovers (Baldwin & Martin, 2004). Second, these agglomeration forces reveal the existence of particular external economies ("pecuniary" externalities, in the words of Krugman, 1991) that increase the competitiveness of local firms in specialized regions. Third, the agglomeration process augments arithmetically the production level of the regions where firms locate. This is a level effect, but because of the *cumulative causation* process of agglomeration, the NEG models might imply a continuous dynamic effect in time, through a series of level increases (or decrease) in regional production[1].

Some studies have already pointed out that the significance of relationship between trade and growth may depend on a threshold in the level of economic development (Balassa, 1985; Moschos, 1989; Sheehey, 1992), as measured by GDP or GDP per capita for example. For countries under that threshold, the relationship between trade and growth does not hold, or even worst, trade has a negative impact on growth. The interpretation is that a country must have a minimum level of industrial capacity to take advantage of world integration. Calderón *et al*. (2001) find that, for a panel of 96 countries, a certain critical mass of exports ("trade openness") may have to be reached before attaining a higher rate of economic growth. Lee & Huang (2002), working on East Asian countries, rely on the export-import ratio as a threshold variable, measuring the degree of export-orientation of a country.

But, based on the previous theoretical review, our hypothesis is that the relationship between trade and growth may also be conditioned on specialization and the extent of structural change. To take advantage of economic integration, a region needs to adapt its industrial structure accordingly. So, instead of relying on some general threshold of economic development, the extent of the specialization process could well be one of the mechanisms governing the relation between trade and growth. Fujita & Hu (2001), working on Chinese provinces, show that growth and trade are more intense in regions where FDI and manufacturing firms concentrate. In Sun & Parikh (2003), the effects of export expansion on growth depend on the regional economic structure, as measured by the share of the manufacturing sector in total production. Weinhold & Rauch (1997) show that specialization has a positive effect on productivity growth, but this effect appears to be significant only for developing countries. For the Spanish case (at the national level), Balaguer & Cantavella-Jorda (2004) find the existence of a cointegration relationship among output, exports and structural change (defined as the share of consumption goods, semi-manufactures and capital goods in total exports). But, in this previous literature, the measure of structural change is essentially based on the intensity of the manufacturing sector in the economy. In our case, we construct a more refined index that encompasses 22 sectors, including 6 service sectors. In addition, our specialization index is defined as a relative measure, using the EU as the benchmark.

2. First empirical strategy: Analysis of regional specialization and structural change

To characterize the relative level of specialization in a given sector, we have constructed the following specialization index (SPEC):

$$\mathrm{SPEC}_{ij} = \frac{\left(\mathrm{EMPij} / \mathrm{EMP}_{iTOT} \right)}{\left(\mathrm{EMP}_{EUj} / \mathrm{EMP}_{EUTOT} \right)} = \frac{\left(\mathrm{share}_{ij}\right)}{\left(\mathrm{share}_{EUj}\right)}$$

corresponding to the employment share of industry *i* in total employment of region *j* divided by the share of this industry in the European Union total employment. Since we are particularly interested in Spain's integration in the European economy, we use the European Union as the benchmark (the EU 15 members-states before enlargement). An index higher than 1 indicates that the region is more specialized in this industry relatively to the EU (inversely if the index is smaller than 1). The SPEC index relates directly to the concept of comparative advantage, which is needed to establish a relationship between trade and specialization. To get a regional indicator characterizing the

[1] At least until the realization of its long-term equilibrium. However, in some NEG models, such a location equilibrium does not always exist.

overall industrial structure, we simply add-up the SPEC index across sectors for each AC. This indicator will be called GSPEC (for General Specialization):

$$\mathrm{GSPEC}_i = \sum_{j=1}^{22} \mathrm{SPEC}_{ij}$$

Since SPEC varies around 1, the summation over all sectors should vary around 22 (the total number of sectors). A higher value indicates that the region's industrial structure is relatively more specialized compared with the EU structure. The word "specialization" is rather abusive here given the level of sectoral decomposition of the data, with only 22 broad sectors[2]. In fact, GSPEC should be seen as a general indicator characterizing the regional industrial structure. Note that the SPEC index is a normalized indicator with respect of the EU benchmark so that it can be compared across sectors. Therefore, we are allowed to sum the SPEC indexes over all industries[3]. This normalization is also convenient because the denominator takes into account industry cycle at the European level. For example, we expect the share of agriculture to gradually decrease with the shift to manufacturing or to the service sector.

Data

We have data on annual GDP, population, exports and imports for Spain's 17 Autonomous Communities. For the trade variables, we use a special database provided by the *Agencia Estatal de Administración Tributaria*, the Spanish custom authorities, from which we can obtain the total annual value of exports and imports by Autonomous Communities, e.g. all trade going to or coming from foreign countries outside Spain[4]. Data on GDP and on population are taken from INE (*Instituto Nacional de Estadística*). To obtain real values, we use GDP, exports and imports deflators available from INE. GDP per capita is simply defined as real GDP divided by population. The trade series are available from 1988 to 2004. We exclude from the sample two Autonomous Communities, the small Islands of Canarias and Baleares, in order to discard influential observations having a negligible economic weight (see Appendix 1 for the list of ACs and abbreviations used).

Data on employment by sector and AC are provided by the INE (*Instituto Nacional de Estadística*) from the *Regional Accounts Statistics*. Employment statistics are available from 1986 to 2003 and follow the NACE Rev. 1 industrial classification at the 2-digit level, for a total of 22 sectors, including 6 service sectors (see Appendix 1 for the list of sectors). The INE's *Regional Accounts Statistics* suffers from a change in the industrial classification in 1995. Hence, for some sectors, the 1986-1995 series had to be re-constructed or interpolated based on two other database: Eurostat's Regional statistics (*Structural business statistics*) and INE's *Industrial Companies Survey*, which are both compatible with the NACE classification. The exact interpolation techniques used to construct the series and to estimate missing values are described more in detail in Appendix 2. European statistics on employment are taken from Eurostat's *national accounts*, completed by a special database constructed by the *Groningen Growth and Development Centre* (60-Industry Database)[5]. The panel is balanced.

Appendix 5 shows some maps of Spain's Autonomous Communities for a selection of indicators. Map 1 indicates the level of GDP per capita by AC. Richer ACs are found in the Northern part of

[2] Genuine growth-enhancing specializations –clusters for example– are observed in much more refined industrial sectors.
[3] The drawback of this normalization is that, in the overall regional economy, the GSPEC indicator tends to overestimate the weight of small sector specializations (and inversely for large sectors). For our purpose, this problem is not too acute since we are looking for an overall account of the specialization process industry by industry, as expressed by the general indicator GSPEC.
[4] Data on intra-Spanish trade between ACs themselves are unfortunately not available.
[5] http://www.ggdc.net.

Spain, particularly those situated at the border with France. Inversely, economic growth (measured by total growth of real GDP between 1986 and 2004) seems to be stronger in the Southern part of Spain, as shown in map 2, which may indicate some sort of convergence effect.

Specialization and structural change

We start this analysis of regional specialization by characterizing the evolution of GSPEC in time. We estimate the trending properties of the series by regressing the log of GSPEC on a trend and a constant for each AC, using OLS. We get an estimated annual growth rate average. Two trends are alternatively used: one covering the whole period (1986-2003) and a trend restricted to the 1993-2003 period. Table 1 presents the trend coefficient results. In the last column, we also give the total growth of GSPEC (in %) between 1988 and 2003. The GSPEC trend is positive (and mostly significant) for all but 4 ACs (Andalusia, Cantabria, Madrid and P.Vasco). For most ACs, the trend is steeper for the 1993-2003 period. Total growth for the whole time sample is positive for all ACs - except the same 4 AC - and substantial for several ACs (C.Leon, C.Mancha, Extremadura, Galicia, Navarra, Rioja), as it can also be shown in map 3 in Appendix 5.

Table 1: Structural change: trend of GSPEC and total growth (1986-2003)

	Trend 1986-2003 (%)	Trend 1993-2003 (%)	Total growth 1986-2003
Andalusia	-0,11%	0,15% **	-2,78%
Aragon	1,05% ***	1,11% ***	15,73%
Asturias	0,29% **	1,01% ***	4,97%
Cantabria	-0,58% ***	-0,13%	-9,55%
Catalonia	0,31% ***	0,52% ***	2,33%
C.Leon	1,30% ***	1,85% ***	25,98%
C.Mancha	1,34% ***	1,58% ***	23,88%
Extremadura	1,89% ***	2,47% ***	29,83%
Galicia	1,47% ***	1,35% ***	28,84%
Madrid	-0,05%	-1,40% ***	-6,73%
Murcia	0,15%	1,18% ***	1,24%
Navarra	1,20% ***	1,32% ***	27,21%
P.Vasco	-0,38% ***	0,12%	-5,21%
Rioja	1,47% ***	2,10% ***	29,12%
Valenciana	0,89% ***	0,75% ***	13,47%

Note: OLS regression of log(GSPEC) on a time trend and a constant. Trend coefficients are expressed in percentage. *=significant at 10%; **=significant at 5%; ***=significant at 1%.

Are Spain's regions getting more specialized relatively to the EU? In fact, this interpretation is erroneous. Clearly, from the construction of the SPEC, a region cannot have a majority of sectors over-specialized (SPEC index higher than 1), or, conversely, a majority of sectors under-specialized (SPEC smaller than 1), since it is calculated using industry shares of total regional employment. Therefore, when summing the SPEC index over all sectors, the value of the general GSPEC indicator should be mostly determined by the number of mid-range industries, e.g. those that have a SPEC index not far from 1. This interpretation is very useful for the analysis of structural change in Spain. In 1986, most of Spain's AC had an industrial structure highly dependent on two or three traditional sectors (agriculture, food and beverage, textiles, etc) – indicated by an SPEC index largely over 1, while the more advanced industries (chemicals, electric and electronic products, etc) and some service sectors (business and telecom notably) where obviously under-developed (SPEC index well below 1). In that case, the GSPEC indicator has a high value because of the overly large value of the SPEC index of these traditional sectors and the overly small SPEC index of all other sectors, indicating the level of industrial under-development relatively to the EU. Structural transformation should imply the passage from an economy based on traditional sectors to more advanced sectors. The development of a larger range of advanced sectors (SPEC rising toward 1) should more than compensate the decline of high-level specializations in some traditional sectors (by construction, a restricted number). In that case, the net effect should be an increase of GSPEC. Therefore, the evolution of GSPEC can be viewed as an indicator of the extent of structural change in the ACs.

For a more comprehensive examination of the series' trending properties, we apply the Perron Broken Trend Stationary methodology (Perron, 1989) which consists of estimating the following model:

(1) $$\Delta GSPEC_{it} = \beta_{i1} + \beta_{i2}T + \beta_{i3}TDU_{Ti} + \alpha_{i1}GSPEC_{it-1} + \alpha_{i2}\Delta GSPEC_{it-1} + e_{it}$$

where: $\Delta GSPEC_{it}$ = logarithm of first-difference of GSPEC;
T = a time trend;
T_i = year of break;
$TDU_{Ti} = t - T_i$ if $t > T_i$, 0 otherwise;
e_{it} is an i.i.d. error term.

TDU_{Ti} is a dummy variable representing a change in the slope of the trend. We are looking for some statistically significant "events" in the trend of GSPEC over the annual observation range 1989-2002[6]. The optimal break point is chosen by selecting the year having the highest *t*-statistic (the largess negative value) associated with the time dummy TDU_{Ti} for each AC. Results are shown in Table 2.

Table 2: The Perron Broken Trend Stationary methodology
Variable: GSPEC (in log)

	General Trend		**Optimal trend change**			**Total effect**	**Evolution of GSPEC**
	Coef	***t*-stat**	**Coef**	***t*-stat**	**Year**		
Andalusia	-0.0112	-2.51 **	0.012	2.69**	1990	0,14%	GSPEC start rising from 1990 (mildly)
Aragon	0.0079	3.21 ***	-	-	-	0,79%	Constant positive trend
Asturias	-0.0055	-1.64	0.011	2.21**	1993	0,58%	GSPEC start rising from 1993 (mildly)
Cantabria	-0.0082	-2.07 *	0.006	1.64	1993	-0,16%	GSPEC decreases (faster from 1993)
Catalonia	-0.0039	-1.07	0.008	1.70	1991	0,49%	GSPEC start rising from 1991
C.Leon	0.0064	2.55 **	0.008	2.27**	1995	1,51%	Constant increase (faster from 1995)
C.Mancha	0.0128	4.96 ***	0.011	3.63***	1993	2,46%	Constant increase (faster from 1993)
Extremadura	0.0126	4.65 ***	0.013	2.17**	1996	2,56%	Constant increase (faster from 1996)
Galicia	0.0296	3.37 ***	-0.017	-2.33**	1990	1,26%	Constant increase (slower from 1990)
Madrid	0.0098	2.33 **	-0.017	-2.68**	1994	-0,72%	No clear pattern.
Murcia	-0.0116	-2.89 **	0.024	3.60***	1994	1,31%	GSPEC start rising from 1994
Navarra	0.0079	2.71 **	-	-	-	0,79%	Constant positive trend
P.Vasco	-0.0117	-3.62 ***	0.013	3.83***	1994	0,22%	First decrease, then mild increase from 1994
Rioja	0.0077	2.97 ***	0.014	3.27***	1995	2,26%	Constant increase (faster from 1995)
Valenciana	0.0103	3.43 ***	-0.005	-2.89**	1997	0,53%	Constant increase (mildly slower from 1997)

Note: The total effect is equal to the summation of the two trend coefficients. The Optimal trend change is identified by taking the year with the highest *t*-student associated with the trend change coefficient. *=significant at 10%; **=significant at 5%; ***=significant at 1%.

The first panel gives the general trend coefficient (β_{i2}) and the second panel indicate the trend change coefficient (β_{i3}). The majority of ACs has a positive trend change somewhere around 1993. For Aragon and Navarra, the change in trend is insignificant, so it is dropped in the regression. One interesting observation is that Laurin (2007a) also find a break in the export series around 1993. This might be a first indication of the links between both variables. In Table 2, we also compute the total value of the trend after 1993 (in %) by summing the two trend coefficients (general trend plus trend change). All ACs, except Cantabria and Madrid, have a positive total trend after 1993. Four AC are lagging in term of structural change, having a negative general trend that is not (or weakly) reversed after 1993: Andalusia, Cantabria, Madrid and P.Vasco. In the last column of Table 2, we summarize the evolution of GSPEC based on the trend analysis and on

[6] Breaks at the each end of the time sample are hard to significantly identify.

graphical observations from Figure 1 (see page 111) that illustrates the GSPEC index for each AC over the period 1986-2003. For most of Spain's ACs, the GSPEC indicator has a clear upward trend, at least from 1993 onward. This trending pattern of GSPEC is a very special feature of Spain's development. As show by Laurin (2003) for European regions, regional specialization may follow very different evolutions in time[7]: stationary evolution, U-shaped, random walks, etc.

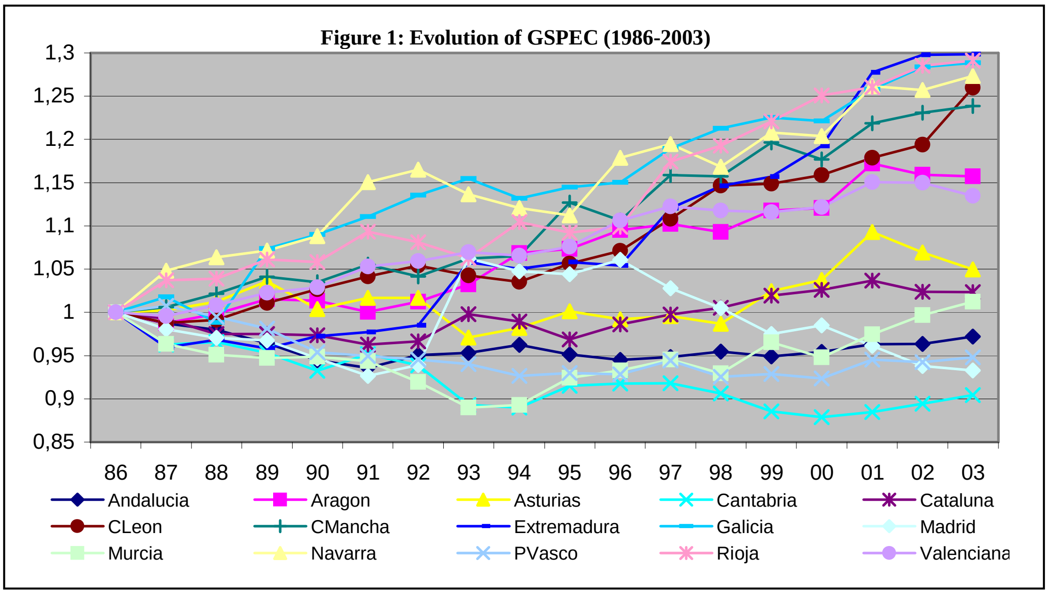


Table 3: Structural change - Mean growth rates of GSPEC, GSPEC-INF and GSPEC-SUP (1986-2003 and 1993-2003)

	GSPEC Mean Growth		GSPEC-INF Mean Growth		GSPEC-SUP Mean Growth	
	86-03	**93-03**	**86-03**	**93-03**	**86-03**	**93-03**
Andalusia	-0,16%	0,21%	0,71%	0,94%	-0,75%	-0,33%
Aragon	0,88%	1,24%	1,07%	1,09%	0,71%	1,43%
Asturias	0,31%	0,33%	0,81%	0,56%	0,03%	0,22%
Cantabria	-0,57%	-0,32%	-0,06%	-0,03%	-0,93%	-0,51%
Catalonia	0,14%	0,53%	0,02%	0,63%	0,30%	0,45%
C.Leon	1,38%	1,65%	0,96%	1,06%	1,67%	2,05%
C.Mancha	1,29%	1,62%	2,09%	2,88%	0,82%	0,88%
Extremadura	1,59%	2,58%	0,32%	1,77%	2,09%	2,89%
Galicia	1,53%	1,17%	2,27%	1,98%	1,15%	0,73%
Madrid	-0,35%	0,03%	-0,04%	0,57%	-0,51%	-0,29%
Murcia	0,10%	0,90%	1,04%	1,62%	-0,45%	0,47%
Navarra	1,46%	0,84%	2,93%	3,08%	0,62%	-0,45%
P.Vasco	-0,31%	0,03%	-0,52%	-0,80%	-0,13%	0,72%
Rioja	1,54%	1,65%	2,22%	1,36%	1,24%	1,85%
Valenciana	0,75%	0,63%	0,38%	0,10%	1,02%	1,01%

Moreover, this positive trending pattern of GSPEC shows the broad industrial transformation the ACs underwent between 1986 and 2003. Indeed, in a majority of cases, this increase in specialization is not caused by a growing dependence on the traditional sectors or by the emergence of some new "specializations", but rather by the development of a larger range of sectors. To see this, we decompose the evolution of GSPEC into two components for each AC.

[7] On the question of the distribution of economic activities in the European Union, see also Midelfart-Knarvik *et al*. (2002), WIFO (1999) and the review of literature of Combes & Overman (2004).

GSPEC-INF is the annual average of SPEC for the 15 sectors having the lowest SPEC values (usually lower or close to 1), and SPEC-SUP is the annual average of SPEC of the other 7 sectors (usually higher or close to 1). The mean growth rates of the two components are given in Table 3. We can observe that in most AC, the mean growth rate of GSPEC-INF is higher (or decreasing less) than for GSPEC-SUP. Again, for some ACs, this is the case only after 1993. Numerically, this indicates that there are a higher number of sectors for which SPEC is increasing toward 1, so that the overall GSPEC indicator is rising. The reduction of over-specialization in the traditional sectors is more than compensated by the development of a larger range of sectors. The industrial structure is thus more evenly distributed across sectors.

In order to provide further insights on this process of industrial diversification, we compute the well-known Krugman specialization index (Krugman, 1991), called the K-SPEC index:

$$\mathrm{K-SPEC_i} = \sum_{j=1}^{18} \mathrm{abs}(\mathrm{share_{ij}} - \mathrm{share_{EU-j}})$$

The K-SPEC proposes a slightly different perspective from our GSPEC index. It measures the degree of similarity of the regional structure relatively to the EU structure. The lower the K-SPEC index, the closer the regional structure is to the EU benchmark. We show in Table 4 the value of the K-SPEC index in 1986 and in 2003, the total growth (in %) level (1986-2003) and the estimated trend (in %). Looking at the estimated trend, the K-SPEC index is decreasing in all ACs, except Murcia and Andalusia. For some ACs, total reduction in percentage between 1988 and 2003 is strong (Galicia, Navarra, Asturias, Cantabria). The regional industrial structures tend to converge towards to EU structure. Paluzie *et al.*(2001) also found that overall specialization in Spain has decreased in most Spanish provinces from 1979 to 1992. At the EU regional level, Molle (1996) and Hallet (2000) confirm that the industrial structure of the European regions tends to become increasingly similar.

Table 4: K-SPEC index

	1986	**2003**	**Growth** (%)	**Trend** (%)
Andalusia	0,399	0,420	5,32%	0,03%
Aragon	0,307	0,236	-22,96%	-0,29%
Asturias	0,544	0,335	-38,38%	-1,24%
Cantabria	0,408	0,275	-32,59%	-0,79%
Catalonia	0,198	0,177	-10,33%	-0,43%
C.Leon	0,443	0,398	-10,04%	-0,34%
C.Mancha	0,537	0,453	-15,65%	-0,19%
Extremadura	0,575	0,529	-7,97%	-0,45%
Galicia	0,745	0,434	-41,70%	-1,24%
Madrid	0,374	0,329	-11,89%	-0,50%
Murcia	0,367	0,366	-0,24%	0,15%
Navarra	0,666	0,399	-40,05%	-1,67%
P.Vasco	0,354	0,320	-9,54%	-0,05%
Rioja	0,552	0,495	-10,23%	-0,16%
Valenciana	0,322	0,319	-0,98%	-0,10%

Note: trend estimated by OLS with a constant.

Table 5 lists the 25 highest specialization levels by industry-region, measured by the SPEC index, at the beginning and at the end of our time sample (average SPEC 1986-1989 and 2000-2003). The highest specialization levels in 1986 are found in the traditional sectors (agriculture, extraction and mining, textiles, food products and beverages), but large “over-specialization” in traditional sectors tend to decrease in most regions. Still, in 2003, the traditional sectors still maintain a big weight in some regions.

Table 5: Highest SPEC specialization level

Average 1986-1989	**Average 2000-2003**

CAA	Sector	SPEC	CAA	Sector	SPEC
Galicia	Agriculture, fishing, forestry	4,352	Navarra	Motor vehicles	4,290
Rioja	Textiles, leather	3,742	Galicia	Agriculture, fishing, forestry	3,656
Navarra	Agriculture, fishing, forestry	3,703	Rioja	Textiles, leather	3,466
PVasco	Basic metals, metal products	3,552	Extremadura	Agriculture, fishing, forestry	3,418
Extremadura	Agriculture, fishing, forestry	3,345	P.Vasco	Basic metals, metal products	3,398
Cantabria	Mining and quarrying	3,160	Valenciana	Other non-metallic mineral products	3,221
Navarra	Mining and quarrying	2,892	Valenciana	Textiles, leather	2,954
Galicia	Mining and quarrying	2,886	Galicia	Mining and quarrying	2,885
CMancha	Agriculture, fishing, forestry	2,781	C.Leon	Mining and quarrying	2,823
PVasco	Rubber and plastic products	2,728	C.Mancha	Textiles, leather	2,633
CLeon	Agriculture, fishing, forestry	2,701	C.Mancha	Agriculture, fishing, forestry	2,615
Andalucia	Mining and quarrying	2,639	Rioja	Food products, beverages, tobacco	2,595
Murcia	Mining and quarrying	2,554	Extremadura	Mining and quarrying	2,590
Cataluna	Textiles, leather	2,303	Aragon	Motor vehicles	2,581
Murcia	Manu. coke, ref. petroleum prod.	2,277	C.Leon	Agriculture, fishing, forestry	2,532
Valenciana	Other manufacturing industries	2,268	Murcia	Agriculture, fishing, forestry	2,521
Asturias	Agriculture, fishing, forestry	2,240	Andalusia	Agriculture, fishing, forestry	2,385
PVasco	Other transport equipment	2,180	Galicia	Other transport equipment	2,335
Rioja	Other manufacturing industries	2,176	P.Vasco	Other transport equipment	2,310
CLeon	Mining and quarrying	2,173	Asturias	Mining and quarrying	2,256
Andalucia	Agriculture, fishing, forestry	2,149	Rioja	Rubber and plastic products	2,256
Cantabria	Agriculture, fishing, forestry	2,135	Catalonia	Textiles, leather	2,216
Asturias	Manu. coke, ref. petroleum prod.	2,066	P.Vasco	Rubber and plastic products	2,212
Valenciana	Other non-metallic mineral prod.	2,065	Murcia	Mining and quarrying	2,205
Asturias	Basic metals, metal products	2,040	Cantabria	Mining and quarrying	2,147

Nevertheless, Spain has benefited from the development of some more advanced sectors. By choosing an illustrative list of the 7 advanced sectors (chemicals, rubber and plastic products, machinery and equipment, electrical and optical equipment, motor vehicles, trailers and semi-trailers, other transport equipment and financial intermediation), Table 6 indicates the evolution of these advanced sectors in the regional structures. The first column computes how many of these 7 sectors have an increasing SPEC index. The next column specifies the number of these increasing sectors that had initially a SPEC value less than 1 in 1986, e.g. sectors evolving toward 1. In the large majority of the advanced sectors, we have a growing specialization reflecting their expansion in the region's industrial structure from a state of underdevelopment relatively to the EU. Only Cantabria and Madrid do not seem to share this pattern of development. On the other hand, as shown in maps 11, 12, 13 and 14, specializations in the advanced sectors are still in 2003 spatially concentrated in the North Eastern part of Spain, e.g. close to France. Inversely, as already observed in map 6, the spatial distribution of specialization in agriculture, fishery and forestry offers almost the photo-negative of the advanced sectors' maps, being concentrated in the South-Western part of the country.

Table 6: Number of advanced sectors growing in SPEC (seven sectors)

	Nb of increasing SPEC (/ 7)	Of which SPEC less than 1 in 1986
Andalusia	4 /7	4 /4
Aragon	5 /7	4 /5
Asturias	6 /7	5 /6
Cantabria	2 /7	2 /2
Catalonia	5 /7	3 /5
C.Leon	5 /7	4 /5
C.Mancha	6 /7	5 /6
Extremadura	6 /7	6 /6
Galicia	7 /7	6 /7
Madrid	2 /7	2 /2
Murcia	4 /7	4 /4
Navarra	6 /7	5 /6
P.Vasco	4 /7	3 /4
Rioja	6 /7	5 /6
Valenciana	3 /7	3 /3

From the ranking of Table 5, we can highlight four main specializations in Spain: (1) the mining, quarrying, metal products and metallurgic sector; (2) the textile sector, (3) the agriculture and food products; (4) the transport equipment sector (including motor vehicles, automobiles)[8]. In the maps of Appendix 5, we show the spatial pattern of specialization for a selection of industries, taking the average SPEC value between 2000 and 2003. The darker shades – indicating a higher SPEC index – are seen more often in traditional industries (maps 6, 7, 8) than for other sectors (maps 11, 12, 13, 14). Specialization in agriculture, fishery and forestry products (map 6) is a common feature of all ACs, except the three most developed ACs (Madrid, Cataluna and P. Vasco). Specialization in food and beverage products (map 7) - which tends to more or less follow specialization in agriculture - is probably related to the mutation of agricultural activities into more value added food processing. Geography plays also a role: ACs situated on the northern border of Spain (Galicia, Asturias, Cantabria, Navarra, Aragon), which is rich in minerals and metals, are heavily specialized in extraction and mining (map 9). Some Northern borders ACs are also specialized in metal and mineral products industry (map 9), which tend to be close to the location of the primary resources. This is the case for the Basque country, situated around metal or mineral producing regions.

A typology of structural change

The SPEC index is calculated with employment data. Data on value added would have been more appropriate for the calculation of specialization indexes. Failing reliable data on value added at the industry level, we construct a GSPEC indicator weighted by the EU level of productivity in each sector. More precisely, we calculate the EU value added per employee (VAP), a proxy for productivity, for each sector. Then, as weights, we take the ratio of sectoral VAP on total EU VAP, so that the sum of weights equals 1:

$$\mathrm{weight}_{jt} = \frac{\left(\mathrm{VA}_{jt-EU} / \mathrm{EMP}_{jt-EU}\right)}{\sum_j \left(\mathrm{VA}_{jt-EU} / \mathrm{EMP}_{jt-EU}\right)}$$

for $j = 1,\ldots,22$ sectors and $t = 1,\ldots, 16$ years. The weights vary across sectors, but also in time. The idea is to take into account the level and the evolution of the EU productivity level in each industry. The weighted GSPEC – called GSPEC-VAP - is then simply the weighted sum of SPEC across sectors:

$$\mathrm{GSPEC\text{-}VAP}_{it} = \sum_{j=1}^{22} \left[\mathrm{weigth}_{jt} \times \mathrm{SPEC}_{ijt}\right]$$

We compare in Table 7 the trending evolution of GSPEC compared with GSPEC-VAP, using again estimated trends. We indicate the ratio of the two trend coefficients (GSPEC-VAP over GSPEC) to show instantly the degree of divergence between the indexes. To understand the interpretation of this weighted indicator, we define 4 types of regions in Table 7 (and as illustrated in map 5, Appendix 5):

Type 1: *GSPEC-VAP is decreasing*. These regions are getting less specialized in increasing or higher-productivity sectors. This situation generally indicates some sort of de-industrialization not compensated by the development of other productivity-enhanced sectors.

Table 7: Growth of GSPEC and GSPEC-VAP (Trend of the indicator**)**

	Trend 1986-2003	Trend 1993-2003

[8] After 1986, Spain has been a major recipient of foreign direct investments in the automobile (notably from French carmakers) and in the aircraft industry (thanks to the development of suppliers affiliated to the Airbus consortium).

		GSPEC	GSPEC-VAP	Ratio	GSPEC	GSPEC-VAP	Ratio
Type 1: Decreasing GSPEC-VAP							
GSPEC and GSPEC-VAP decrease	Cantabria	-0,58%	-0,78%	1,34	-0,13%	-0,49%	3,77
	Madrid	-0,05%	-0,41%	8,20	-1,40%	-2,01%	1,44
GSPEC increases but GSPEC-VAP decreases	Andalusia	-0,11%	-0,40%	3,64	0,15%	-0,37%	-2,47
	P.Vasco	-0,38%	-0,83%	2,18	0,12%	-0,44%	-3,67
Type 2 "East Coast": lower structural change and GSPEC increases more rapidly than GSPEC-VAP							
	Catalonia	0,31%	0,07%	0,23	0,52%	0,29%	0,56
	Valenciana	0,89%	0,38%	0,43	0,75%	0,34%	0,45
Type 3: higher structural change and similar trends							
	Aragon	1,05%	0,92%	0,88	1,11%	0,87%	0,78
	C.Mancha	1,34%	0,97%	0,72	1,58%	0,97%	0,61
	Extremadura	1,89%	1,88%	0,99	2,47%	2,17%	0,88
	Galicia	1,47%	1,56%	1,06	1,35%	1,02%	0,76
	Rioja	1,47%	1,32%	0,90	2,10%	1,84%	0,88
Only from 1993(Type 3-93)	Asturias	0,29%	0,02%	0,07	1,01%	0,90%	0,89
	Murcia	0,15%	-0,65%	-4,33	1,18%	0,75%	0,64
Type 4 "Car producers": GSPEC-VAP increases more rapidly than GSPEC							
	C.Leon	1,30%	1,98%	1,52	1,85%	2,35%	1,27
	Navarra	1,20%	1,70%	1,42	1,32%	1,88%	1,42

Note: Ratio of trends GSPEC-VAP trend over GSPEC. Trends estimated by OLS in logs with a constant.

The Basque country is a good example. This region was one of the most industrialized regions in Spain in 1986. But this region was subject to a strong de-industrialization period (particularly in the heavy industries) not fully compensated by the development of other high-productivity sectors. This region is losing ground in term of productivity-intensity of its industrial structure relatively to the EU. Note that Madrid's actual productivity situation, as a region-capital centered on services, may be underestimated by our methodology[9].

Type 2: *GSPEC is increasing more rapidly than GSPEC-VAP*. We find in this case Catalonia and Valenciana, two neighbour regions situated on the East Coast of Spain. These regions are evolving towards a low-productivity industrial structure relatively to the EU, which might not be necessarily a desirable situation from an economic development perspective, except if these specializations are grounded on a true productivity-driven comparative advantage[10].

Type 3: *Both indicators are evolving in more or less the same way*: these regional structures are shifting from traditional to more advanced sectors. Their industrial structure tends to follow the European productivity structure. This is the case for a majority of ACs. For Murcia and Asturias, the evolution of both indicators becomes much more similar only from 1993 onward.

Type 4: *GSPEC-VAP increases more rapidly than GSPEC*. These regions are getting more specialized particularly in higher-productivity sectors. But in truth, this situation is an artefact of the transport equipment industry. C.Leon and Navarra are the two most specialized ACs in this sector. The growing weight of the transport equipment industry – a high productivity sector - is sufficient to explain the steeper trend of GSPEC-VAP.

[9] The city is mostly specialized in services, but the productivity weights associated with the 6 service sectors are not especially high. However, it is well known that the service sector has a vital role for the urban economic development.

[10] In the case of Catalonia, we believe that this region is producing value added and high productivity products in these traditional industries (food and beverage, textiles).

Of course, the actual productivity levels in each region do not necessarily follow the EU levels. For example, the specialization may be driven by a higher regional productivity relatively to the EU, which is the idea behind the comparative advantage model. But, the constructed weighted index still offers an interesting portrait of the evolution of regional industrial structures. But more importantly, the classification of Table 7 will show to be useful in analysing the links between growth, trade and specialization in the next section. For that matter, two important points must be highlighted: (i) The GSPEC is upward trending (at least from 1993) in all but 4 regions; (ii) In almost all cases where GSPEC is increasing, structural change implies an expansion of more advanced sectors, reflecting the extent of industrial structural change in Spain's ACs.

3. Second empirical strategy: Structural change as a threshold

In a companion paper (Laurin, 2007a), we have investigated the existence of a long-run relationship between per capita GDP and trade variables (exports, imports and total trade), for the 15 Spanish Autonomous Communities between 1988 and 2004, using several cointegration tests. Building on these results, we examine in this section how the relationship between GDP per capita and exports (the cointegration results) can be conditioned on the level of specialization or on the extent of structural change[11].

We will focus in particular on the results of two cointegration tests extracted from (Laurin, 2007a): the **Augmented Dickey-Fuller** (ADD) test (Dickey & Fuller 1979, 1981) and the **SURE panel ADF cointegration tests** based on Taylor & Sarno (1998). Both tests are based on the two-step Engel-Granger residual-based cointegration methodology (Engle & Granger, 1987). The first step is to estimate by OLS the relationship between GDP per capita and exports (in real terms and in log):

(2) $\log(\text{GDP per capita}_{it}) = \alpha_i + \beta_i \log(\text{Exports}_{it}) + e_{it}$

where the index *i* denotes Autonomous Community and index *t* denotes the sample period (T=17). If the series are cointegrated, the residuals e_{it} from this regression should be stationary. Therefore, the second step involves taking a unit root test on the predicted residuals $\hat{e}_{it}$. If $\hat{e}_{it}$ has a unit root, then equation (2) is not a cointegrating relationship. The ADF unit root test is based on the following equation:

(3) $\Delta\, \hat{e}_{it} = \alpha i + \rho_i\, \hat{e}_{it-1} + \text{lags}(\Delta\, \hat{e}_{it-j})_i + u_{it}$

The null hypothesis of no cointegration implies that $\rho_i = 0$, e.g. there is a unit root in the residual series. The lag structure corrects for serial correlation[12]. The ADF *t*-statistic corresponds to the *t*-student of the ρ_i coefficient. MacKinnon (1991) has computed the appropriate critical values for the residual-based Engel-Granger ADF cointegration test for any sample size T.

The ADF procedure computes a test value for each AC individually. But the ACs, being regions of a same country, are not independent from each other. Hence, we devise a **SURE-ADF cointegration tests**. The methodology consists of estimating the ADF residual-based equation (3) as a system of N=15 equations (one equation for each AC), using Zellner's (1962) seemingly unrelated estimator (SURE), which takes into account the contemporaneous correlation among the

[11] In the working paper version of this study, we have tried to insert the GSPEC series directly into the cointegration equation. However, this reduces the time sample to T=16 from an already small sample. Second, the additon of GSPEC in the relationship does not change the significance of the cointegration tests between GDP per capita and exports. In fact, we show that exports and GSPEC might share some common trends, so that GSPEC does not bring much more explanatory power.

[12] We are constrained to a maximum of 2 lags because of the shortness of the time period. The lag length is selected by the general-to-specific approach (Hall, 1994; Campbell & Perron, 1991), subsequently deleting insignificant lags (at 10%) from two lags to none.

disturbances u_{it} (hence the cross-correlation between regions). Laurin (2007a) computes the appropriate confidence intervals using a sieve bootstrap.

The results of both ADF and ADF-SURE tests are presented in Table 8 for each AC, in order of their estimated ρ coefficient. The cointegration test is insignificant in nearly all regions, but interestingly, the ranking of ρ coefficients follows almost perfectly the typology of ACs presented in section 2 (Table 7)[13]. The upper ranking corresponds to all type-3 regions (except Catalonia and Madrid), for which structural change tends to follow the EU productivity structure (GSPEC-VAP and GSPEC are evolving in more or less the same way). Below the last type-3 region (Aragon), we find Valenciana, the type-1 regions and the two automobile-producing type-4 regions (Navarra and C.Leon). For the SURE estimates, we get a similar ranking. The low cointegration results for C.Leon and Navarra might be largely driven by the high variability of the automobile sector, which explains respectively 50% and 45% of annual regional export variability, the highest level of all sectors-regions.

Table 8: ADF and SURE cointegration test for the relation GDP per capita-Exports
(in order of the coefficient value)

ADF cointegration results				SURE cointegration results			
Type	**Region**	**ρ coef**	**t-stat**	**Type**	**Region**	**ρ coef**	**t-stat**
Type 3 - 93	Murcia	-0,805	-5,05***	Type 3	Rioja	-0,736	-17,12***
Type 3 - 93	Asturias	-0,784	-3,15	Type 3	Galicia	-0,705	-8,50
Type 3	Rioja	-0,665	-3,70*	Type 3 - 93	Asturias	-0,676	-7,55
Type 3	Galicia	-0,637	-2,55	Type 3	Extremadura	-0,662	-8,12
« East Coast »	Catalonia	-0,581	-3,89	« East Coast »	Catalonia	-0,596	-8,52
Type 3	Extremadura	-0,529	-2,44	Type 3 - 93	Murcia	-0,554	-13,7**
Type 3	C.Mancha	-0,413	-2,11**	Type 3	Aragon	-0,481	-6,89
Capital-City	Madrid	-0,354	-2,20	Capital-City	Madrid	-0,385	-5,96
Type 3	Aragon	-0,339	-2,33	Type 3	C.Mancha	-0,373	-5,93
« East Coast »	Valenciana	-0,331	-3,04	« East Coast »	Valenciana	-0,366	-5,45
Type 1	Andalusia	-0,321	-2,13	Type 1	P.Vasco	-0,247	-4,12
Type 1	Cantabria	-0,269	-2,19	Type 1	Cantabria	-0,242	-5,39
"Auto"	C.Leon	-0,197	-1,42	"Auto"	C.Leon	-0,229	-3,85
Type 1	P.Vasco	-0,167	-1,07	"Auto"	Navarra	-0,212	-3,53
"Auto"	Navarra	-0,164	-0,99	Type 1	Andalusia	-0,198	-3,07

The *t*-statistics are taken from the Engle-Granger ADF cointegration tests between GDP per capita and Exports in log. Significance based on the critical values estimated by MacKinnon (1991). *=significant at 10%; **=significant at 5%; ***=significant at 1%.

The ranking of the ρ coefficients in Table 9 seems to coincide with our categorization of regions, but this result would not be very informative if there is actually no significant difference between the coefficients of the four types of regions. In Appendix 4, the existence of significant differences in the SURE ρ coefficients across types of ACs is confirmed.

As a comparison, in Table 9, the ACs are ordered by real GDP level and GDP per capital in 1988 and 2003, along with their respective ADF cointegration *t*-stat (from Table 8). In the two last lines, we provide the correlation coefficient and rank correlation between the GDP figures and the ADF *t*-stats. If the level of economic development acts as a threshold variable in the relationship between growth and exports, we would expect a positive correlation between GDP and the cointegration statistic in absolute value. The correlation and rank correlation are close to zero for

[13] One may wonder about the usefulness of analysing cointegration results that do not appear to be significant. A distinction must be made between significance of the ρ coefficient and significance of the cointegration test. In all tests, except for one ore two individual cases, the ρ coefficient is significantly different from zero by the standard *t*-student distribution. But, based on the distribution of each cointegration test in small sample, the *t*-statistics are not sufficiently high to accept the hypothesis of cointegration. Hence, the rejection of the cointegration hypothesis does not necessarily imply that the ρ coefficient is not significantly different than zero. The ρ coefficient measures the rate of convergence back to equilibrium. In our case, the ρ coefficient offers some indication of the relative evolution of exports relatively to GDP (or vice-versa), particularly after the break in the relationship around 1993.

GDP. Both more developed regions, such as Madrid and P.Vasco, and poorer ones, such as Navarra and Cantabria, have low *t*-stats. If GDP per capita is used instead, the correlation coefficients are higher, but negative! Note also in map 4 (appendix 5) that there is no clear spatial distribution for the cointegration ADF *t*-stats.

Table 9: Coefficient and rank correlation between level of economic development and individual ADF cointegration *t*-statistics (in order of GDP 2003)

	***t*-test**	**Real GDP 2003** (millions of euros)	**Real GDP 1988** (millions of euros)	**GDP per capita 2003** (euros)	**GDP per capita 1988** (euros)
Catalonia	-3,89	106 527	67 722	15 260	11 143
Madrid	-2,20	101 970	63 638	17 079	12 971
Andalusia	-2,13	81 795	50 592	10 334	7 283
Valenciana	-3,04	56 732	36 015	12 199	9 450
P.Vasco	-1,07	37 458	25 122	17 197	11 653
C.Leon	-1,42	33 392	23 658	13 043	9 079
Galicia	-2,55	31 552	21 827	11 135	7 563
C.Mancha	-2,11 **	20 402	13 800	10 804	8 171
Aragon	-2,33	18 300	12 316	14 270	10 317
Murcia	-5,05 ***	14 377	8 678	10 792	8 379
Asturias	-3,15	12 847	9 699	11 726	8 635
Extremadura	-2,44	10 425	6 658	9 431	6 057
Navarra	-0,99	10 241	6 582	16 942	12 641
Cantabria	-2,19	7 362	4 932	12 892	9 305
Rioja	-3,70 *	4 393	2 524	14 543	9 573
Correlation		**0,0431**	**0,0287**	**-0,3424**	**-0,2702**
Rank correlation		**0,0696**	**0,0357**	**-0,2643**	**-0,175**

Instead of using GDP statistics, we now investigate the correlation between the evolution of specialization and the cointegration results, taking the trends of GSPEC estimated previously (Table 1). In Table 10, we give the coefficient and rank correlation between the coefficients of the trends (for both periods 1986-2003 and 1993-2000) and the cointegration results (*t*-stats and ρ coefficients in absolute value). Following our hypothesis, a region experiencing rapid structural transformations should display a stronger relationship between growth and trade. The correlation coefficients are indeed positive, especially when we consider structural change undertaken from 1993 onwards. The correlations are much higher without C.Leon and Navarra, the two automobile-producing regions.

Table 10: Correlation between structural change and cointegration results

Correlation with trend 1986-2003	**ADF** coef.	**ADF** *t*-stat	**SURE** coef.	**SURE** *t*-stat
Correlation coefficient	0,149	0,037	0,417	0,248
Rank correlation	0,285	0,118	0,467	0,368
Without Navarra and C.Leon				
Correlation coefficient	0,349	0,134	0,652	0,403
Rank correlation	0,688	0,569	0,499	0,293

Correlation with trend 1993-2003	**ADF** coef.	**ADF** *t*-stat	**SURE** coef.	**SURE** *t*-stat
Correlation coefficient	0,301	0,132	0,428	0,382
Rank correlation	0,293	0,092	0,438	0,407
Without Navarra and C.Leon				
Correlation coefficient	0,511	0,316	0,648	0,489
Rank correlation	0,697	0,599	0,539	0,299

Note: trends taken from Table 1. Cointegration results taken from Table 8.

This correlation analysis strengthens the hypothesis of a close relationship between trade, growth and structural change. Admittedly, these observations remain purely illustrative, and unfortunately, with only 15 regional units, it will be difficult to advance further towards the identification of a significant threshold effect.

4. Third empirical strategy: The determinants of regional cross-correlation

In this next section, we study the determinants of the cross-correlation pattern between ACs to further illustrate the effects of structural change and specialization on this relationship. The hypothesis is that the correlation between regions in their relationship between growth and trade may depend on their similarity in terms of industrial structure, specialization and the extent of structural change. The cross-correlation pattern is estimated by the variance-covariance matrix estimated from the SURE ADF cointegration test presented previously. Taking the residual-based ADF equation (3), this variance-covariance matrix is simply defined by:

$$E\left(u'_{it}, u_{jt}\right) \qquad \text{for i,j = 1,…, 15 Autonomous Communities.}$$

Hence, the off-diagonal elements of this matrix give the cross-correlation between equations, e.g. between regions. Note that the residual-based equation estimates the data generating process of the equilibrium residual between GDP per capita and exports. It follows that the cross-correlation pattern expresses the similarity across regions in the disequilibrium/convergence process relating GDP per capita and the trade variable, since the residual e_{it} in equation (3) measures the estimated disequilibrium between the series. Table A3 (Appendix 3) shows the variance-covariance matrix calculated from the SURE cointegration test.

Statistical facts about the pattern of cross-correlations

Looking closely at the variance-covariance matrix, we first identify groups of regions sharing a high cross-correlation between them and then try to characterize these groups in terms of structural change, specialization and geographical distance. The reader is also referred to some geographical maps, all printed in Appendix 5. In Table 11, we show the average value of cross-correlations between different types of regions. The ACs having a low ρ coefficient (bottom of SURE ranking in Table 9, under C.Mancha) all share a very high cross-correlation between them. Excluding Navarra and C.Leon (the “Auto” type), the group average correlation is 0.522. The cross-correlations between “Auto” regions and other low ranking regions are quite low, while their own bilateral correlation is high (0,639). This confirms that the low cointegration results for these two ACs come from a different structural process. The other ACs (top of SURE ranking) do not show such a strong cross-correlation pattern between them. The group average correlation is only 0.294.

However, specialization and geography might also explain the correlation between the regions. In Table 11, we also focus on the correlation pattern between regions sharing a high specialization in the four main specialization sectors identified in section 2: the mining, quarrying, metal products and metallurgic sector, the textile sector, the agriculture and food products sector and the automobile sector. We have already discussed the case of the automobile producing regions. Map 14 indicates the spatial concentration in the Motor vehicles industry in Spain. Navarra’s only high bilateral correlation is with C.Leon. For C.Leon, high correlations are observed also with Aragon (specialized as well in the automobile industry) and two neighbor regions (Cantabria, C.Mancha). Next, we can also groups the northern ACs at the frontier of the Pyreneans: Asturias, Cantabria, Galicia and P.Vasco. These four regions are highly cross-correlated together (average correlation: 0,614). Besides their geographic closeness, one characteristic linking these regions is the specialization in mining and in the related sector of metals and metallurgy, as we can see from Table 11, and in maps 8 and 9. Related to this group are neighboring regions of C.Leon and Aragon, also specialized in these sectors. In addition, we could also include Catalonia, Spain's most important AC in term of GDP and which presents the highest bilateral correlations with the northern border ACs.

Table 11: Cross-correlation and Specialization index in a selection of industries – Average SPEC (2000-2003)

Average cross correlation by ranking of SURE cointegration results
Total average correlation: 0,346
ACs with low ρ coefficient (without C.Leon and Navarra): 0,523
ACs with higher ρ coefficient: 0,294

Group Transport equipment: average correlation: 0.346				**Group Northern AC (mining, quarrying and metallurgic sector)** average correlation: 0,614 (Asturias, Cantabria, Galicia, P.Vasco)					
Motor vehicles, trailers and semi-trailers		**Other transport equipment**		**Mining and quarrying**		**Basic metals, metal products**		**Average of both sectors**	
Navarra	4,306	PVasco	2,369	Asturias	10,262	P.Vasco	3,398	Asturias	2,173

Aragon	2,581	Galicia	2,274	C.Leon	4,062	Navarra	2,048	C.Leon	2,113
CLeon	1,644			Galicia	1,700	Asturias	2,008	P.Vasco	1,326
Cataluna	1,366			Extremadura	1,543	Cantabria	1,732	Cantabria	1,307
Galicia	1,301			Aragon	1,342	Rioja	1,336	Aragon	1,280
				Cantabria	1,206	Catalonia	1,176	Galicia	1,255
				Murcia	1,166				

Group Agriculture/ Food industries average correlation: 0,416						**Group Textile** average correlation: 0,448	
Agriculture		**Food and beverage products**		**Average of both sectors**		**Textile products**	
Galicia	3,490	Rioja	2,607	Rioja	2,352	Rioja	3,585
Extremadura	3,488	Navarra	1,762	Extremadura	2,332	Valenciana	2,965
C.Mancha	2,593	Murcia	1,752	Galicia	2,275	C.Mancha	2,626
Murcia	2,509	C.Leon	1,539	Murcia	2,131	Catalonia	2,203
Andalusia	2,504	C.Mancha	1,415	C.Mancha	2,004	Aragon	1,336
C.Leon	2,452	Cantabria	1,252	C.Leon	1,996	Galicia	1,282
Rioja	2,098	Extremadura	1,176	Andalusia	1,708	Murcia	1,142
Asturias	1,830	Catalonia	1,090	Navarra	1,600		
Aragon	1,686			Cantabria	1,420		

We can further define in Table 11 a third group composed of the regions specialized in agriculture and in food/beverage products: Andalusia, Rioja, Extremadura, Murcia and C.Mancha (group average correlation: 0.416). Maps 6, 7 and 10 illustrate the spatial distribution of the agriculture, the food/beverage and the textile industry across ACs. Looking at the textile industry ranking in Table 11, it so happens that we recover almost the same ACs (except Valenciana) than in the food/beverage products ranking.

Cross-correlation regression exercise

We now proceed to an original regression exercise to identify more formally the determinants of bilateral correlations between ACs. In Laurin (2007b), we have computed the SURE cointegration test (described in section 3) for three relationships: GDP per capita-Exports, GDP per capita-Imports, and Exports-Imports. Each relationship is related to a (15x15) SURE variance-covariance matrix, e.g. 15x15=225 elements. The variance-covariance matrix being symmetric, we can leave out the observations in the upper triangular matrix. Since we are interested in pair-wise correlations, we also exclude the diagonal elements of the matrix (the region's own variance). This leaves 105 observations by matrix (225 observations minus 15 diagonal elements, minus upper diagonal elements = 105 observations). Then, the elements of each matrix are stacked into a single (1 x 315) vector of pair-wise correlations (105 elements x 3 matrix = 315 observations). Hence, the dependent variable corresponds to the estimates of the cross-correlation existing between regions, e.g. across the residual-based equations (equation 3) in the SURE system.

The objective is to regress these bilateral correlations on different determinants explaining the pattern of correlation across regions in their relation between GDP and trade. As determinants, we define variables reflecting the various concepts and empirical findings discussed so far throughout this study. First, we have highlighted the important role of geography. Notably, ACs tend to be correlated to neighbours, provided that their industrial structure is not too much dissimilar.

Geography will be taken into account by two variables.

> FRONTIER is a dummy equal to one if the two regions share a common border, and zero otherwise.
>
> DIST is the inverse of square root distance separating the two regions.

Distance is defined as the amount of road kilometres needed to join the capital city of each AC, as obtained from the Internet Route planer *Via Michelin*. 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[14]. The farther the partner region, the lower should be the pair-wise correlation, since space matters for the transmission of economic effects. Hence, for the inversed distance value DIST and for FRONTIER, we expect a positive coefficient. With the introduction of these two variables as determinants of the cross-correlation pattern, the estimation procedure becomes analogous to a spatial autocorrelation analysis where the weighting matrix is the distance or contiguity between regions, but in the time-series dimension[15].

In the spirit of the gravity models of trade, the volume of transactions (trade or other types of economic, financial or social transactions) between two regions should be proportional to their combined economic weight[16]. Regions having a higher GDP level should have a greater impact on other regions. And we should observe stronger economic relations between richer regions than poorer ones. To measure this gravity effect, we take the product of GDPs between the two regions (labelled GDPG, for GDP "Gravity"). Regions may also be economically linked by the intensity of migration flows occurring between them. For example, business and social networks can develop between two regions through the people migrating from one region to the other (Rauch, 2001; Combes *et al*. 2003) To measure this phenomenon, we take the sum of domestic migration flows between any pair of ACs from 1997 to 2004 (MIGRATION). Intra-Spanish domestic migration flows between ACs are taken from *INE*'s Residential Variations Statistics. The coefficients of GDPG and MIGRATION should be positive.

Geography and mobility are not the only factors linking regions together. Our assumption is that the relationship between GDP and trade should be influenced by structural change. In section 3, we have seen that the cointegration results seem to follow our typology of ACs according to the type of structural change. The GSPEC index increases in all but four ACs. But, from Table 7, the discriminating factor was the type of structural change; e.g. the shift from an industrial structure based on traditional industries to the development of more advanced sectors. Hence, we devise the following bilateral index of structural change (CHANGE):

$$\mathrm{CHANGE}_{ik} = \mathrm{abs}\left[\frac{\mathrm{growthGSPEC_i}}{\mathrm{growthGSPEC-VAP_i}} - \frac{\mathrm{growthGSPEC_k}}{\mathrm{growthGSPEC-VAP_k}}\right] \quad \text{for } i, k = 1, \ldots, 15; \quad i \neq k$$

where *i* and *k* are the index of two different regions. CHANGE is thus the absolute difference between regions in the ratio of growth of GSPEC (between 1986 an 2003) over growth of GSPEC-VAP. This variable indicates the similarity between regions in the value added intensity of structural change (relatively to the EU productivity level). We expect a negative coefficient for CHANGE: two regions having a different type of structural change should be less correlated. Alternatively, following our typology in Table 7, we construct a qualitative variable (TYPE) defined as:

$\mathrm{TYPE}_i = 1$ if i = Cantabria, Madrid, Andalusia, P.Vasco (Type 1 regions)
$\mathrm{TYPE}_i = 2$ if i = Catalonia, Valenciana (Type 2 regions, "East Coast" regions)
$\mathrm{TYPE}_i = 3$ if i = Aragon, C.Mancha, Extremadura, Galicia, Rioja (type 3 regions)
$\mathrm{TYPE}_i = 4$ if i = Asturias, Murcia (type 3-93 regions)
$\mathrm{TYPE}_i = 5$ if i = Navarra, C.Leon (type 4 regions, "automobile producers")

---

[14] For example, most Spanish goods hauled to the rest of Europe must cross the Pyrenees. There are two main crossing points for trucks, at each end of the Pyrenees: one in the West end (San Sebastian) and the other in the East end (Girona). So, being geographically close to France does not lead necessarily to a lower hauling route since the trucks must first make a more or less long detour to join these crossing points before getting in France.

[15] Contrary to Moran's spatial autocorrelation statistic for example, we investigate each pair-wise cross-correlation, using directly distance and contiguity as determinants, instead of taking a weighted average of the residuals, in cross-section, for a given period in time.

[16] As a matter of fact, it is unfortunate that data on intra-national trade flows between ACs are unavailable.

Then, to express the similarity in the structural change process, we simply compute the absolute difference in TYPE:

$$DEVTYPE_{ik} = abs(TYPE_i - TYPE_k)$$

In addition, structural change can be partly captured by the evolution of the agriculture sector. In 1986, most ACs where highly specialized in this sector relatively to the EU. Development into other sectors should imply that the share of the agriculture sector decreases in time. The variable DEVAGRI takes the absolute difference of the ratio of the employment share in agriculture in 1986 over the share in 2003:

$$DEVAGRI_{ik} = abs\left[\frac{shareAGRI86_i}{shareAGRI03_i} - \frac{shareAGRI86_k}{shareAGRI03_k}\right]$$

Similarity between regions in their relationship between trade and GDP does not depend only on structural change, but also on the specialization sectors of each AC. Therefore, to measure the difference in regional industrial structures, we compute the absolute difference between the SPEC index of the two regions for a selection of sectors:

$$\text{Sectoral difference}_{ij} = abs(SPEC_{ij} - SPEC_{kj})$$

Where *j* is the industry index. For the SPEC level, we use the initial average value over the years 1986 to 1990. We have also tried taking the average over the 4 last years (2000-2003), but it appears that the initial SPEC levels are more significant in the regressions. In fact, the initial specialization pattern is a good indication for characterizing the type of structural change that will follow. We choose to concentrate on the following groups of sectors:

AGRI: Agriculture, hunting and forestry
MINING: Mining of energy producing materials + other mining and quarrying
AUTO: Automobile industry
FOOD-TEXTILE: Food and beverage industry + textile industry
ADVANCE: chemical/rubber/plastic products + metallic mineral/basic metals/fabricated metal products + electrical/optical equipment.

These sectors are selected because they seem to be the main Spanish specializations identified earlier. Also, recall that the regions specializing in the food industry tend to be also specialized in the textile industry. We also observe a high correlation between the sectoral differences of the chemical, the metal-mineral and the electrical/optical sectors. These sectors are more advanced value-added industries relatively to traditional sectors. Hence, we have combined these sectors into one group labelled ADVANCE.

Finally, we compute the absolute difference of the GSPEC index (average value 1999-2004) between any two regions (DEVGSPEC). The greater the dissimilarities between regions (the greater the absolute difference), the lower should be the cross-correlation. We thus expect a negative coefficient for all industrial structure differences.
The estimation results are presented in Table 20. The first regression (1) includes only geographic and gravity variables. The product of bilateral GDPs (GDPG) is positive, as expected, and significant in all regressions. FRONTIER is also positive and significant. However, distance (DIST) has the wrong sign, but this variable is not significant at all and we have already observed that the cointegration test between GDP and exports does not seem to follow a clear spatial pattern (map 4). In the second regression (2), the variables characterizing the regional industrial structure are added. Both variables measuring differences in the process of structural change (CHANGE, DEVAGRI) have the expected negative sign and are significant, but differences in actual GSPEC level are not significant. The actual level of specialization does not say anything about the

productivity structure of the region. In regression (3), we use DEVTYPE instead of CHANGE. Similarly, the coefficient of DEVTYPE is negative and significant. CHANGE, DEVAGRI and DEVTYPE may be more instructive to characterize growth-enhancing structural change.

In regression (4), we take into account the industrial structure using the sectoral differences. Confirming the previous statistical observations, the textile/food, the mining and the automobile industries are significant determinants of the cross-correlation pattern. AGRI and MODERN have the wrong sign, but their coefficients are insignificant. For a robustness check, a fixed-effect for each 3 matrix is added in regression (5) and this does not affect the results. Finally, the MIGRATION variable is added in regression (6). This variable is highly correlated with the product of bilateral GDPs (GDPG), so we omit the latter in specification (6). MIGRATION has a positive and significant coefficient: the intensity of migration flows between ACs constitutes a channel by which economic effects may be transmitted.

Table 18: Regression results (OLS)
Dependent variable: bilateral cross-correlations

	Geo/gravity	**Structural change**	**Structural change**	**Industrial structure**	**Fixed effects**	**Migration**
	(1)	(2)	(3)	(4)	(5)	(6)
GDPG	0.667*** (3.97)	0.790*** (4.89)	0.496*** (2.82)	0.473*** (2.70)	0.616*** (4.22)	-
DIST	-1.314 (-1.21)	-1.724 (-1.61)	-1.19 (-1.14)	-1.00 (-0.85)	-1.52 (-1.32)	-2.26* (-1.91)
FRONTIER	0.076* (1.89)	0.066* (1.64)	0.077* (1.83)	0.066 (1.47)	0.077* (1.82)	0.073* (1.73)
CHANGE	-	-0.047* (-2.85)	-	-	-0.037** (-2.37)	-0.039** (-2.29)
DEVAGRI	-	-0.282* (-1.87)	-0.310** (-1.98)	-	-	-
DEVGSPEC	-	-0.005 (-0.77)	-0.004 (-0.63)	-	-	-
DEVTYPE	-	-	-0.029** (-2.51)	-	-	-
AGRI	-	-	-	0.011 (0.07)	0.015 (0.11)	-0.007 (-0.05)
FOOD-TEXTILE	-	-	-	-0.037** (-2.55)	-0.032** (-2.15)	-0.032** (-2.13)
MINING	-	-	-	-0.006* (-1.75)	-0.004 (-1.26)	-0.005 (-1.38)
AUTO	-	-	-	-0.080*** (-3.07)	-0.084*** (-3.31)	-0.084*** (-3.30)
MODERN	-	-	-	.019 (1.39)	0.017 (1.31)	0.023* (1.68)
MIGRATION	-	-	-	-	-	5.34e-07** (2.53)
Constant	0.280*** (5.54)	0.402*** (6.15)	0.416*** (6.07)	0.378*** (6.28)	-	-
F-test (*p*-value)						
Matrix fixed-effect	-	-	-	-	27.90*** (0.000)	33.05*** (0.000)
R2	0.046	0.082	0.076	0.105	0.183	0.168
Nb obs	315	315	315	315	315	315

Note: OLS regressions. White heteroscedasticity standard errors. *=significant at 10%; **=significant at 5%; ***=significant at 1%.

These results show that bilateral correlations between the ACs, in their relationship between growth and trade, are mostly determined by economic geography, but also on similarity in the type and evolution of the regional industrial structure. This finding is important since it brings further evidence of the links between trade, growth and industrial structure.

Conclusion

In this paper, we have tried to show how regional specialization and structural change affects the relationship between trade and economic growth. We have implemented three empirical strategies to enlighten this issue. First, we have shown that the changing pattern of industrial specialization in Spain's Autonomous Communities involved a process structural change by which over-specialization in traditional sectors was being replaced by the expansion of more advanced sectors (in terms of value-added or productivity).

Second, we have investigated the correlation between the extent of structural change and the cointegration results for the relationship GDP per capita and exports. The cointegration ADF *t*-stat, the SURE *t*-stat and the convergence coefficient ρ (in absolute value) tend to be higher for regions undergoing a more extensive process of structural change, particularly in terms of value added relatively to the European Union. Hence, the extent of structural change may be a threshold variable conditioning the relationship between trade and growth.

Third, taking the variance-covariance matrix estimated by the SURE cointegration test, we have examined the determinants of the cross-correlation pattern between the ACs in their cointegration relationship between GDP and exports. We have shown that this regional cross-correlation depends on economic geography, on the extent of structural change and on similarities in the industrial structure (sectoral specializations). This original analysis brings further evidence of the importance of structural change and specialization to explain the strength of the relationship between GDP per capita and trade.

Admittedly, we have mostly relied on a set of converging evidence to show the links between growth, trade and structural change. First, the cointegration methodology is difficult to implement in a small sample. Also, to model growth using both trade and structural change as determinants is a tricky issue. Trade and structural change are likely to be highly correlated in any regression specification determining the growth rate. For example, in our case, our index of structural change did not add much additional explanatory power to the cointegration equation between GDP and Exports. Finally, with only 15 regional units, it is difficult to test the existence of a structural change threshold in a formal and robust way; we would need much more counterfactual cross-units. We only hope that future research will be able to rely on more extensive regional trade data for other European countries.

Appendix 1: List of sectors and Autonomous Communities

Table A1: 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 A2: 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	

Appendix 2: construction of data

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: Eurostat's *Structural business statistics* and INE's *Industrial Companies Survey*, which both are 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: we take the ratio of the 1995 value over the 1994 value in the reconstructed data, and apply this ratio to the 1995 level in the actual data, 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. This sector is excluded from the sample. Accordingly, for the computation of the SPEC index, the sectoral share is obtained using the regional total for only available sectors.

Appendix 3: Variance-covariance matrix

Table A3: Variance-covariance matrix estimated by SURE for the relationship between GDP per capita and Exports

	Anda.	Aragon	Asturias	Cantabria	Catalonia.	C.Leon	C.Mancha	Extrem.	Galicia	Madrid	Murcia	Navarra	P.Vasco	Rioja
Aragon	0,305													
Asturias	0,492	0,274												
Cantabria	0,520	0,159	0,658											
Catalonia	0,497	0,220	0,698	0,727										
C.Leon	0,191	0,520	0,347	0,569	0,497									
C.Mancha	0,572	0,588	0,547	0,686	0,548	0,423								
Extremadura	0,421	0,302	0,146	0,393	0,473	0,382	0,464							
Galicia	0,360	0,342	0,564	0,619	0,592	0,261	0,733	0,403						
Madrid	0,593	0,353	0,514	0,656	0,609	0,573	0,469	0,575	0,462					
Murcia	0,415	0,547	-0,080	0,068	0,139	0,138	0,609	0,403	0,294	-0,040				
Navarra	0,157	0,258	-0,014	0,313	0,103	0,639	0,239	0,229	-0,097	0,353	0,305			
P.Vasco	0,502	0,439	0,688	0,610	0,551	0,308	0,579	0,433	0,436	0,642	0,041	0,128		
Rioja	0,176	0,294	-0,183	-0,345	-0,159	-0,262	0,150	0,451	-0,048	-0,217	0,507	-0,258	0,168	

Valenciana	0,506	0,414	0,246	0,265	0,172	0,088	0,422	0,457	0,451	0,671	0,088	-0,035	0,568	0,208

Appendix 4: Homogeneity tests

In Table A4, we test for the existence of significant differences in the SURE ρ coefficients across types of ACs, using an F-test. Madrid and Catalonia – as special cases – are excluded from the tests. First, equality of coefficients is tested between the ACs of the same type. For type 1, 2, 3-93 (Murcia and Asturias) and 4, the F-test rejects any differences in their coefficients within types. On the other hand, differences between the coefficients of the type 3 regions are significant, but this is a larger group. We can now compare the coefficients across types. From Table 8, notice that C.Mancha is the lower bound ranking AC within the type 3 regions. The types 1 and 4 are all ranked below C.Mancha. Hence, to test the homogeneity hypothesis across group, in the lower panel of Table A4, we compare the coefficient of C.Mancha with the coefficient of the top-ranking AC in type 1 (P.Vasco) and in type 4 (Navarra). The F-test confirms the existence of a significant difference between these two types and the type 3 regions. Based on these homogeneity tests, we re-estimate the SURE system, but restricting the coefficients of type 1, of type 4 and of type 3-93 regions to be equal within each type. The coefficients of all other ACs are kept unrestricted. The left panel of Table A4 give the SURE results. Then, we compare the restricted coefficient of type 1 and type 4 with C.Mancha, which still appears at the lower-end of type 3 regions. The F-tests are all significant: there is a significant difference between these types of regions. There is also a significant difference between the group 3-93 Murcia-Asturias and the type 1 regions.

Table A4: F-test for significant difference between coefficients

Unrestricted SURE-Homogeneity test		
Homogeneity test within groups		
Group	**F-test**	***p*-value**
Type 1	0.40	0.8201
Type 4 "Auto"	0.08	0.7797
Type 3	35.72	0.0000
Type 3 – 93	1.68	0.1951
Comparison with C.Mancha		
P.Vasco vs C.Mancha	2.84	0.0918
Navarra vs C.Mancha	3.91	0.0479

Restricted SURE (coefficient restricted by types of ACs)					
	SURE Estimates			**Homogeneity test**	
Region	**Coefficient**	***t*-stat**		**F-test**	***p*-value**
Type 4 "Auto"	-0,236	-5,13	**vs C.Mancha**	4.44	0.0351
Type 1	-0,270	-8,11	**vs C.Mancha**	4.52	0.0335
Type 3-93	-0,637	-15,83	**Type 3-93**		
Extremadura	-0,715	-8,03	**vs type 1**	48.18	0.0000
Rioja	-0,712	-19,11			
	-0,669	-9,57			
Catalonia	-0,647	-9,02			
Madrid	-0,451	-8,78			
Aragon	-0,440	-7,41			
C.Mancha	-0,405	-6,64			
Valenciana	-0,382	-7,13			

Appendix 5: Maps of Spain's Autonomous Communities: selected statistics

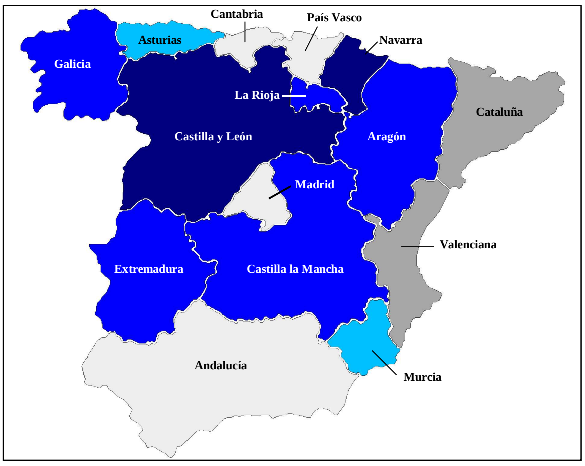
Map 1: GDP per capita in 2004

Map 2: Total growth of GDP between 1986 and 2004

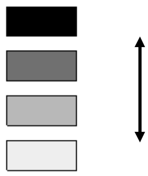
Map 3: Average growth of GSPEC (estimated trend), 1988-2003

Map 4: ADF t-statistic for the relationship GDP per capita - Exports

Map 5: Autonomous Communities by types of structural change (from Table 9)



Legend Maps 1 to 4

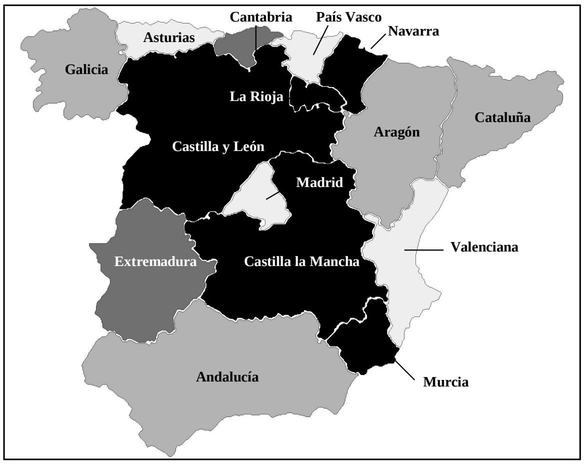


Legend Map 5

- Type 1: Decreasing GSPEC-VAP
- Type 2: "East Coast"
- Type 3-93 (only after 1993)
- Type 3: strong structural change
- Type 4: "Car producers"

Map 6: SPEC index for Agriculture, fishery and forestry products

Map 7: SPEC index for Manufacture of food products, beverages and tobacco



Map 8: SPEC index for Extraction and Mining industry

Map 9: SPEC index for Manufacture of basic metals and fabricated metal products

Map 10: SPEC index for Manufacture of textiles and textile products & leather and leather products

Legend

- Very high specialization (over 1.60)
- High specialization (over 1.15)
- EU average (between 0.85 and 1.15)
- Under-specialization (under 0.85)

Map 11: SPEC index for Manufacture of chemicals, chemical products and man-made fibres

Map12: SPEC index for Manufacture of machinery and equipment n.e.c.

Map 13: SPEC index for Manufacture of electrical and optical equipment

Map 14: SPEC index for Manufacture of motor vehicles, trailers and semi-trailers & other transport equipment

Legend

Very high specialization (over 1.60)

High specialization (over 1.15)

EU average (between 0.85 and 1.15)

Under-specialization (under 0.85)

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