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Provincial Convergence In Spain: A Spatial Econometric Analysis[*]

José Villaverde Castro*

*Professor of Economics, University of Cantabria (Spain). E-mail: villavej@unican.es

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Abstract: This paper examines the process of provincial convergence that has taken place in Spain between 1985 and 2002. By taking labour productivity as its variable of analysis, the paper estimates the so-called “classical” models of convergence, concluding that, contrary to what has been suggested by previous work, convergence has not stagnated. After stressing the limitations of this type of approach, the paper attempts to overcome them, by, on the one hand, estimating the density function and the degree of internal mobility in the provincial productivity distribution; and on the other, by considering the influence of possible spatial effects on the aforementioned distribution. The conclusion arrived at is three-fold: we confirm the existence of provincial convergence of productivity; we reveal the low level of intradistributional mobility; and we do indeed find spatial effects, although they do not seem to be too relevant for the convergence process.

JEL Classification: R12, C49, O47

Key words: convergence, productivity, provinces, spatial effects, distribution.

1. Introduction

Regional economists and, in particular, macroeconomists have been recently interested in territorial convergence for more than a decade, since the topic was again taken up for economic analysis in the late 1980s and early 1990s and used as a test bank for discriminating between competing growth theories: neo-classical models versus endogenous growth models. There have been a large number of empirical studies on the phenomenon of spatial convergence, and although it is frequently considered that the rate of convergence (wherever it occurs) is approximately 2% annually, the results are not conclusive. In the Spanish case, most research carried out to date has taken the autonomous region as its unit of analysis, with relatively few looking at convergence at the provincial level[1]. Moreover, practically none of these studies has attempted to accurately evaluate the influence of space on the convergence process, something which can also be said for research using other scopes of reference[2].

Despite this relative lack of attention for the spatial phenomenon, one of the stylised facts of regional analysis is that economic activity tends to concentrate in certain areas[3], with obvious examples in the European case being the so-called "hot banana", and in Spain, the "Mediterranean arch"[4]. The existence of these corridors or axes of growth underlines the fact that space undoubtedly matters[5]. Space plays a significant role in the process of economic growth and convergence, since, for instance, the probability to reach a higher state of economic development is greater for poor areas surrounded by richer areas than for poor areas surrounded by poor areas.

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[1] Among the pioneering work on provincial convergence since the early 1990s – which generally revealed that the convergence process had slowed (or stagnated) in the second part of the 1980s– we might mention Dolado, González Páramo and Roldán (1994), García Greciano, Raymond and Villaverde (1995), Villaverde (1996) and Villaverde and Sánchez-Robles (1998). More recent work of interest includes, among others, Goerlich and Mas (2001).

[2] In these cases, the units of analysis tend to be either European regions (see, for example, López Bazo *et al.*, 1999; Villaverde (2003) and Villaverde and Maza, 2003, among others) or US states (Rey and Montouri, 1999).

[3] One of the aims of the "new economic geography" is trying to explain industrial location and, in particular, why firms often cluster together provoking substantial agglomeration or concentration effects.

[4] The "hot banana" comprises the area from the South East of England to Northern Italy, containing Southern Germany, South East of France, the Ruhr area, the Ile de France and the Benelux. The "Mediterranean arch" is made up of the Mediterranean provinces of Gerona, Barcelona, Tarragona, Castellón, Valencia, Alicante, Murcia and Almería.

[5] The "manufacturing belt" in the USA is another example of these agglomeration effects.

This being so, it is a fact, however, that the traditional approach to convergence do not in general take spatial characteristics of the distribution into account, since it treat their objects of study (geographical units such as states, regions, provinces, etc.) as if they were absolutely independent from each other. This implies, logically, that this type of analysis has some important limitations, a fact which becomes particularly clear in estimations of σ and β-convergence. As we considered that empirical models developed to analyse real convergence should include the possibility of spatial effects, this study attempts to some extent to get round this problem, as well as some others common to what Sala-i-Martín (1996) calls the "classical approach to convergence". With this in mind, our analysis is focused on the distribution of labour productivity[6] in the 50 Spanish provinces[7], for the sample period that goes from 1985 to 2002.

The paper is structured as follows. In Section 2, following the aforementioned classical approach, we carry out a convergence analysis, with the aim of determining the existence or otherwise of β and σ convergence. In the next section, and in view of the limitations of this type of approach, we attempt to overcome it by analysing the distribution of the provincial productivity in more detail. Initially, our interest is devoted to the overall shape characteristics of the provincial productivity distribution and its evolution over time. Afterwards, we are interested in elucidating the internal mixing or rank mobility that occurs within this distribution over time. Subsequently, in Section 4, we examine the possible presence of spatial dependence in the provincial productivity distribution, for which we undertake both an exploratory data analysis and –employing a strategy based on the modelling of spatial dependence- a confirmatory one. Finally, the last section presents our main conclusions.

2. Provincial productivity convergence in Spain: the classical approach

[6] Labour productivity was calculated, in real terms (constant 1986 pesetas), as the quotient of GDP and employment, using for both variables series from FUNCAS (Spanish Savings Banks Foundation). With regards the GDP – and given the changes introduced in the SEC-95 methodology – we had to link the 1985-1999 series (at factor prices) with the 1995-2002 series (at basic prices). For employment, we should mention a jump in 1995 as a consequence of changes in the EPA (Spanish labour force survey).

[7] From a political-territorial perspective Spain is organised, since 1978, in 17 regions (called "autonomous communities") which are made up of 50 provinces (See Fig. 1 and the Annex).

Most of the empirical studies on territorial convergence take per capita GDP as variable of reference; less frequently, productivity is used. It is important to remember, however, that from a theoretical point of view, economic growth models – particularly those with neoclassical roots, on which the hypothesis of β-convergence is based[8]– refer exclusively to productivity. As Paci (1997), points out, only in the case of full employment, and under the assumption that the relation between population and employment remains constant over time and is equal for all the territorial units considered, is it irrelevant whether the analysis is carried out with per capita GDP or productivity. In practice, however, it is virtually impossible to fulfil these assumptions, which means that the results obtained in the convergence analyses naturally differ depending on whether the variable under study is per capita GDP or labour productivity. A slightly extreme example of this situation is seen for the sample period (1985-2002) for the case of Spain compared to the European Union (EU): as we can see in Figure 2, there is a process of convergence of per capita GDP at the same time as one of divergence in terms of productivity[9]. Faced with a situation such as this, caused by an obvious divergence in the ratio of employment to population between Spain and the EU, and taking into consideration what we have said about the choice of the dependent variable in neoclassical growth models, we have opted to take labour productivity as our variable of reference. This variable, at the national level, experienced an accumulated growth of almost 26%, which represents an annual average rate of 1.3%.

With regards the empirical question, there are two measures of convergence habitually used in regional analysis: β and σ -convergence[10]. Applied to our case, the first (β-convergence) occurs when provinces with lower initial levels of productivity tend to grow, on average, faster than those with higher initial levels and eventually catch up with them; the second (σ -convergence), which is a more restrictive concept of

[8] In the neoclassical growth models, economic growth is driven by factor (capital and labour) accumulation and technical progress, which is assumed to be endogenous. In this type of models convergence occurs due to diminishing returns to capital; this means that policy actions to correct income or productivity differentials are viewed as unnecessary.
[9] The figure makes use of data from the publication “Summary of Indicators” from the Bank of Spain; the GDP is expressed in purchasing power parities.
[10] A detailed account of the most commonly used convergence indicators is provided by Villaverde (2004). Generally speaking, β-convergence has been more popular with macroeconomists while σ-convergence has been mainly the focus of regional economists.

convergence[11], is seen when the cross-sectional dispersion of the provincial productivity diminishes over time.

Our starting point consists of estimating an equation of absolute β-convergence, as follows:

$$\frac{1}{T}\mathrm{Log}\left(\frac{Y_{i,02}}{Y_{i,85}}\right) = \alpha + \beta\ \mathrm{Log}\left(Y_{i,85}\right) + u_i \qquad (1)$$

where $Y_{i,t}$ is the labour productivity of province i in year t, T is the number of years of the sample and u the error term. In accordance with conventional analysis, if the coefficient β is negative and statistically significant, we can conclude that absolute β-convergence exists. The results obtained, shown in Table 1, allow us to say that between 1985 and 2002 there was a process of absolute β-convergence in labour productivity between the Spanish provinces. This process of convergence –explained by the regression in more than 66%– occurred at a rate of 1.9% per year, which implies that the time required for the provinces to close half of the productivity gap between their initial values and their steady state is 21.9 years[12]. Considering that the majority of provinces with low productivity are found in the south of the country, we re-estimated the previous equation introducing a dummy variable to control for their lower level of development[13]; although the dummy is in fact significant, its low value (the coefficient is equal to 0.0015) leads us in fact to ignore it when we consider the spatial influence later on.

With the existence of β-convergence confirmed, Figure 3 shows the results for σ-convergence, calculated as the coefficient of variation of the logarithm of productivity.

[11] It is widely known that β-convergence is a necessary but not sufficient condition for σ-convergence. The presence of σ-convergence implies not only that β <0, but also that -1< β <0.

[12] The rate of convergence is calculated using the expression: -Log(1+ β T)/T. In turn, the expression used to calculate the time required to close half the gap separating the productivity of the provinces from their corresponding steady state is: τ = -Log(2)/ Log (1+β) .

[13] This is the case of "conditional" β – convergence, in which a set of variables is introduced in equation (1) conditioning the steady state of each province. In a somewhat arbitrary way, the provinces included in our"south" dummy variable are all the provinces of Andalusia and Extremadura, along with Murcia, Alicante, Ciudad Real, Toledo, Cuenca and Albacete.

As can be seen, throughout the time period under study, the dispersion in the provincial distribution of productivity has diminished, and at an extremely fast rate: the drop in the coefficient of variation between 1985 and 2002 was no less than 41.6%, which implies an annual rate of convergence of 3.2%, clearly superior to that estimated by the β-convergence.

Having confirmed the presence of both types of convergence, an important question from the socio-economic perspective –but which, nevertheless, is rarely given much attention– is the way in which this convergence has occurred. In our case, the process has taken place as a consequence of an increasing concentration of production and employment in the provinces that initially had the highest levels of productivity; and correlatively, of a reduction in the participation, in both variables, of the provinces that were least efficient (least productive) in the base year. Logically, for convergence to have occurred the process of concentration has been more intense in employment than in production (see Table 2).

3. Provincial productivity in Spain: distributional dynamics

Although it does illustrate some important features of the provincial distribution of productivity in Spain, the analysis of the previous section does suffer from some significant limitations: in particular, as various authors have pointed out –see, especially, Quah, 1993, 1996a and 1996b– the "classical approach" does not capture the richness of the dynamic of the distribution, since it only encompasses some of its moments: its mean, in the case of β-convergence, and its variance, in the case of σ-convergence.

With a view to getting round some of these limitations, and to deepen our understanding of the provincial distribution of productivity in Spain, we proceeded to estimate the associated density functions for the first and last years of the sample period. By offering an approximation of the external form of the distribution, these density functions summarise the distribution more precisely than the previously calculated measures of position (β-convergence) or dispersion (σ-convergence). In particular, density functions can reveal, for each year, important insights as to the current situation of provincial productivity disparities while, when viewed in a dynamic process, can explain some aspects of the provincial growth process.

Following the standard procedure, the density functions were obtained by carrying out a non-parametric[14] analysis, using the kernel method -in particular we have estimated a Gaussian kernel with optimal bandwidth[15]. The results obtained (Figure 4) reveal several important changes occurring over the sample period in the external form of the distribution, changes which doubly confirm the process of convergence mentioned previously: first, because of the overall decline in the level of dispersion of provincial productivity distributions; and second, because in 2002 there is a greater concentration of its probabilistic mass around its mean than in 1985[16]. In addition, and with regards to the potential for polarisation or stratification phenomena, a comparison of the two density functions reveals that a peak (mode) for low productivity levels disappears, while another appears for relatively high levels. We might conclude, therefore, that an incipient provincial polarisation at low levels of productivity has been replaced by another, also incipient, at high levels; to some extent, these poles can be assimilated to convergence clubs.

In spite of the supplementary information about the external form of the provincial productivity distribution (and its variation over time) provided by the density functions in Figure 4, they say nothing about any changes that might have occurred within the distribution. Occasionally, however, and particularly in the perspective of economic policy options, these intradistributional movements can be as significant as the changes seen in the external form of the distribution, or indeed even more so.

A simple way of dealing with this question consists of estimating transition matrices, which –by mapping the provincial productivity distribution from one period into the distribution for the next period- represent the probability that a province belonging to a group formed by particular levels of productivity jumps to another with different levels.

[14] In this type of analysis no functional form is imposed, *a priori*, on the distribution; as is said informally, non-parametric estimations “let the data speak”.

[15] A kernel can be understood as being a smoothed version of a histogram; the bandwidth of the kernel reflects the smoothness degree employed in the estimation of the density function.

[16] The 1985 distribution is skewed to the left while the 2002 distribution is almost symmetric. At the same time, the relative kurtosis in the distribution has changed over time. In 1985 the distribution is platykurtic while in 2002 is leptokurtic.

When this occurs there is said to be mobility in the distribution (the more changes that occur, the more mobility there is); while, in contrast, when this does not occur there is said to be persistence. This type of analysis –which has the undeniable advantage of assigning percentages to the level of mobility and persistence– has however the disadvantage that the results obtained from it may depend critically on the number of groups or intervals of productivity chosen when estimating the transition matrix. In this sense, it seems clear that, *ceteris paribus*, the greater the number of intervals, the greater the level of mobility, and consequently the lower the level of persistence.

This problem is easily solved by estimating a stochastic kernel, which provides the probability of transiting between any two levels of value ranges of the provincial productivity distribution. A stochastic kernel is, therefore, conceptually equivalent to a transition matrix with the number of intervals tending to infinity. Figure 5 (Panel a) presents, for labour productivity (taking the national mean as base 100) and for the sample period 1985-2002, the stochastic kernel of the Spanish provinces corresponding to transitions of five years. In the 3-D graph of Panel a, the X-axis represents the productivity values in year t, the Y-axis the productivity values five years later, while the Z-axis represents the density (or conditioned probability) at each point in the X-Y plane. The lines running parallel to the t+5 axis show the probability of transiting from the point in the X-axis being considered to any other point in the Y-axis. Since the probability mass is concentrated on the positive diagonal, we can conclude that the distribution has a high level of persistence. This phenomenon is seen more clearly in the 2-D graph of Panel a, which shows the contour lines obtained by making cuts parallel to the X-Y plane: the lines obtained connect, therefore, points of equal height or density. Taking into account that these contour lines concentrate on the positive diagonal, we confirm our earlier conclusion that the level of mobility within the provincial productivity distribution is very low, or equally, that the level of persistence is very high. This result appears to be quite logical since it is likely that for transitions over five years changes in provincial rankings will not be very significant. In contrast, when we consider longer transitions –17 years in our case (Figure 5 Panel b) – the level of mobility within the distribution is, naturally, higher, despite the fact that the contour lines continue to show a high level of persistence. It is precisely this result that would seem to justify, at least in part, the application of a regional policy at the national level[17].

4. Provincial productivity convergence in Spain: a spatial econometric approach

The analysis carried out in the two previous sections did not take the geographical location of the Spanish provinces into account; it is, therefore, insensitive to their spatial distribution. Indeed, the results would not be modified in the slightest if for example, Asturias (in the north of the country) were located in Granada (south), or Huelva (southwest) in Tarragona (northeast). This is the case because the units of analysis –the provinces– are considered to be absolutely independent of each other, which ignores possible spatial interactions between them.

The spatial location can be –and in some cases undoubtedly is– of great importance for the processes of economic development and convergence; endogenous growth theory and the new economic geography provide interesting arguments in this respect (spillover effects, technological diffusion, economies of scale, market size, transport costs, etc.) to justify the potential relevance of space to development (or backwardness) and convergence (or divergence). Spatial econometrics provides, in this sense, various techniques of analysis that attempt to evaluate the impact of geography on the aforementioned processes[18].

Applying a spatial approach, in this section we carry out a new analyses of provincial convergence in productivity with two basic objectives: to offer, initially, a spatial perspective of the pattern of provincial growth in productivity; and to subsequently extend the model of β-convergence to include possible spatial effects that have been ignored previously.

In our case, this is a question of the existence or otherwise of autocorrelation or spatial dependence; this is understood to exist when there is some type of functional relation

[17] The suitability of such a policy is indeed reinforced in view of the increasing concentration of GDP and employment pointed out in Section 2. This type of policy is somewhat stressed by endogenous growth models, in which the presence of increasing returns to scale may lead to the possibility of persistent and even increasing real spatial disparities.
[18] An analysis that illustrates spatial econometrics can be seen in Moreno and Vayá (2002), among others.

between what occurs in a province and what occurs in another or others. The so-called exploratory spatial data analysis (ESDA) allows us to show, at the univariate level, the presence or absence of spatial dependence by calculating a number of statistics[19]. The most familiar of all of them is Moran's I[20], which in addition has the advantage of allowing for an easily interpretable graphical representation in the form of a scatterplot or scattermap. In our case, we have opted to present the scattermaps for the first and last years of the sample (Figure 6), which allow us to clearly see the existence of a phenomenon of positive spatial autocorrelation between the Spanish provinces in terms of labour productivity: both maps show –the 2002 one even more clearly– that the provinces with a low (high) relative productivity tend to be close to each other –i.e., they are geographically concentrated.

Having shown the existence of global positive spatial dependence in the Spanish provincial distribution of productivity, it is more than likely that the equation of β-convergence previously estimated will also be affected by problems of spatial dependence, which will lead to some difficulties with the estimators (Anselin, 1988). To decide if this is the case, spatial econometrics has designed a whole series of tests, some of an *ad hoc* nature (such as Moran's I) and others based on the maximum likelihood estimation of a spatial model. Among these last are, for example: the Maximum Likelihood test, the Wald test, and above all those based on the Lagrange multiplier. With regards to these last ones, the LM-ERR test, along with the associated robust LM-EL, tests for the absence of spatial autocorrelation in the regression residuals; while the LM-LAG test, along with the associated robust LM-LE, tests for the absence of spatial autocorrelation in the variables, also called substantive spatial autocorrelation. The results obtained in our case (see Table 3) show that there is no substantive autocorrelation, but that there is residual autocorrelation[21]; this implies that a shock in a particular province spills over to all or part of the national territory.

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[19] All computations have been carried out by using the SpaceStat 1.91 software, by Luc Anselin.

[20] This indicator is used to test the null hypothesis that the variable analysed is distributed randomly in space.

[21] The robust test LM-LE is not rejected at the 95% level, so we conclude that there is no substantive autocorrelation. In contrast, the test LM-ERR and its robust LM-EL throw up p-values of less than 0.05, which indicates that the null hypothesis is rejected (absence of spatial autocorrelation) in the residuals. We conclude, therefore, that the equation of β-convergence estimated previously presents spatial dependence in the residuals. When, as in our case, there is residual autocorrelation, the estimations of the parameters are, like in a temporal context, inefficient although unbiased; as a result, statistical inference is not reliable.

The procedure for correcting the aforementioned autocorrelation in the residuals consists of including an autoregressive structure of spatial dependence in the error term of the model to estimate, so that the new regression equation is as follows:

$$\frac{1}{T}\mathrm{Log}\left(\frac{Y_{i,02}}{Y_{i,85}}\right) = \alpha + \beta\ \mathrm{Log}\left(Y_{i,85}\right) + \varepsilon \qquad (2)$$

$$\text{where} \quad \varepsilon = \lambda W\varepsilon + u \quad \text{and} \quad u \approx N(0,\sigma^2 I)$$

In this new equation, λ is the autoregressive parameter expressing the intensity of spatial autocorrelation (interdependences) in the error term, while W represents the weights matrix, defined –like in the case of Moran's scattermap– in terms of the inverse of the standardised distance: its elements $w_{i,j}$ reflect the intensity of the interdependence between the provinces *i* and *j*. In this model the effects of the spatial dependence (diffusion) appear in two ways, since the rate of growth of the productivity of a province *i* is influenced, on the one hand, by the growth rates of the other contiguous provinces, and on the other, by its own initial level of productivity, weighted in both cases by W[22].

The results of the maximum likelihood estimation of this new equation of β-convergence are shown in Table 4. As can be seen, all the coefficients –including the one corresponding to the autoregressive parameter λ– are significant[23]. Moreover, this model presents better results compared to the previous one, whatever the goodness of fit measure is considered. This occurs, indeed, with regards to the maximum likelihood test (LIK) –which passes from 240.5 to 249.6– as well as in Akaike's Information Criterion (AIC) –which passes from –477.1 to –495.1– and Schwartz's Criterion (SC) –which jumps from –473.2 to –491.3.

[22] Manipulating Equation 2 (see Toral, 2002; or Anselin, 2003) allows us to obtain the following equation, in which the third and fourth terms on the right-hand side refer to the aforementioned spatial effects:

$$\frac{1}{T}\mathrm{Log}\left(\frac{Y_{i,02}}{Y_{i,85}}\right) = \text{constant} + \beta\ \mathrm{Log}\left(Y_{i,85}\right) + \rho W \frac{1}{T}\mathrm{Log}\left(\frac{Y_{i,02}}{Y_{i,85}}\right) + \gamma W \frac{1}{T}\mathrm{Log}\left(Y_{i,85}\right) + u$$

where $\rho = \lambda$; $\gamma = -\lambda\beta$

[23] The fact that the parameter λ is significant and positive confirms what the spatial dependence tests suggested about the ordinary least-squares estimation.

The process of convergence, once the presence of spatial autocorrelation in the residuals is taken into account, occurs at a slightly lower rate than in the classical model (1.8% compared to 1.9%)[24], which implies that the time required for provinces to close half the gap separating them from their steady state is now 22.5 years (compared to 21.9 years in the classical case). Thus, the relevant conclusion we obtain is that spatial effects –although present in the distribution- have not affected, to a great extent, the speed of provincial productivity convergence in Spain during the sample period.

5. Conclusions

In contrast to what the first works on provincial convergence led us to believe, the process of real convergence between Spanish provinces has continued throughout the period of analysis considered in this paper. This convergence, which has been of both types (β and σ) and which is confirmed examining the corresponding density functions, has occurred in parallel with a growing process of concentration of GDP and employment in the most efficient provinces, more intense, logically, in employment than in GDP. If this last result is worrying from a socio-economic perspective, thus justifying the application of a compensatory regional policy at the national level, the scarce mobility within the provincial distribution of productivity provides another argument in favour of this policy. Finally, the paper has revealed the existence of a certain spatial dependence between the Spanish provinces, a finding that led us to re-estimate the equation of β-convergence; the results obtained from this new model, which are better than those of the classical one, confirm the existence of β-convergence but at a slightly lower rate than that of the classical model.

[24] This is a very general result in this type of analysis, as can be seen for example in Rey and Montouri (1999) and Moreno and Vayá (2002).

References

Anselin, L., *Spatial Econometrics: Methods and Models*, Kluwer, Dordrecht, 1998.

Anselin, L., "Spatial Externalities, Spatial Multipliers, and Spatial Econometrics" International Regional Science Review, vol. 26, n. 2, 2003, pp. 153-166.

Dolado, JJ., González Páramo, JM. and Roldán, JM., "Convergencia económica entre las provincias españolas: evidencia empírica (1955-1989)", Banco de España, *Documento de Trabajo*, no. 9406, 1994.

Garcia Greciano, B., Raymond, JL. and Villaverde, J., "La convergencia de las provincias españolas, *Papeles de Economía Española*, no. 64, 1995, pp. 38-53.

Goerlich, F. and Más, M., "*La evolución económica de las provincias españolas (1955-1998). Vol II, Desigualdad y Convergencia"*, Fundación BBVA, 2000.

Lopez Bazo, E., Vayá, E., Mora, AJ. and Suriñach, "Regional economic dynamics and convergente in the European Union", *Annals of Regional Science,* vol. 33, 1999, pp. 334-370.

Quah, D., "Gallton´s fallacy and tests of the convergence hypothesis" *Scandinavian Journal of Economics,* vol. 95, no. 4, 1993, pp. 427-443.

Quah, D., "Regional convergence clusters in Europe" *European Economic Review,* vol. 40, no. 3-5, 1996a, pp. 951-958.

Quah, D., "Empirics for economic growth and convergence" *European Economic Review,* vol. 40, no. 6, 1996b, pp. 1353-1375.

Moreno, R. and Vayá, E, "Econometría espacial: nuevas técnicas para el análisis regional. Una aplicación a las regiones europeas" *Investigaciones Regionales,* vol. 1, 2002, pp. 83-106.

Paci, R., "More similar and less equal: Economic Growth in the Euroepan Regions" Weltwirtschaftliches Archiv, vol. 133, no. 4, 1997, pp. 609-634.

Rey, S. and Montouri, B., "US Regional Income Convergente: A Spatial Econometric Análisis", *Regional Studies,* vol. 33, no. 2, 1999, pp. 143-156.

Sala-i-Martin, X., "The classical approach to convergence analysis". *Economic Journal,* vol. 106, no. 437, 1996, pp. 1019-1036.

Toral, A., "La mesure de la distance dans le processus de convergence regionale en Espagne", *Revue d'Économie Régionale et Urbaine,* no. 5, 2002, pp. 789-803.

Villaverde, J., Desigualdades provinciales en España, 1955-1991, *Revista de Estudios Regionales*, no. 45, 1996, pp. 89-108.

Villaverde, J., "Regional Convergence, Polarisation and Mobility in the European Union, 1980-1996". *Journal of European Integration*, no. 1, 2003, pp 73-87.

Villaverde, J., "Indicators of Real Economic Convergence. A Primer", *UNU-CRIS e-Working Papers*, no. W-2004/2, 2004

Villaverde, J. and Sánchez-Robles, B., Disparidades provinciales y clubes de convergencia en España. *Revista de Estudios Regionales*, no. 52, 1998, pp.177-199.

Villaverde, J. and Maza, A., "Desigualdades regionales y dependencia espacial en la Unión Europea", *CLM-Economía*, vol. 2, 2003, pp. 109-128.

Table 1

OLS ESTIMATION RESULTS FOR THE UNCONDITIONAL β-CONVERGENCE EQUATION

Dependent variable: $\frac{1}{T}\mathrm{Log}\left(\frac{Y_{i,02}}{Y_{i,85}}\right)$		
	Coefficient	t-Statistic
Constant	0,20521	10,242428
β	-0,0311554	-9,885057
Adjusted R-squared	0,6637	
LIK	240,526	
AIC	-477.052	
SC	-473,228	

Table 2
PROVINCIAL CONTRIBUTION TO SPANISH GDP AND EMPLOYMENT (Selected years)

	Ten most productive provinces		Ten less productive provinces	
	1985	2002	1985	2002
GDP	47,1	47,4	8,1	7,9
Employment	39,5	42,7	12,3	9,7

Table 3
DIAGNOSTIC FOR SPATIAL DEPENDENCE

	Value	p-value
Moran I	5,936381	0,000000
LM-ERR	24,434674	0,000000
LM-EL	6,259792	0,012351
LM-LAG	19,441868	0,000000
LM-LE	0,266986	0,605361

Table 4
MAXIMUN LIKELIHOOD ESTIMATION RESULTS FOR THE SPATIAL DEPENDENCE MODEL

Dependent variable: $\frac{1}{T}\mathrm{Log}\left(\frac{Y_{i,02}}{Y_{i,85}}\right)$		
	Coefficient	z-value
Constant	0,200307	10,242428
β	-0,0303736	-13,289972
λ	0,830104	8,088082
LIK	249,560	
AIC	-495,120	
SC	-491,296	

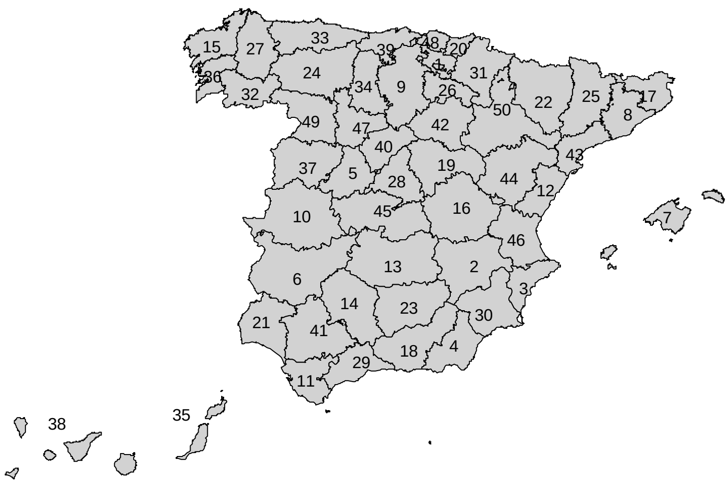


Fig. 1.- SPANISH PROVINCIAL ORGANIZATION

Fig. 2.- REAL CONVERGENCE SPAIN (EU= 100)

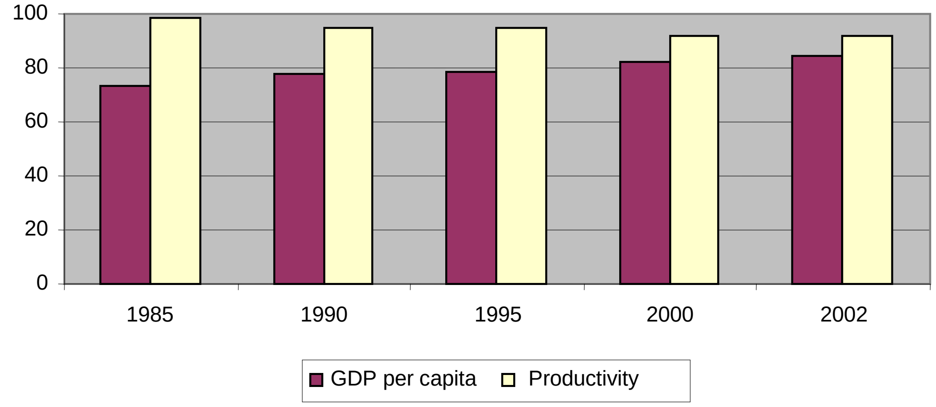


Fig. 3.- σ - CONVERGENCE IN (LOG) PRODUCTIVITY

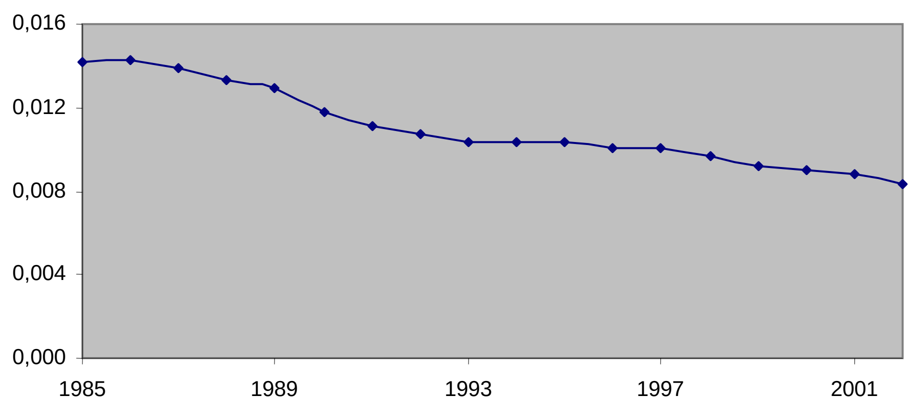
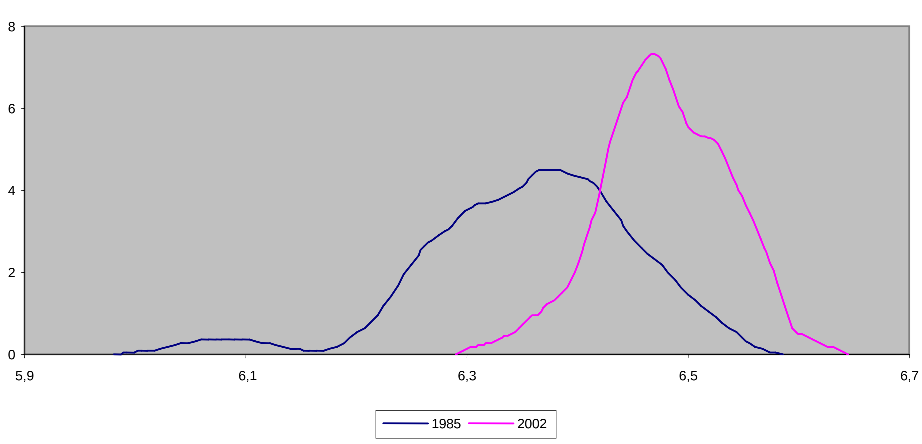
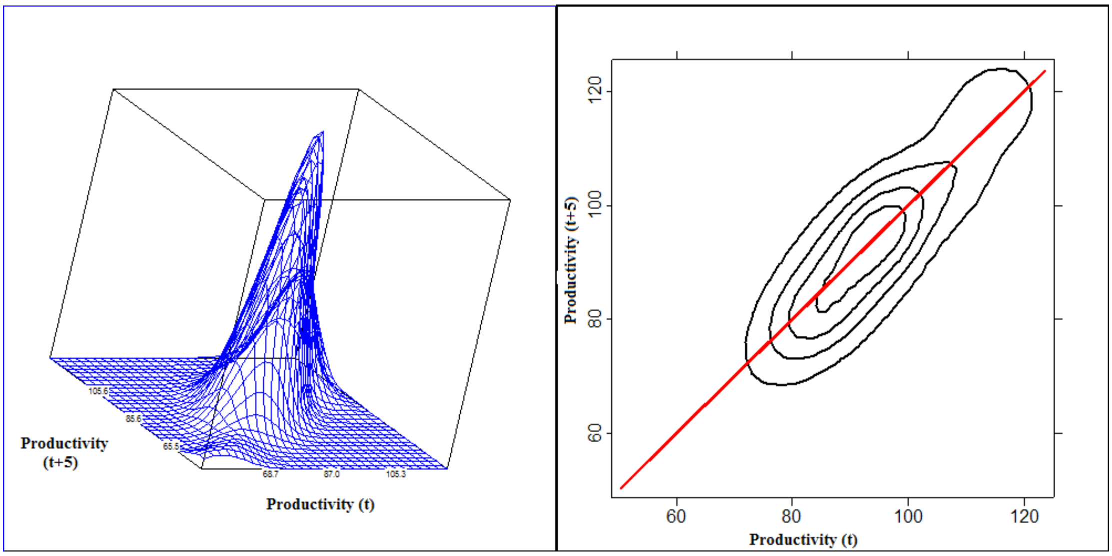
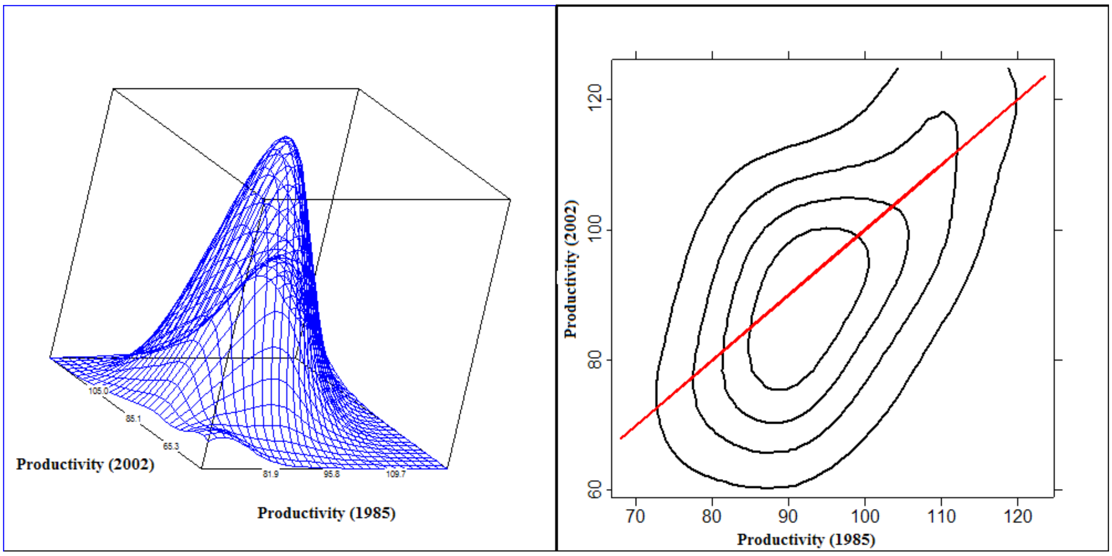


Fig. 4.- DENSITY FUNCTIONS IN (LOG) PRODUCTIVITY



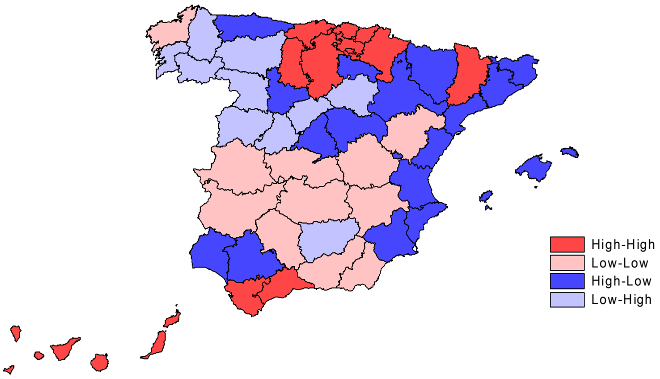


a) Five years transition periods

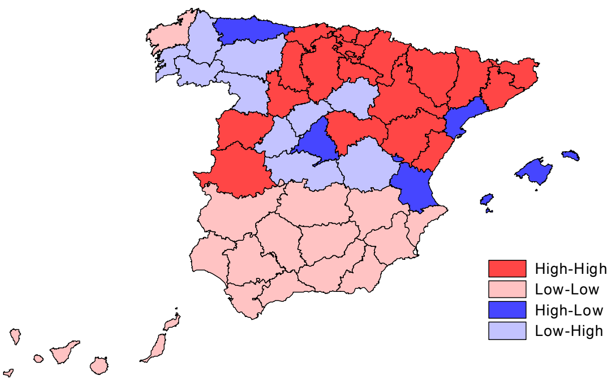


b) 1985-2002

Fig. 5.- DISTRIBUTION DYNAMICS



1985



2002

Fig. 6.- MORAN SCATTERMAPS

ANNEX: SPANISH PROVINCES AND REGIONS

1	Alava (País Vasco)	26	Rioja, La
2	Albacete (Castilla-La Mancha)	27	Lugo (Galicia)
3	Alicante (C. Valenciana)	28	Madrid
4	Almeria (Andalucía)	29	Málaga (Andalucía)
5	Avila (Castilla y León)	30	Murcia
6	Badajoz (Extremadura)	31	Navarra
7	Baleares	32	Orense (Galicia)
8	Barcelona (Cataluña)	33	Asturias
9	Burgos (Castilla y León)	34	Palencia (Castilla y León)
10	Cáceres (Extremadura)	35	Palmas, Las (Canarias)
11	Cádiz (Andalucía)	36	Pontevedra (Galicia)
12	Castellón (C. Valenciana)	37	Salamanca (Castilla y León)
13	Ciudad Real (Castilla-La Mancha)	38	Tenerife (Canarias)
14	Córdoba (Andalucía)	39	Cantabria
15	Coruña (Galicia)	40	Segovia (Castilla y León)
16	Cuenca (Castilla-La Mancha)	41	Sevilla (Andalucía)
17	Girona (Cataluña)	42	Soria (Castilla y León)
18	Granada (Andalucía)	43	Tarragona (Cataluña)
19	Guadalajara (Castilla-La Mancha)	44	Teruel (Aragón)
20	Guipúzcoa (País Vasco)	45	Toledo (Castilla-La Mancha)
21	Huelva (Andalucía)	46	Valencia (C. Valenciana)
22	Huesca (Aragón)	47	Valladolid (Castilla y León)
23	Jaén (Andalucía)	48	Vizcaya (País Vasco)
24	León (Castilla y León)	49	Zamora (Castilla y León)
25	Lerida (Cataluña)	50	Zaragoza (Aragón)

The names in brackets refer to Autonomous Communities (Regions)