Applied Economics Letters, 2005, **12**, 697–700

Provincial convergence in Spain: a spatial econometric approach

José Villaverde

University of Cantabria, Avda. de los Castros, s.n., 39005, Santander, Spain
E-mail: villavej@unican.es

This article examines the process of provincial convergence in labour productivity that has taken place in Spain between 1985 and 2002. In order to quantify the influence of space on the convergence process, it applies a spatial econometric approach, concluding that although spatial effects do indeed exist, they do not seem to be too relevant for the aforementioned process.

I. Introduction

Regional economists and macroeconomists have resumed their interest in territorial convergence since the topic was taken up for economic analysis in the late 1980s and early 1990s and used as a test bank for discriminating between growth theories. Although, there has been a large number of empirical studies on this phenomenon, frequently considering that the rate of convergence is around 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.

This is the case because the 'classical approach to convergence' (Sala-i-Martin, 1996) do not in general take spatial characteristics of the distribution into account, since it treats 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 that becomes particularly clear in estimations of σ and β-convergence.[2] To try to overcome this problem, our aim is to quantify the impact of spatial effects on the process of β-convergence in labour productivity in the Spanish provinces, for the sample period 1985–2002.

The starting point is the equation of absolute β-convergence, as follows:

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

where $Y_{i,t}$ stands for 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, it can be concluded that absolute β-convergence exists. Table 1 illustrates that between 1985 and 2002 there was a process of absolute β-convergence in labour productivity between the Spanish provinces. This process of convergence 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 22 years.

[1] See, for instance, García Greciano *et al.* (1995), Villaverde (1996), and Villaverde and Sánchez-Robles (1998). More recent work of interest includes, among others, Goerlich and Mas (2001).
[2] 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.

Applied Economics Letters ISSN 1350-4851 print, ISSN 1466-4291 online © 2005 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/13504850500190030

Table 1. OLS estimation results for the unconditional β-convergence equation

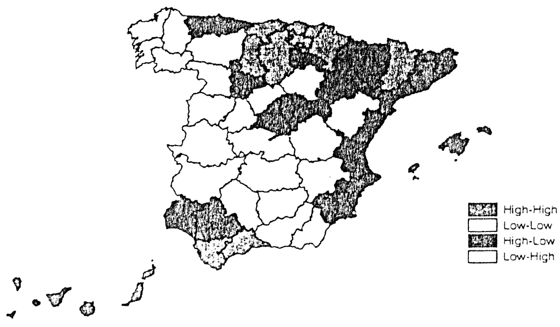
Dependent variable: $(1/T)\log(Y_{i,02}/Y_{i,85})$		
	Coefficient	t-statistic
Constant	0.20521	10.242428
β	−0.0311554	−9.885057
Adjusted R^2	0.6637	
LIK	240.526	
AIC	−477.052	
SC	−473.228	

This analysis did not take the geographical location of the Spanish provinces into account; it is, therefore, insensitive to their spatial distribution. Indeed, the results shown in Table 1 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).

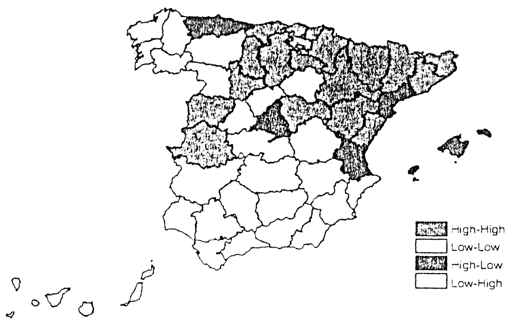
The spatial location can be – and in some cases undoubtedly is – of great importance for the processes of economic development and convergence; endogenous growth theory and the new economic geography provide interesting insights (spillover effects, technological diffusion, economies of scale, market 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.[3]

Applying a spatial approach, one carries out a new analysis of Spanish 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.

Spatial dependence is understood to exist when there is some type of functional relation between what occurs in a province and what occurs in another or others. The so-called exploratory spatial data analysis allows us to show, at the univariate level, the presence or absence of spatial dependence by calculating a number of statistics.[4] The most familiar of all of them is Moran's I,[5] which in addition has the advantage of allowing for an easily interpretable graphical representation in the form of a scatterplot or scattermap. In this case one has opted to present the scattermaps for the first and last years of the sample (Fig. 1), which allow one to see clearly 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.



1985



2002

Fig. 1. Moran scattermaps

Having shown the existence of a 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). In order 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

[3] An analysis that illustrates spatial econometrics can be seen in Moreno and Vayá (2002), among others.
[4] All computations have been carried out by using the SpaceStat 1.91 software, by Luc Anselin.
[5] This indicator is used to test the null hypothesis that the variable analysed is distributed randomly in space.

Table 2. Diagnostic of 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 3. Maximun likelihood estimation results for the spatial dependence model

Dependent variable: $(1/T)\log(Y_{i,02}/Y_{i,85})$		
	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	

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 this case (Table 2) show that there is no substantive autocorrelation, but that there is residual autocorrelation;[6] this implies that a shock in a particular province spills over to all or part of the national territory.

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:

$$\frac{1}{T}\log\left(\frac{Y_{i,02}}{Y_{i,85}}\right) = \alpha + \beta\log(Y_{i,85}) + \varepsilon$$
$$\text{where} \quad \varepsilon = \lambda W\varepsilon + u \text{ and } \quad u \approx N(0, \sigma^2 I) \quad (2)$$

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 – such as in the case of Moran's scattermap – in terms of the inverse of the standardized 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.[7]

The results of the maximum likelihood estimation of this new equation of β-convergence are shown in Table 3. As can be seen, all the coefficients – including the one corresponding to the autoregressive parameter λ – are significant.[8] 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 (LIK) test – 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.

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%),[9] 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 22 years in the classical case). Thus, the relevant conclusion one

[6] 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. It is concluded, 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.

[7] 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:

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

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

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

[9] 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).

obtains 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.

Acknowledgement

The author would like to thank A. Maza for his useful comments and suggestions.

References

Anselin, L. (1988) *Spatial Econometrics: Methods and Models*, Kluwer, Dordrecht.

García Greciano, B., Raymond, J. L. and Villaverde, J. (1995) La convergencia de las provincias españolas, *Papeles de Economía Española*, **64**, 38–53.

Goerlich, F. and Mas, M. (2000) *La Evolución Económica de las Provincias Españolas (1955–1998), Vol. 2, Desigualdad y Convergencia*, Fundación BBVA.

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

Rey, S. and Montouri, B. (1999) US regional income convergence: a spatial econometric analysis, *Regional Studies*, **33**, 143–56.

Sala-i-Martin, X. (1996) The classical approach to convergence analysis, *Economic Journal*, **106**, 1019–36.

Villaverde, J. (1996) Desigualdades provinciales en España, 1955–1991, *Revista de Estudios Regionales*, **45**, 89–108.

Villaverde, J. (2004) Indicators of real economic convergence. A primer, UNU-CRIS e-Working Papers W-2004/2.

Villaverde, J. and Sánchez-Robles, B. (1998) Disparidades provinciales y clubes de convergencia en España, *Revista de Estudios Regionales*, **52**, 177–99.