Artigo submetido a 13 de Março de 2017; versão final aceite a 10 de Setembro de 2017
Paper submitted at March 13, 2017; final version acepted at Setember 10, 2017

Regional Convergence and Productive Structure in Iberian Regions: A Spatial Approach

Convergência Regional e Estrutura Produtiva nas Regiões Ibéricas: Uma Abordagem Espacial

Elías Melchor-Ferrer
emelchor@ugr.es
Department of International and Spanish Economics. University of Granada
Faculty of Economics

Abstract/ Resumo

This article empirically analyses conditional convergence between Spanish and Portuguese NUTS-3 regions during the period 2000-2014, considering both the spatial dependence between these units and the impact of productive structure on this process. The existence of spatial autocorrelation in the growth of regional Gross Domestic Product per capita (GDPpc) makes it necessary to explore various econometric models that have been proposed. The Spatial Durbin Model was selected because of its better degree of fit, and the results obtained confirm the existence of conditional regional convergence, enabling us to estimate the spatial spillovers that drive this process. This analysis is focused on direct and indirect effects of the explanatory variables considered: initial GDP pc, population density and the four main activity sectors. Finally, we highlight the main differences between Spanish and Portuguese regions.

Keywords: regional convergence, spatial spillovers, Iberian countries, Spatial Durbin Model.

JEL codes: Q18, R11, R12

Este artigo analisa empiricamente a convergência condicional entre as regiões NUTS-3 espanholas e portuguesas durante o período 2000-2014, considerando tanto a dependência espacial entre essas unidades como o impacto da estrutura produtiva nesse processo. A existência de autocorrelação espacial no crescimento do Produto Interno Bruto Regional per capita (PIBpc) torna necessário explorar diferentes modelos econométricos propostos na literatura. Depois de selecionar o Modelo Spatial Durbin devido ao seu melhor grau de ajuste, os resultados obtidos nos permitem afirmar a existência de convergência regional condicional, bem como estimar os spillovers espaciais que conduzem esse processo. Esta análise está focada nos efeitos diretos e indiretos das variáveis explicativas: PIBpc inicial, densidade populacional ea importância relativa dos principais setores de atividade. Finalmente, sublinhemos as principais diferenças entre regiões espanholas e portuguesas.

Palavras-chave: Convergência regional, Spillovers espaciais, Países ibéricos, Modelo de Durbin

Código JEL: Q18, R11, R12

Acknowledgements: The author would like to thank the anonymous reviewers for their helpful and constructive comments and suggestions, which greatly contributed to improving the final version of the paper.

1. INTRODUCTION

Spain and Portugal are not only neighbours, but have similar patterns of political evolution (accession to democracy, integration within the EU) and to a lesser extent of economic development (except the years prior to the Great Recession of 2009, when the expansionary phase of the economic cycle was especially positive for Spain). Traditionally, convergence analysis is performed on an individualised, country-by-country, basis (Soukiazis & Antunes, 2006; Badia-Miró et al., 2012; Ligthart, 2002), although in some cases an Iberian perspective has been adopted (Viegas & Antunes, 2013). According to these studies, until the mid-1980s disparities narrowed significantly, due to the provision and mobility of production factors; since then, EU structural and cohesion funds have played a key role in maintaining this process, although this issue has also been questioned (Boldrin & Canova, 2001).

Some studies (Viegas & Antunes, 2013; Marelli, 2007; Maroto-Sánchez & Cuadrado-Roura, 2008) have demonstrated the existence of differential patterns of behaviour between Spanish and Portuguese regions (henceforth, Iberian regions), in two ways: i) convergence stopped for Spanish regions during the period 1991-2000, while it continued for Portuguese ones; and ii) the Spanish regions, in general, have grown more strongly. However, previous studies seem to be contradictory on what has since happened for Portuguese regions (reduction or increase in the dispersion of GDPpc), in contrast to the decreasing convergence among Spanish regions until the beginning of the Great Recession.

The progressive end of regional convergence in GDPpc has run in parallel to transfers of labour from the less to the more productive sectors, a change that has been particularly important in the poorest European regions (Maroto-Sánchez & Cuadrado-Roura, 2008). Therefore, changes in the productive structure have probably affected regional beta-convergence, and so it would be useful to examine whether the recent growth of GDPpc in the Iberian regions is explicable in terms of these variables, taking into account spatial feedback effects.

In this paper, we analyse conditional convergence among the NUTS-3 Iberian regions between 2000 and 2014. Furthermore, given the differences between Spanish and Portuguese regions, we perform a comparative analysis of the similarities and differences among the three groups of regions. After a brief review of the theoretical framework applied, in the second section of this paper we specify the model to be used and the data source. The third section begins with a preliminary spatial analysis that reveals catch-up effects among the poorest regions, although with some differences between Spanish and Portuguese regions, mainly in the magnitude of these effects. Finally, we estimate the model and the direct and indirect effects underlying the conditional regional convergence.

2. REGIONAL GROWTH AND ITS DETERMINANTS

While the literature on regional growth reflects broad consensus on the need to incorporate elements from both supply and demand-based models, empirical analysis of growth in neoclassical models has shown that, in the main, supply factors determine the characteristics of the production function (Ayuso, 2007). In recent years, renewed attention has been paid to these models, sparked by the interest aroused by the analysis of economic convergence and its determinants, which has produced empirical evidence on the catch-up process in income per capita. Thus, studies by Barro and Sala-i-Martin (1990; 1992) and Sala-i-Martín (1996) defined concepts of convergence (sigma and beta) and posited the existence of a steady-state solution towards which income per capita will tend as the consequence of diminishing marginal returns and the exogenous nature of technology. This process is known as absolute (or unconditional) beta convergence.

In the 1980s, this adaptation of the neoclassical growth model developed in the 1950s by Solow (1956) and Swan (1956) came to the foreground when different studies observed that the correlation between the per capita GDP growth and initial per capita GDP in a given period could not be estimated empirically (Melihovs & Davidsons, 2006). In consequence, researchers have sought alternatives based on the assumption of increasing or constant returns on capital, and in this respect various theories of endogenous growth have been proposed (Lucas, 1988; Romer, 1986). According to these theories, the structural characteristics of regions may give rise to the known as conditional convergence (Ezcurra, 2001). The latter may be estimated in two ways: i) by creating groups of regions with common features (e.g. when the sample includes regions of different countries), which will result in different steady states; ii) by introducing into the absolute convergence model different variables (X) acting as a proxy of existence of various steady states, a situation such a state, for example population density, human capital or productive structure. This is described in the following expression:

$$\left(\frac{1}{T}\right) ln\left(\frac{Y_{it}}{Y_{it-T}}\right) = \alpha + \beta\, ln(Y_{it-T}) + \phi\, ln(X_{it-T}) + u_{it} \qquad (1)$$

where Y_{it} and Y_{it-T} are income per capita at the final and initial moments, respectively, in region i, T is the length of the period analysed, $\left(\frac{1}{T}\right) log\left(\frac{Y_{it}}{Y_{it-T}}\right)$ is the annual cumulative growth rate of region i in the period t-T to t, β and ϕ are the coefficients to be estimated and u_{it} represents the error term of the random disturbance.

However, in the case of regions belonging to different countries, there may be multiple steady states, due to the existence of different contexts (technology, rates of savings, public policies, infrastructure, etc.) (Battisti & De Vaio, 2008). As a result, some groups of regions might present high levels of convergence, while others do not. This phenomenon may be due to the presence of spatial autocorrelation (Anselin, 1988), not necessarily affecting regions in the same country. The concept of spatial autocorrelation measures the proximity of regions in comparison with other nearby regions, and can be positive or negative. According to Griffith (1987), "positive spatial autocorrelation means that geographically nearby values of a variable tend to be similar on a map: high values tend to be located near high values, medium values near medium values, and low values near low values", and vice versa for negative spatial autocorrelation.

Spatial autocorrelation is usually measured by Moran's index (1950), which reflects the linear dependence between a variable at a specific location and the mean value of the same variable for its neighbours. Its value can be positive or negative depending on whether the scatter of points reflects a straight line sloping from the lower left-hand to the upper right-hand corner or from the upper left-hand to the lower right-hand corner, respectively. However, as this index does not provide information on the correlation between the geographic units considered, it is necessary to calculate the local coefficients of spatial dependence (LISA - Local Index of Spatial Association), also known as Local Moran's Index (Anselin, 1995), to test the null hypothesis of no local spatial autocorrelation for each territory. This test not only identifies regional clustering, but can also reveal the presence of significant spatial clusters or outliers by region. Local measures of spatial autocorrelation are implemented as LISA Significance and LISA Cluster maps. The first of these shows the locations presenting a significant Local Moran index, according to the degree of significance. This is necessary because even if the index is significant for the research area as a whole, significant clustering might only be found in certain regions. The second map shows how, within a regional cluster, the indicator can reflect one of five categories: not significant, high-high, low-low (when regions with high or low values cluster with others with similar values), high-low and low-high (when regions of high or low values are surrounded by others with lower and higher regional values, respectively).

The spatial nature of economic growth has been a factor of increasing significance over the last two decades, a trend supported by abundant empirical evidence, especially in terms of capital – physical, human and technological (Fingleton & López-Bazo, 2006; Naveed & Ahmad, 2014; Kubis & Schneider, 2012; Ertur & Koch, 2007; Ezcurra & Rios, 2015) – or productive structure. These studies have shown that geographic location does matter in terms of regional growth performance. Therefore, it is necessary to include the location in growth models, because otherwise the results obtained could be biased and any conclusions misleading.

3. MODEL, VARIABLE DEFINITION AND DATA SOURCES

3.1. Model specification

Recent research on economic growth and regional convergence has incorporated the analysis of spatial spillovers, acknowledging that traditional determinants of regional growth are subtly altered when the spatial effect is taken into account (Abreu et al., 2005). The spatial econometric approach has been employed in several studies alongside convergence models, both unconditional (Rey & Montouri, 1999) and conditional (López-Bazo et al., 1999; Fingleton & López-Bazo, 2006; Ezcurra & Rios, 2015). In both cases, the results obtained provide strong evidence in favour of the existence of spatial externalities, highlighting the need to account for shocks and spillovers among regions.

In this paper, the model definition used is related to our study goal of estimating the direct and indirect effects exerted on growth in Iberian regions by the growth in neighbouring ones. Thus, we adopt a conditional beta-convergence model with the following explanatory variables: population density, productive structure, and initial GDPpc. The starting point for defining the model is equation (1), adapted to incorporate the spatial component. To do so, the following considerations must be taken into account: i) as observed above, panel data models will be used, and therefore fixed or random spatial effects are also considered, in order to select the best specification; ii) in order to model interactions between spatial units in the dataset, we select the spatial weight matrix (W) that best describes the data; and iii) T=5, following previous studies in this field (Ramos et al., 2010; Ezcurra & Rios, 2015; Iacovone et al., 2015); therefore, we consider a five-year period between the explanatory variables and the annual cumulative growth rate. Thus, the model specification analysed is:

$$\left(\frac{1}{5}\right) ln\left(\frac{Y_{it}}{Y_{it-5}}\right) = \alpha_{it} + \mu_i + \delta W\left(\frac{1}{5}\right) ln\left(\frac{Y_{it}}{Y_{it-5}}\right) + \beta_1 ln(Y_{it-5}) + \theta_1 W ln(Y_{it-5}) + \beta_2 ln(X_{2,it-5}) + \theta_2 W ln(X_{2,it-5}) + \cdots + \beta_n ln(X_{n,it-5}) + \theta_n W ln(X_{n,it-5}) + u_{it} \qquad (2)$$
$$u_{it} = \lambda W u_{it} + \varepsilon_{it}$$

where,

$\left(\frac{1}{5}\right) ln\left(\frac{Y_{it}}{Y_{it-5}}\right)$ is the annual cumulative growth rate of GDPpc;

$W\left(\frac{1}{5}\right) ln\left(\frac{Y_{it}}{Y_{it-5}}\right)$ is the spatial autoregressive component of GDPpc;

$ln(Y_{it-5})$ is the initial value of GDPpc;

$Wln(Y_{it-5})$ is the interaction effect among the initial GDPpc of different units;

$ln(X_{n,it-5})$ is the initial value of *n* additional explanatory variables;

$Wln(X_{n,it-5})$ is the interaction effect among the initial value of *n* additional explanatory variables of different units; and

α_{it} and μ_i are, respectively, the vector of time period or spatial, fixed or random effects;

u_{it} is the disturbance term of the different units;

δ: spatial autoregressive coefficient;

β_n and θ_n are the vectors of *n* unknown parameters to be estimated;

λ, Wu_{it} and ε_{it} are, respectively, the spatial autocorrelation coefficient, the interaction effects among the disturbance terms of the different units, and the vectors of the disturbance terms.

This general model can be simplified to a spatial Durbin model (SDM), a spatial autoregressive model (SAR), a spatial error model (SEM) or even ordinary least squares (OLS), depending on the value of the parameters δ, θ and λ. However, some of these models are less appropriate in empirical research because they impose prior restrictions on the magnitude of the indirect effects (Elhorst, 2014). In consequence, they should be carefully analysed to determine which is most appropriate for the phenomenon to be studied.

The SDM provides a general starting point for discussion of spatial regression model estimation, since this model subsumes the above models and captures both the direct effect of neighbours' expected outcome on own outcomes and also the indirect impact on other regions (LeSage, 2008). As LeSage says (2008; p. 34): "The magnitude of this type of feedback will depend upon: (1) the position of the region in space (or in general in the connectivity structure), (2) the degree of connectivity among regions governed by the weight matrix W used in the model, (3) the parameter $W\left(\frac{1}{5}\right) ln\left(\frac{Y_{it}}{Y_{it-5}}\right)$ measuring the strength of spatial dependence, and (4) the magnitude of the coefficient estimates for β and θ".

For the SDM model, LeSage and Fischer (2008) provided a framework for interpreting the resulting estimates, which has been widely accepted as a standard approach for spatial models. This framework is based on three types of impact on economic growth rates arising from changes in explanatory variables: i) the direct effect, which summarises the impact of changes of an explanatory variable in region *i* on the dependent variable of the same region; ii) the indirect effect, reflecting the impact on the dependent variable in a given region of changes in independent variables of a neighbouring region; and finally iii) the average total effect, which is a scalar summary measure that includes both direct and indirect effects, and can be interpreted as the total impact on the dependent variable of changes in an independent variable.

3.2. Variable definition and data sources

The statistical source used was Regional Economic Accounts (ESA-2010), published by Eurostat, and the Spanish and Portuguese National Statistical Offices, for missing values for some regions. The ESA database presents statistics for Gross Domestic Product (GDP) at current market prices, but for the purposes of this study, the corresponding deflator index was applied, and the data, thus, are expressed in constant euros (base year 2000). This index was not available for the NUTS-3 regions, and so the index published for the corresponding NUTS-2 region was applied. Finally, the GDP was divided by the population to obtain GDPpc. Population and sectoral employment data were also obtained from Eurostat, in the first case using the number of persons whose usual residence was in the country on 1 January of the respective year, and in the second case, taking as employed persons, by activity sector, all those who had worked for at least one hour for pay or profit during the reference week, in accordance with the relevant international classification systems (NACE) for the main economic sectors.

The population density was obtained by dividing the population by the area of the region (in square kilometres). Productive structure was calculated as the employment in each sector as a proportion of the total, taking the four main activity branches: agriculture (including forestry and fishing), industry, construction and services.

Our specification produced 82 different units (see Appendix A) corresponding to the NUTS-3 Iberian regions (except Ceuta and Melilla, two Spanish cities in northern Africa) and 15 observations for each group (2000-2014). The cumulative growth rate for the dependent variable is for the corresponding five-year period and the first available rate is for the period 2000-2005. There were 820 observations for the entire sample (570 for the Spanish regions and 250 for the Portuguese ones), which is far greater than the number of parameters to be estimated, thus ensuring the presence of many degrees of freedom. Although data were available for the period 1995-1999, it was not possible to extend the study period due to the lack of harmonised series on regional GDP by NUTS-3 (SEC-2010) for the entire period for both Spain and Portugal. Moreover, data pre-dating 2000 for the Portuguese regions are expressed according to the NUTS 2002 classification, which differs from the present one.

3.3. Spatial weights matrix selection

The first step in the analysis of spatial autocorrelation was to construct W, which contains information on the “neighbourhood” structure for each location (Anselin, 2003). In this study, the matrices considered were based on the geographical distance between the sample regions, which in itself is strictly exogenous (Ezcurra & Rios, 2015). Specifically, we analysed matrices based on the k-nearest neighbours (k = 2 to 10) computed from the distance between the centroids of the regions (Le Gallo & Ertur, 2003). As is common practice in applied spatial research, the spatial weights were normalised in order to remove dependence on extraneous scale factors, so that the entries of each row add up to 1.

The criteria to select the matrix that best describes the data are based on an assessment of the empirical fit of the estimated model. When estimation is based on maximum likelihood, the standard R^2 is invalid, and so maximising the log-likelihood ratio could be a more appropriate measure of fit. Another option is to select the model that exhibits the lowest parameter estimate of the residual variance. Elhorst et al. (2013) suggest that the best description among the spatial weight matrices requires the highest log-likelihood function value and the lowest parameter estimate of the residual variance. Following Gibbons and Overman (2012), we explored the sensitivity of this parameter by modifying the definition of the set of neighbours in the estimation of a SMD model (see Table 1).

Table 1. Spatial weight matrices (residual variance)

	Iberian regions	*Spanish regions*	*Portuguese regions*
2-nearest neighbours	9.34E-06	1.26E-05	3.68E-06
4-nearest neighbours	9.17E-06	9.43E-06	4.98E-06
5-nearest neighbours	9.18E-06	9.40E-06	**3.67E-06**
6-nearest neighbours	1.31E-05	9.25E-06	3.92E-06
7-nearest neighbours	**8.79E-06**	**8.99E-06**	4.51E-06
8-nearest neighbours	9.03E-06	9.01E-06	3.86E-06
10-nearest neighbours	9.53E-06	9.11E-06	5.33E-06

The best description obtained from the spatial weights matrices varies according to the group of regions concerned. For the Iberian and Spanish regions, we adopted the 7 nearest neighbours matrix, while for the Portuguese regions, the 5 nearest neighbours matrix was employed. These spatial weight matrices give a much better fit than the others, and so they are used in the rest of this study.

4. EMPIRICAL RESULTS

As noted above, in this study, we analyse space-time data on spatial units that follow the pattern defined in the spatial weight matrices selected above. An initial analysis was conducted to determine whether space is a relevant factor in regional growth in Iberian regions. In this case, the increasing availability of data sets allows us to estimate panel data models that offer extensive modelling possibilities, including fixed and random effects models. However, despite the popularity of the latter type of model, there are several conditions that must be satisfied, and even then, its use in spatial research is, to say the least, controversial. On the other hand, fixed effects models could take into account spatial, time-period, or spatial and time-period fixed effects. Therefore, given the wide range of modelling options, special care should be taken to select the spatial panel data model that best describes the data. For this purpose, we have followed the selection framework provided by Elhorst (2014), who makes Matlab routines freely available at the following website:

http://www.regroningen.nl/elhorst/software.shtml.

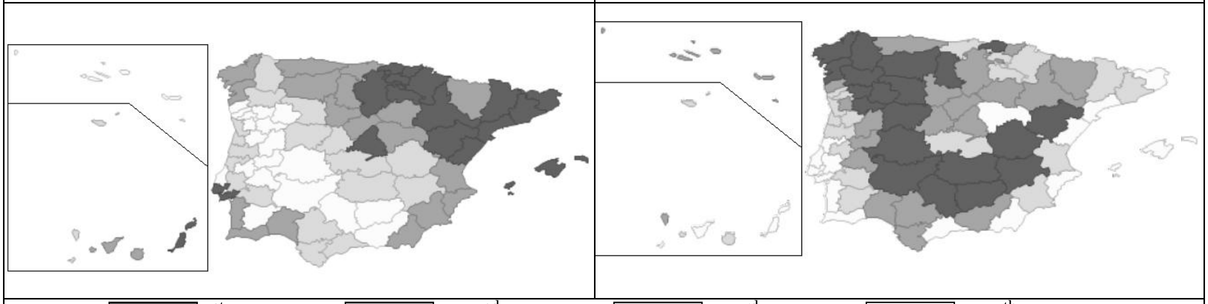
4.1. Regional growth in Iberian regions: a preliminary spatial analysis

After examining the quartile maps (see Fig. 1, left), it became apparent that in 2000 the lowest GDPpc values were found in the southwestern third of the Iberian Peninsula: almost all of Portugal (except Lisbon and, to a lesser extent, Algarve and Alentejo Litoral), plus Extremadura, Central Andalusia and the southern Castilian regions in Spain. The highest values (the top two quartiles), on the other hand, were observed in the regions located in the northeast quadrant, plus Lisbon and several Atlantic (Alentejo Litoral, Algarve and Huelva) and Mediterranean (Almeria, Murcia and Alicante) regions. This distribution of economic activity closely resembles that existing a decade earlier, as observed previously (Le Gallo & Ertur, 2003).

Figure 1 (right) shows that the Portuguese regions with the highest growth rates in the period are precisely those bordering Spain (especially the northern Portuguese regions: Terras de Trás-os-Montes, Alto Tâmega and Douro), which is indicative of spillover effects and/or common explanatory factors of this situation, for example, the impact on Portuguese border regions of the economic growth of some Spanish border regions (Viegas & Antunes, 2013). In fact, the Portuguese regions with the lowest growth rates are those bordering (or very close to) Huelva, the only Spanish borderland region in the second quartile. In either case, there is a clear perception of lower GDPpc growth in the Portuguese regions.

Figure 1. Quartile map of GDP per capita in constant prices (2000)

2000 (Levels – million)	*Cumulative growth rate (2000-2014), %*



1st range; 2nd range; 3rd range; 4th range

To determine whether the spatial distribution of GDPpc in the Iberian regions is randomly distributed in the space, the global Moran's Index was obtained, to detect spatial autocorrelation. This test produced a value of 0.620 for GDPpc, which is above the value at which the null hypothesis of no spatial autocorrelation would be rejected (E (I) = - 0.012). The spatial pattern observed in 2000 remained largely unaltered until 2014, when the index reached 0.606.

The Moran's Index test results for the three groups of regions considered lead us to conclude that spatial autocorrelation was significant in 2000 for both Iberian countries, but to a lesser extent for Portugal. This situation was similar to that observed in 2014 except for Spain, where Moran's Index rose, while for Portugal it decreased. This explains why the overall test result for the Iberian countries decreased slightly.

Table 2. Moran's Index test

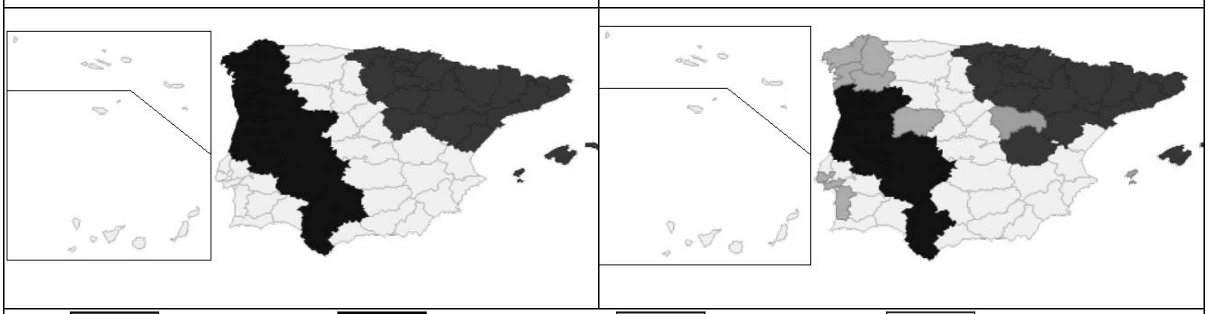
Group of regions by country	*2000*			*2014*		
	Index	*z-value*	*p-value*	*Index*	*z-value*	*p-value*
Iberian countries	0.6200	11.858	0.00001	0.6064	11.5986	0.00001
Spain	0.5091	8.3521	0.00001	0.4656	7.6621	0.00001
Portugal	0.4505	5.0211	0.00008	0.3442	4.0330	0.00053

Note: When z-value is greater than -1.96 and lower than 1.96, Moran's Index suggests there is a high likelihood that the spatial distribution of the residuals is the result of a random process. Otherwise, the p-value is lower than 0.05 and so the hypothesis of no spatial correlation is rejected at the level of 5% probability.

After confirming the presence of spatial autocorrelation in Iberian regions, the next step is to detect spatial clusters or spatial outliers that indicate, respectively, significantly high or low values of GDPpc growth.

Figure 2. GDP per capita in constant prices (2000). LISA cluster map.

2000	*2014*



High-High; Low-Low; Low-High; High-Low

The LISA cluster map (see Fig. 2) shows that most of the Portuguese regions present a positive autocorrelation of low values (low-low) both for 2000 and 2014, the only exceptions being in South Portugal: Algarve, Alentejo (Central, Baixo and Litoral), Oeste, Leziria do Tejo and Lisbon Metropolitan Area. In 2014 (Fig. 2, right), it is remarkable that Lisbon and Alentejo Litoral present high growth rates (see Fig. 1, right) while having low-value neighbours, which suggests the existence of potential spatial outliers. A similar situation can be observed in Spanish borderlands such as Salamanca and Galicia (NUTS-2 region). At the opposite extreme, we find regions with a positive autocorrelation of high values, mostly in Spain and in the north-eastern quadrant of the Iberian Peninsula. These circumstances, in general, were repeated in 2014.

4.2. Model selection

To select the most appropriate model for our study goal, it is necessary to investigate the (null) hypothesis that spatial and time-period fixed effects are non-significant. To do so, we estimated equation (1) by OLS: i) without fixed effects, ii) with spatial fixed effects, and iii) with time-period fixed effects. We then performed two log-likelihood ratio (LR) tests. The results obtained (see Table 3) indicate that both hypotheses must be rejected for all groups of regions, at p< 0.01. In consequence, the model can be extended with spatial and time-period fixed effects. Having confirmed the significance of these components, a SDM is adopted for initial testing to determine whether it can be simplified to the SAR or SEM. This choice is taken for two reasons: i) SDM subsumes the latter, and ii) with SDM, both direct and indirect effects can be analysed (LeSage, 2008).

From an econometric point of view, when exploratory spatial data analysis detects spatial effects, OLS estimates are unreliable. To avoid potential bias, we must determine which part of the spatial autocorrelation function affects either the independent variable or the error term (spatial lag or spatial errors, respectively). The most appropriate test for selecting the best model specification is to use two log-likelihood ratios: SDM against SAR, and SDM against SEM. As can be observed in Table 3, the probability value for both tests is less than 0.05 (similar results are obtained with the Wald test). Accordingly, the SAR and SEM models must be rejected, in favour of SDM, and henceforth this is the functional form used to study beta-convergence in the Iberian regions and to analyse spillover effects.

Table 3. Model specification test

Log-likelihood Ratio Test	*Iberian regions*	*Spanish regions*	*Portuguese regions*
LR joint significance spatial fixed effects	1721.858***	1196.824***	338.419***
LR joint significance time-period fixed effects	597.991***	411.844***	284.599***
LR SDM against SAR test	127.285***	29.866***	85.385***
LR SDM against SEM test	33.741***	35.267***	76.011***

Notes: Statistic significant: * at 10% level, ** at 5% level, *** at 1% level.
LR joint significance spatial and/or time-period fixed effects with probability greater than 5% implies rejection of spatial and/or time-period fixed effects, respectively.
LR SDM against SAR/SEM test with probability lower than 5% implies that SDM cannot be simplified to SAR or SEM, respectively.

4.3 Conditional convergence: estimates and spillover analysis

Table 4 shows the estimation results for a panel data SDM model applied to the analysis of the conditional beta convergence. The table also shows the negative sign of the estimated coefficient for initial GDPpc and all groups of regions, which is consistent with previous studies in this field, and indicates that regions with level of GDPpc achieve higher annual rates of growth. The estimated coefficients range from -0.194 for the Iberian regions to -0.129 for the Portuguese ones, and are greater than those for any other explanatory variable (lagged or not). Population density also seems to have a negative effect on the growth of GDPpc, especially for the Portuguese regions, where the coefficient (-0.099) is greater than for the Iberian regions (-0.092), while for the Spanish ones, the coefficient, although significant, is less than half the latter values (-0.044).

Therefore, regions with a low population density tend to have a higher rate of growth of GDPpc, as is readily observable in the inner Portuguese regions.

Regarding sectoral employment in the Iberian regions, the estimated coefficients are positive and significant only for agriculture and industry, although their values (0.003 and 0.010, respectively) are clearly lower than for population density. Similar results were obtained for the Spanish and Portuguese regions, with slight variations: i) in the Spanish regions, the employment share in agriculture is not significant, but in construction it is, at 10%, probably reflecting the impact of the housing bubble that persisted in Spain until 2008; and ii) in the Portuguese regions, the estimated coefficient for employment share in agriculture is slightly greater than for industry, which suggests that the first sector played a more significant role in economic growth. In either case, however, the values obtained are very small compared to the two first explanatory variables.

Spatially lagged explanatory variables such as GDPpc, population density, employment share in industry and services would also be significant in the Iberian regions, but with a positive sign. As in the previous case, the first two variables are the most significant, followed at a considerable distance by the other two. In other words, the neighbour's initial value of these variables contributes positively to growth in a given region. For Spanish and Portuguese regions, in general, only the neighbour's employment shares are significant (although for Portugal the neighbour's initial GDPpc is significant at 10%). Whereas for Spanish regions the most important variable is employment share in services, for Portuguese regions, this situation is shared with other sectors such as industry and agriculture. Furthermore, the coefficients for the Portuguese regions are greater than for the Spanish ones.

Table 4. Estimation results of conditional beta-convergence

Determinants	*Iberian regions*		*Spanish regions*		*Portuguese regions*	
	Coefficient	*t-stat.*	*Coefficient*	*t-stat.*	*Coefficient*	*t-stat.*
Initial GDP per capita	-0.194***	-31.61	-0.146***	-12.70	-0.129***	-10.55
Population density	-0.092***	-13.57	-0.044***	-3.79	-0.099***	-7.59
Agriculture	0.003***	2.69	0.002	1.36	0.008***	3.06
Industry	0.010***	7.05	0.010***	6.57	0.007**	2.08
Construction	0.002	1.34	0.004*	1.71	0.002	0.96
Services	0.006	1.28	0.009	1.19	0.009	1.44
Neighbour's initial GDPpc	0.118***	9.55	0.017	0.81	0.050*	1.94
Neighbour's population density	0.081***	8.56	-0.008	-0.39	-0.006	-0.17
Neighbour's agriculture	0.003	1.11	0.009**	2.55	0.029***	5.69
Neighbour's industry	0.009**	2.27	0.004	1.02	0.042***	4.47
Neighbour's construction	0.005	1.49	0.008*	1.75	0.008	1.43
Neighbour's services	0.047***	4.06	0.064***	3.41	0.074***	6.21
Neighbour's GDPpc growth rate	0.600***	17.58	0.449***	9.11	0.451***	8.04
R^2	0.972		0.978		0.973	
Corrected R^2	0.762		0.775		0.777	
Residuals variance	9.00E-06		9.00E-06		4.00E-06	
Log-likelihood	3630.736		2526.936		1221.934	
Observations	820		570		250	

Notes: Levels of variation are expressed in logs. Statistic significant: * at 10% level, ** at 5% level, *** at 1% level.
Corrected R^2 is R^2 without the contribution of fixed effects.

Neighbouring regions have a significant impact on regional growth, an effect that can be measured through the autoregressive parameter value δ. A value of 0.6 for this parameter indicates that a 10% growth in the GDPpc of a region will produce 6% growth in the same variable in a neighbouring region. The parameters estimated for the Spanish and Portuguese regions are significant at 1% level, although their values are lower than for the Iberian regions and strikingly similar (0.449 and 0.451, respectively).

The coefficients for the initial GDPpc and that of the neighbouring region have opposite signs (-0.194 and 0.118, respectively). This suggest that regions with lower income levels tend to grow at a faster rate and that the proximity of these regions to those with a higher level of economic activity generates spillover effects from the latter. Therefore, the Iberian regions not only grow faster because of their greater distance to the steady state, but they also benefit if neighbouring regions exhibit high levels of GDPpc.

To correctly measure the effect of the initial level of GDPpc on regional growth, it is necessary to analyse both direct and indirect impacts (see Table 5). The first of these quantifies the impact (on average) on the annual rate of growth of GDPpc in a region, by reference to its own level in the initial year, while the second quantifies the feedback effects that occur when this level affects growth in neighbouring regions. In the Iberian regions, the direct effect (-0.1941) is slightly lower than the parameter estimate (-0.194), and so the feedback effects are very small (-0.0001). Nevertheless, they do have a positive impact on the convergence of the Iberian regions. However, for the Spanish and Portuguese regions, this impact is greater (-0.0039 and -0.0014, respectively), representing an increase of 2.60 and 1.07%. These values indicate the presence of spatial spillovers in Spain and Portugal for GDPpc (especially in the first case), but very slight ones for the Iberian regions as a whole.

With respect to other explanatory variables, our results show that direct effects for population density and employment share in industry are significant (at 1% level) in all the regional groups considered, but with different signs: negative and positive, respectively. The magnitude of the latter is very similar, in turn, for population density, although the value for the Portuguese regions is more than double that for the Spanish ones. In both cases, these values are greater than for employment share, independently of the sector.

Table 5. Estimation of direct, indirect and total effects in the Spatial Durbin model

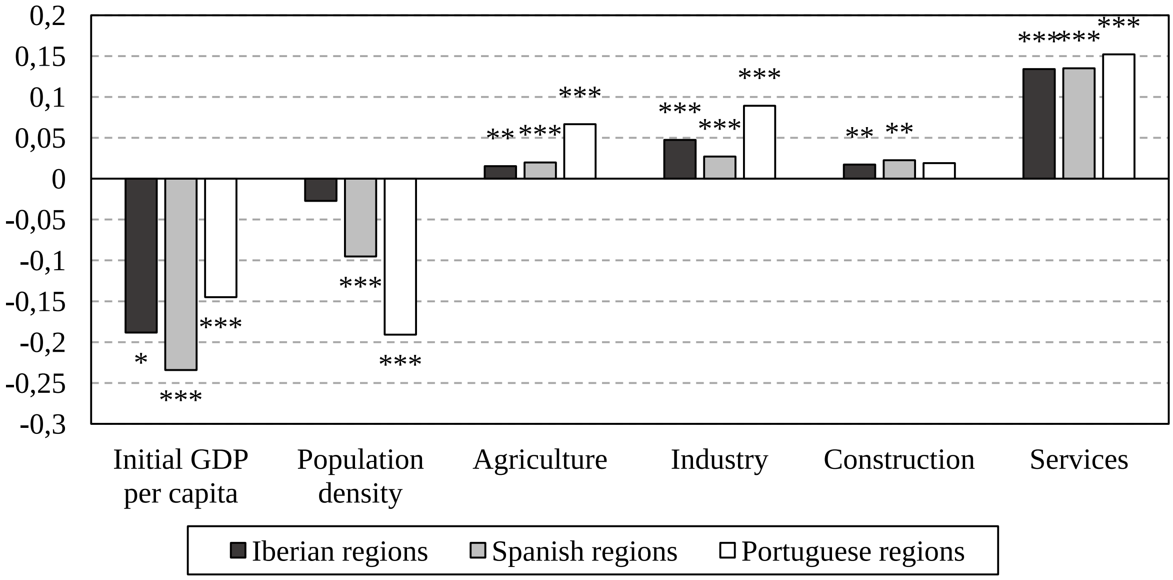
Effects	*Initial GDP per capita*	*Population density*	*Agriculture*	*Industry*	*Construction*	*Services*
Iberian regions						
Direct	-0.1941*** (-33.299)	-0.0894*** (-13.836)	0.0038*** (3.126)	0.0118*** (7.281)	0.0028* (1.783)	0.0123** (2.384)
Indirect	0.0057 (0.254)	0.0621*** (3.475)	0.0116* (1.94)	0.0356*** (3.821)	0.0144* (1.841)	0.1218*** (4.444)
Total	-0.1884*** (-8.469)	-0.0272 (-1.534)	0.0154** (2.421)	0.0474*** (4.645)	0.0172** (2.032)	0.1341*** (4.551)
Spanish regions						
Direct	-0.1499*** (-13.898)	-0.0469*** (-4.282)	0.0028** (2.052)	0.0112*** (6.516)	0.0048** (2.094)	0.0159* (1.969)
Indirect	-0.0843*** (-2.943)	-0.0484 (-1.646)	0.0171*** (2.905)	0.016** (2.224)	0.0177** (2.104)	0.1192*** (3.725)
Total	-0.2342*** (-8.366)	-0.0953*** (-3.303)	0.0199*** (3.07)	0.0271*** (3.387)	0.0225** (2.362)	0.1351*** (3.778)
Portuguese regions						
Direct	-0.1304*** (-11.093)	-0.1033*** (-8.351)	0.0108*** (4.139)	0.0109*** (3.015)	0.003 (1.229)	0.0156** (2.651)
Indirect	-0.0146 (-0.360)	-0.0875* (-1.735)	0.0559*** (6.671)	0.0783*** (4.577)	0.016 (1.594)	0.1365*** (6.796)
Total	-0.145*** (-3.629)	-0.1908*** (-3.833)	0.0667*** (7.135)	0.0892*** (4.71)	0.019 (1.702)	0.1521*** (7.25)

Note: T-statistics shown in brackets. Statistic significant: * at 10% level, ** at 5% level, *** at 1% level.

Furthermore, there are significant direct effects for employment share in agriculture in the Portuguese regions, and also for the Iberian ones, albeit with a lower value. However, this is not the case for the Spanish regions, which implies that Portuguese agriculture exerts a notable influence on the magnitude of direct effects for the Iberian regions, and the same could also be said for the construction sector in Spain.

By contrast, the indirect effect reflects the average impact of the neighbour's initial GDPpc on the region's growth; however, this value is not significant and, therefore, the total impact is negative, and is quantified as -0.1884. This means that regions that presented a 10% lower initial GDPpc, five years previously, achieve average growth rate increases of 1.88%. This is also true for the Portuguese regions, although with a lower value (1.45%), but not for the Spanish ones, where indirect effects are significant, which reinforces the convergence effect (2.34%). The outcome of this is that the initial level of GDPpc in a typical region increases when the GDPpc grows in a neighbouring region. The negative and positive signs of the direct and indirect effects, respectively, show that the change in initial GDPpc of a region (on average) has a negative impact on the regional growth (direct effect), which in turn has a positive influence on growth in others (indirect effect) due to the presence of positive spatial dependence on neighbouring regions' GDPpc.

Figure 3. Estimated total effects for explanatory variables in conditional convergence



Note: Statistic significant: * at 10% level, ** at 5% level, *** at 1% level.

The total effect of population density in Iberian regions is not significant, because the negative direct effect is compensated by the positive indirect one. Both of these effects are significant and present similar values. Of particular importance is the negative and significant total effect for the Portuguese regions, the value of which (-0.1908) is twice that obtained for the Spanish regions (-0.0953), highlighting the impact of population density on the convergence process in the first-named regions, even exceeding the total effect of initial GDPpc.

With regard to employment sectoral structure in the Iberian regions, all sectors have a positive and significant impact (at 1% or 5% level) on regional growth. However, the role played by the services sector is much greater than that of the other sectors. A similar situation is observed in both the Spanish and the Portuguese regions, except for the construction sector in the latter.

In the Iberian regions, the change in the initial level of services employment share in neighbouring regions is approximately ten times greater than the direct effect. In other words, when the initial services share changes in a region, not only the growth rate of that region but also that of others will change. The proportion of change in other regions and in the region itself is approximately 1 to 9.9. Furthermore, according to the t-statistics, this indirect effect is significantly different from zero at a significance level of 1%. This would indicate that neighbouring regions with an initial low/high services share level stimulate lower/higher growth in the region, because neighbouring regions enhance the region's decreasing/increasing returns to scale.

5. CONCLUSIONS

During the period 2000-2014, GDP per capita in the Iberian regions grew at a cumulative growth rate of 0.303%, while in the Spanish and Portuguese regions it increased at 0.313% and 0.03%, respectively. Our spatial analysis shows that in 2000 the lowest GDPpc values were found in the south-western third of the Iberian Peninsula: almost all of Portugal (except Lisbon and, to a lesser extent, Algarve and Alentejo Litoral), plus Extremadura, Central Andalusia and the southern Castilian regions in Spain. The highest values were observed in the northeast quadrant regions, plus Lisbon and several Atlantic (Alentejo Litoral, Algarve and Huelva) and Mediterranean regions (Almeria, Murcia and Alicante). Furthermore, the global Moran's Index test results suggest that the GDPpc in the Iberian regions is not randomly distributed over the space, both for the Iberian regions as a whole and for those in Spain and Portugal individually.

To determine whether the recent growth of GDPpc and the regional beta-convergence in the Iberian regions is explicable in terms of changes in productive structure and population density, and taking spatial feedback effects into account, we included spatial effects in a traditional conditional convergence model, following previous research in this field. On the basis of the estimation test results for the panel data model, the SDM model was used to study the conditional beta-convergence and the spillover effects in the Iberian regions.

With this model, we observed a negative sign of the coefficient for initial GDPpc, for all groups of regions, which is consistent with previous research findings and indicates that regions with lower levels of GDPpc will exhibit higher annual rates of growth. The estimated coefficients are greater than those for any other explanatory variable (lagged or otherwise). Furthermore, the coefficients obtained for the initial GDPpc in a region and that in a neighbouring one have opposite signs. This suggest that regions with lower income levels tend to grow more strongly and, moreover, that the proximity of these regions to those with a higher level of economic activity generates spillover effects by the latter. Therefore, the Iberian regions not only grow faster because of their greater distance to the steady state, but they also benefit if the neighbouring regions exhibit high GDPpc levels.

Population density also seems to have a negative effect on the growth of GDPpc, especially for the Portuguese regions, because their coefficients are greater than for the Iberian regions, while in the case of the Spanish regions, although significant, the coefficient is less than half this value. Therefore, in regions with a low population density, the GDPpc growth rate tends to be higher, as is readily observable in the inner Portuguese regions.

The coefficients for employment share according to the activity sector are positive and significant only for agriculture and industry, but with values that are clearly lower than those for population density. These results are similar for both the Spanish and the Portuguese regions, with some particular features: i) in the Spanish regions, the employment share in agriculture is not significant, but in construction it is significant at 10%; and ii) in the Portuguese regions, the coefficient for employment share in agriculture is slightly greater than for industry, indicating the greater weight of the first sector in regional economic growth.

Spatially lagged explanatory variables, such as GDPpc, population density and employment share in industry and services, are also significant in the Iberian regions, with a positive sign. Thus, the neighbour's initial value of these variables is positively associated with growth in a given region. For the Spanish and Portuguese regions, in general, only the neighbouring region's employment share is significant. While for the Spanish regions the most important variable is employment share in services, for the Portuguese ones, industry and agriculture are equally important.

To correctly measure the impact of the initial level of GDPpc on regional growth, it is necessary to analyse both direct and indirect impacts. In the Iberian regions, the direct effect is slightly lower than the parameter estimated, and therefore feedback effects are very small. For the Spanish and Portuguese regions, however, this impact is greater, which indicates the presence of spatial spillovers in Spain and Portugal in GDPpc (especially in the former).

With respect to other explanatory variables, the direct effects for population density and employment share in industry are significant in all the regional groups considered, but with different signs: negative and positive, respectively. It is particularly significant that the population density effect for the Portuguese regions is greater than that for the Spanish ones. In addition, employment share in agriculture has a notable impact in the Portuguese regions. This is not the case in Spain, which suggests that Portuguese agriculture exerts a major influence on the impact of direct effects for the Iberian regions, and the same might also be said for the construction sector in Spain.

The indirect effect of GDPpc is significant for the Spanish regions, but not for the Portuguese or Iberian ones, which reinforces the convergence effect in the first case. In consequence, the initial level of GDPpc in a typical Spanish region will increase when that of a neighbouring region does. The negative and positive signs of the direct and indirect effects, respectively, show that the change in initial GDPpc of a region (on average) impacts negatively on the region's own growth (direct effect), which in turn has a positive influence on growth elsewhere (indirect effect), due to the presence of positive spatial dependence on neighbouring regions' GDPpc.

Regarding the total effect of population density, of particular importance is the negative and significant total effect for the Portuguese regions, the value of which is twice that of the Spanish regions, indicating the relevance of population density to the convergence process in Portugal, where it even exceeds the total effect for initial GDPpc. With regard to employment sectoral structure in the Iberian regions, although all sectors have a positive and significant impact on regional growth, the impact of the services sector is much greater than that of the other sectors. The change in the initial level of services employment share in neighbouring regions appears to be approximately ten times greater than the direct effect, which suggests that neighbouring regions with an initial low/high services share level stimulate lower/higher growth in the region, because neighbouring regions enhance the region's decreasing/increasing returns to scale.

With respect to convergence in the Iberian regions, it is important to recall the role played by the European Regional Development Fund and the European Social Fund in promoting economic and social cohesion, by reducing disparities between Member States and regions. These funds played an important role in the economic success of the two countries between 1995 and 2004. Thus, the cohesion policy contributed to increasing the density of the motorway network in Portugal by 200%, and it is also estimated to have limited the rise in unemployment. Undoubtedly, these factors have enhanced the spatial integration between the Spanish and Portuguese economies. Therefore, it would be interesting to include these European funds in a future analysis as an explanatory variable, in order to determine the impact of such financial instruments in strengthening regional convergence in the Iberian regions.

Finally, in view of the importance of services employment in these economies, in future research it would be useful to disaggregate services employment by activity branches to determine which of them present a better fit in the model considered.

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APPENDIX A. NUTS CLASSIFICATION FOR SPAIN AND PORTUGAL

NUTS-0	NUTS-1	NUTS-2	NUTS-3	NUTS-0	NUTS-1	NUTS-2	NUTS-3
ES Spain	ES1 North West	ES11 Galicia	ES111 A Coruña	ES Spain	ES6 South	ES61 Andalusia	ES612 Cádiz
			ES112 Lugo				ES613 Córdoba
			ES113 Ourense				ES614 Granada
			ES114 Pontevedra				ES615 Huelva
		ES12	ES120 Asturias				ES616 Jaén
		ES13	ES130 Cantabria				ES617 Málaga
	ES2 North East	ES21 Basque Country	ES211 Araba/Álava				ES618 Sevilla
			ES212 Gipuzkoa			ES62	ES620 Murcia
			ES213 Bizkaia			ES63	ES630 Ceuta (ES)
		ES22	ES220 Navarra			ES64	ES640 Melilla (ES)
		ES23	ES230 La Rioja		ES7 Canary Islands	ES70	ES703 El Hierro
		ES24 Aragon	ES241 Huesca				ES704 Fuerteventura
			ES242 Teruel				ES705 Gran Canaria
			ES243 Zaragoza				ES706 La Gomera
	ES3	ES30	ES300 Madrid				ES707 La Palma
	ES4 Centre	ES41 Castile and Leon	ES411 Ávila				ES708 Lanzarote
			ES412 Burgos				ES709 Tenerife
			ES413 León	PT Portugal	PT1 Mainland	PT11 Norte	PT111 Alto Minho
			ES414 Palencia				PT112 Cávado
			ES415 Salamanca				PT119 Ave
			ES416 Segovia				PT11A Area Metropolita-na do Porto
			ES417 Soria				PT11B Alto Tâmega
			ES418 Valladolid				PT11C Tâmega e Sousa
			ES419 Zamora				PT11D Douro
		ES42 Cas-tile La Mancha	ES421 Albacete				PT11E Terras de Trás-os-Montes
			ES422 Ciudad Real			PT15	PT150 Algarve
			ES423 Cuenca			PT16 Centro	PT16B Oeste
			ES424 Guadalajara				PT16D Região de Aveiro
			ES425 Toledo				PT16E Região de Coim-bra
		ES43 Ex-tremadura	ES431 Badajoz				PT16F Região de Leiria
			ES432 Cáceres				PT16G Viseu Dão Lafões
	ES5 East	ES51 Cata-lonia	ES511 Barcelona				PT16H Beira Baixa
			ES512 Girona				PT16I Médio Tejo
			ES513 Lleida				PT16J Beiras e Serra da Estrela
			ES514 Tarragona			PT17	PT170 Area Metropolitana de Lisboa
		ES52 Valencian Community	ES521 Alicante			PT18 Alentejo	PT181 Alentejo Litoral
			ES522 Castellón				PT184 Baixo Alentejo
			ES523 Valencia				PT185 Lezíria do Tejo
		ES53 Bale-aric Islands	ES531 Ibiza, For-mentera				PT186 Alto Alentejo
			ES532 Mallorca				PT187 Alentejo Central
			ES533 Menorca		PT2	PT20	PT200 Região Autonoma dos Açores
	ES6	ES61	ES611 Almería		PT3	PT30	PT300 Região Autonma da Madeira