Geographic and Demographic Determinants of Regional Growth and Convergence: a Network Approach[1]

Determinantes Geográficos e Demográficos do Crescimento e da Convergência Regionais: uma Abordagem de Rede

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Abstract/Resumo

This paper examines the evolution of spatial similarities and disparities in the Iberian Peninsula, using data on GDP per capita of 81 NUTS 3 Portuguese and Spanish regions over the period 1995-2012. The main geographic and demographic determinants of growth are taken into account, dividing the regions in several groups, namely "(common)-border", "interior (without border)", "coastal", "metropolitan" and "ultra-peripheral". After a brief analysis of the relative performance of regions and the quantification of sigma and beta-convergence trends, a network approach is applied, based on a metric space build from the correlation coefficients between the log-differences of regional GDP per capita. This metric space and the corresponding topological setting are use to develop networks of Iberian regions, uncovering the main geographic and demographic determinants of regional growth and convergence.

Keywords: Regional growth and convergence; Portuguese and Spanish regions; demographic and geographic determinants of growth; network dynamics

JEL Codes: R11; R12; C45

Este artigo examina a evolução das similitudes e das disparidades espaciais na Península Ibérica, utilizando dados sobre o PIB por habitante de 81 regiões NUTS 3 portuguesas e espanholas, no período 1995-2012. Os principais fatores geográficos e demográficos que determinam o crescimento são tidos em consideração, dividindo as regiões em cinco categorias, a saber, "fronteiriças"; "interiores"; "litorais"; "metropolitanas" e "ultra-periféricas". Depois de uma breve análise à performance relativa das regiões e à quantificação da convergência sigma e beta, usa-se uma abordagem de rede baseada num espaço métrico construído a partir dos coeficientes de correlação entre as diferenças logarítmicas do PIB por habitante das regiões. Este espaço métrico e a topologia correspondente são usados para construir as redes de regiões ibéricas, ilustrando os principais determinantes geográficos e demográficos do crescimento e da convergência regionais.

Palavras-chave: crescimento e convergência regionais; regiões de Portugal e Espanha; determinantes demográficos e geográficos do crescimento; dinâmica de rede

Códigos JEL: R11; R12; C45

[1] **Acknowledgments.** We would like to thank the financial support from national funds by FCT (Fundação para a Ciência e a Tecnologia). This article is part of the Strategic Project: UID/ECO/00436/2013. We also thank the useful comments made by two anonymous referees.

1. INTRODUCTION

This paper examines the evolution of spatial disparities in the Iberian Peninsula, using data on GDP per capita of Portuguese and Spanish regions over the period 1995-2012. During many centuries, the relation between the two Iberian countries was marked by conflicts, misunderstanding and weak economic relations (Royo and Manuel, 2001). In 1986 they became members of the European Economic Communities, now European Union, and started a period of partnership and strong economic integration. According to Diéguez and Caramelo (2001), one of the main consequences of this political event was felt in the common border areas of these countries, that finally started to cooperate, after centuries of hostility, or mutual ignorance at best. However, the full potential of economic cooperation among Iberian regions is far from exhausted (Carvalho and Mourato, 2010; Ribeiro and Silva, 2011), and the same is concluded by McCallum (1995) when assessing the importance of national borders to Canadian-US regional trade patterns.

Another important advantage of sharing a common economic and political space, not entirely explored until now, is the facilitation of inter-regional movement of workers, in response to asymmetric shocks or as a result of several other economic and non-economic factors, such as the median family income, employment growth, tax burdens, regional and local government education and health outlays, cost of living, climate amenities (Gunderson et al, 2008). Moreover, a variety of researchers have also found evidence that geographic distance is an important determinant of interstate and regional migration (Cushing, 1986; Gunderson and Sorenson, 2010 and Butters et al, 2012). So, the proximity of Iberian regions in the European context, and particularly, the common border regions of Portugal and Spain, are expected to generate strong migration flows with a great impact on regional per capita growth and convergence. An interesting discussion of migration impacts is made by Bakens and Nijkamp (2010) and the characterization of this phenomenon in the Portuguese interior regions is provided in Ramos and Jacinto (2010).

This paper tries to empirically quantify the strength (or weakness) of a "border effect" in the dynamics of regional performance in the Iberian Peninsula. It will also characterize the interplay of geographic and demographic effects, dividing the remaining regions (those not around the common border between Portugal and Spain) in "coastal" and "interior" (a self explained division) and large "metropolitan" ones (those with urban areas with a population of more than 700.000 persons in Spain, and more than 300.000 in Portugal), independently of being "coastal" or "interior".

In Araújo and Lopes (2013) a similar study was made for the period starting in 1995 and ending in 2008, the year before the start of the great recession. The main contribution of the present paper is threefold: i) improving the application of the Stochastic Geometry Technique and the corresponding Network Approach to the Regional Growth and Convergence setting; ii) extending the data to 2012, in order to encompass the effects of macroeconomic shocks post-2008 on Iberian regional growth and convergence; iii) performing a specific analysis of the Portuguese and Spanish Networks.

The rest of the paper is organized as follows. The next section describes the data and the classification of regions and makes a quantitative analysis of regional growth and convergence over the period 1995-2012. The main section of the paper (Section 3) applies a stochastic geometry technique and a network approach to uncover the regional economic dynamics. Using a metric based on the correlation coefficients between the GDP per capita of the Iberian regions, a method is applied to reconstruct a metric space from the empirical data. Having a metric defined in the space of Iberian regions, some topological coefficients are used to extract further information from the data, namely to illustrate the relative strength of the administrative, geographic and demographic effects on the regional development process. Section 4 ends the paper with some concluding remarks.

2. REGIONAL GROWTH AND CONVERGENCE IN THE IBERIAN PENINSULA

The analysis of regional growth, convergence and spatial correlations made in this paper is based on the time series of GDP per capita of the regions of Portugal and Spain, provided by the Regional Database of EUROSTAT: Regional Economic Accounts (available at: http://ec.europa.eu/eurostat). The period covered is 1995-2012 and the regional level at which the analysis is made is NUTS 3, because it is preferable to assess the regional economic performance at the most detailed level as possible, and the NUTS 2 level is not adequate for this purpose. There are 30 NUTS level 3 regions in Portugal, 28 in mainland and 2 autonomous regions (Madeira and Azores islands). In Spain there are 59 NUTS level 3 regions: 47 in mainland, two archipelagos (Baleares islands – 3 NUTS 3 regions; Canarias islands – 7 NUTS 3 regions) and two (NUTS 3) enclave cities in Northern Africa (Ceuta and Melilla). As the values for GDP per capita in the NUTS 3 regions of Baleares and Canarias are not available for the whole period in the EUROSTAT database, we work with the values for the NUT 2 level in these cases. So, our database has 81 regions, 30 of Portugal and 51 of Spain.

The next step is to classify the regions according to our analytical purpose. As we give priority to assessing the (political and administrative) effect on regional growth performance when there is a common border, we begin by isolating the 17 regions affected by this criterion (10 in Portugal and 7 in Spain), and call them (common) "Border" regions. The next criterion was of a pure geographical nature, dividing the regions in those having some part of its territory with a sea cost ("Coastal" regions) and those having not ("Interior" regions). This is an obvious classification that does not deserve much explanation. However, we complement this classification with a further criterion, a demographic one due to the agglomeration of economies and being associated to the new economic geography (Krugman, 1991; Krugmam and Venables, 1995) and endogenous growth (Lucas, 1988). An autonomous category is created for large "Metropolitan" regions, being considered (relatively) large those having more than 700.000 inhabitants in Spain and more than 300.000 in Portugal. Combining both criteria we have then 38 (non common frontier) interior regions (10 in Portugal; 28 in Spain), 22 (non common frontier) coastal regions (6 in Portugal; 16 in Spain) and 12 large metropolitan regions (3 in Portugal; 9 in Spain).

Finally, being particularly different, for political, administrative and geographical reasons, we group in a separated category the so called (ultra-)"Peripheral" regions of Madeira, Azores, Baleares, Canarias, Ceuta and Melilla. A list with all the regions considered, the corresponding NUTS 3 code and the classification labels (1: Coastal, 2: Border, 3: Interior, 4: Metropolitan, 5: Peripheral; S: Spanish; P: Portuguese) is presented in Appendix 1.

We start with an easy but suggestive assessment of regional economic growth in the Iberian Peninsula, comparing the annual average growth of GDP per capita of Spanish and Portuguese regions. Looking at the top 10 regions according with this indicator (see Table 1), 8 of them are Portuguese and relatively low developed, one is a Spanish interior regional (Badajoz) and the other an ultra-peripheral one (Baleares Islands), which points to a trend of convergence and to the advantages of economic backwardness. Regarding the bottom 10 regions (see Table 2); the picture is more mixed and divided, with 6 Spanish regions and 4 Portuguese regions, most of them occupying an intermediate position in the GDP per capita scale.

Table 1. Gdp per capita average annual growth rate, top 10 regions

N	NUT3	CLA.	REGION	AG95-12
1	PT300	PP	Madeira	2,94
2	ES530	EP	Illes Baleares	2,60
3	PT166	PI	Pinhal Interior Sul	2,22
4	PT117	PF	Douro	1,66
5	PT181	PL	Alentejo Litoral	1,60
6	PT167	PI	Serra da Estrela	1,57
7	PT200	PP	Açores	1,51
8	PT118	PF	Alto Trás-os-Montes	1,48
9	ES431	EB	Badajoz	1,45
10	PT168	PF	Beira Interior Norte	1,42

Source: Eurostat and authors' calculations

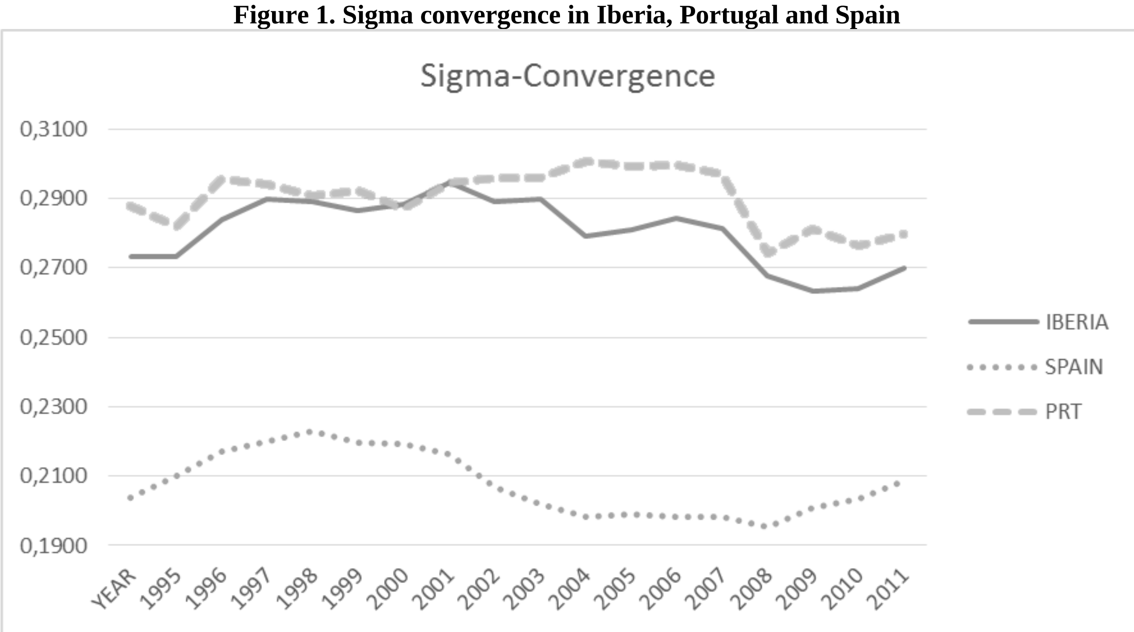
Table 2. Gdp per capita average annual growth rate, bottom 10 regions

N	NUT3	CLA.	REGION	AG95-12
72	ES700	EP	Canarias (ES)	-0,06
73	ES514	EL	Tarragona	-0,07
74	ES522	EL	Castellón	-0,09
75	PT16B	PL	Oeste	-0,13
76	ES521	EM	Alicante	-0,16
77	PT172	PM	Península de Setúbal	-0,17
78	PT161	PL	Baixo Vouga	-0,21
79	PT114	PM	Grande Porto	-0,28
80	ES640	EP	Melilla (ES)	-0,30
81	ES424	EI	Guadalajara	-0,45

Source: Eurostat and authors' calculations

The classical approach to national and regional relative growth assessment revolves around the convergence debate, based on several methods and research strategies, namely sigma and beta convergence (Barro and Sala-i-Martin, 1991; 1992). Sigma convergence is measured by the evolution of dispersion (standard deviation or coefficient of variation) of GDP per capita of countries or regions. In the case of the Iberian Peninsula a very slight decrease of this indicator emerges, between 1995 and 2012, with two contradictory trends: an increasing one (divergence) until 2001, and a decreasing one (convergence) after this year (see Figure 1). It is also worth noting that the dispersion of regional per capita GDP is greater in Portugal (coefficient of variation around 0.29) than Spain (coefficient of variation around 0.21). This result is in accordance with other studies of this phenomenon (Costa e Fonseca, 2005; Sanchez and Roura, 2008; Viegas and Antunes, 2011).

Figure 1. Sigma convergence in Iberia, Portugal and Spain



Source: Eurostat and authors' calculations

Beta convergence is measured by the (inverse) relation between annual average growth and initial level of GDP per capita, absolute (unconditional) or relative (conditional on differences in structural factors of growth). This inverse relation is associated with the negative signal of the parameter beta estimated in the following regression:

$$\frac{1}{T}\ln\left[\frac{Y_{r,T}}{Y_{r,0}}\right] = \alpha + \beta ln\left[Y_{r,0}\right] + \varepsilon \quad \textbf{(1)}$$

The velocity of convergence implicit in this relation (Barro and Sala-i-Martin, 2004) is given by:

$$\beta' = \frac{\ln(1+T\beta)}{T} \quad \textbf{(2)}$$

An exercise of absolute beta convergence in the Iberian Peninsula, Spain and Portugal was made, at the level of NUTS 3 regions, and the results are shown in Table 3. The main conclusion is favorable to the convergence hypothesis, giving the negative signal of the parameter estimated, but the statistical significance is limited to the global (Iberian Peninsula) and Portuguese cases. However, in all the cases the velocity of convergence is very low (inferior to one percent). This result is also consistent with previous studies of regional convergence in Spain and Portugal (Lopes, 2004; Soukiazis and Antunes, 2004; Cardoso and Pentecost, 2011; Viegas and Antunes, 2011).

Table 3: Beta convergence in Iberia, Portugal and Spain - 1995/2012

Regression	Iberia	Spain	Portugal
Number of observations	81	51	30
R^2	0,120	0,051	0,205
Adjusted R^2	0,109	0,032	0,176
Constant	0,079**	0,064	-0,121*
t-stat.	*3,620*	*1,820*	*2,881*
ln GDPpc 95	-0,007*	-0,006	-0,012*
t-stat.	*-3,280*	*-1,624*	*-2,683*
Annual speed of convergence	0,66%	0,57%	1,09%
Half-life of convergence	104,80	121,32	63,47

Note: ** significant at 1%; * significant at 5%
Source: Eurostat and authors' calculations

There are more sophisticated techniques for measuring convergence, as the convergence clubs approach of Quah (1996) or the Markov chains and related models (Fingleton, 1997; Le Gallo, 2004), among others. At the regional level, an important subject to deal with is the spatial autocorrelation, implying the convenience to use a geographic distance (weight) matrix in the convergence regressions (Eckey and Türk, 2007). In this paper, we follow a different approach to model the regional growth connections and disparities, which combines a stochastic geometry technique with network analysis. Although based on the same data (regional GDP per capita values), this approach is different from classical (sigma and beta) convergence analysis. Instead of measuring dispersion of GDP per capita among regions or regressing future average growth rates on initial values, all the annual growth rates are taken into account and compared in order to build a topological space of regional growth and convergence, highlighting the main similarities and differences between regions.

3. IBERIAN REGIONAL PERFORMANCE THROUGH A NETWORK APPROACH

From the time series with the GDP per head values of a set of Portuguese and Spanish regions a stochastic geometry technique (Vilela Mendes et al., 2003) is used to define networks of Iberian regions, to which the usual network coefficients are computed. The stochastic geometry technique is simply stated in the following terms:

1) pick a set of N regions and their historical data over a chosen time interval and
2) considering the vectors $\vec{p}(k)$ with the GDP per head yearly values of each region (k), define a normalized vector

$$\vec{\rho}(k) = \frac{\vec{p}(k) - \langle \vec{p}(k) \rangle}{\sqrt{n\left(\langle \vec{p}^{\,2}(k) \rangle - \langle \vec{p}(k) \rangle^2\right)}} \quad \textbf{(3)}$$

where n is the number of components (number of time labels considered in the chosen time interval) in the vector $\vec{p}$ and < > the average value of the observations over time,

3) compute an Euclidean distance ($d_{k,l}$) (as proposed in Mantegna, 1999) between each pair of regions

$$d_{k,l} = \sqrt{2(1-C_{kl})} = \|\vec{\rho}(k) - \vec{\rho}(l)\| \quad \textbf{(4)}$$

where C_{kl} is the correlation coefficient between the pair of regions (k and l) computed along the chosen time interval (of length n).

The fact that $d_{k,l}$ is a properly defined distance gives a meaning to geometric notions and geometric tools in the study of the set of regions. Given the Euclidean distances between each pair of regions, the question now is reduced to an embedding problem: one asks what is the smallest geometric object (in number of dimensions) containing the set of regions. If the proportion of systematic information present in correlations between regions is small, then the corresponding geometric object will be a low-dimensional entity.

The systematic information contained in the low-dimensional space captures the structure of the deterministic correlations and economic trends that are driving the economic space, whereas the remainder of the space may be considered as being generated by random fluctuations.

The following technique was used for this purpose:

4) after the distances ($d_{k,l}$) are calculated for the set of N regions, they are embedded in R^{N-1} with coordinates $\vec{x}(k)$.

5) the center of mass $\vec{R}$ is then computed and the coordinates reduced to the center of mass

$$\vec{R} = \frac{\sum_k \vec{x}(k)}{k} \quad \textbf{(5)}$$

$$\vec{y}(k) = \vec{x}(k) - \vec{R}) \quad \textbf{(6)}$$

6) the matrix

$$T_{ij} = \sum_k \vec{y}_i(k)\vec{y}_j(k) \quad \textbf{(7)}$$

is diagonalized to obtain the set of normalized eigenvalues and eigenvectors $\{\lambda_i, \vec{e}_i\}$.

7) the eigenvectors $\vec{e}_i$ define the characteristic directions of the set of regions and their coordinates $z_i(k)$ are obtained by the projection.

$$z_i(k) = \vec{y}_i \bullet \vec{e}_i \quad \textbf{(8)}$$

8) the characteristic directions correspond to the eigenvalues (λ_i) that are clearly different from those obtained from surrogate data. They define a reduced subspace of dimension d, which carries the systematic information related to the correlation structure of the regional space.

This corresponds to the identification of empirically constructed variables that drive the set of regions, and, in this framework, the number of surviving eigenvalues is the effective characteristic dimension of this regional space. As regional spaces can be described as low dimension objects, the geometric analysis is able to provide crucial information about their dynamics.

Different applications of this technique, namely for the identification of periods of stasis and of mutation of financial markets have been described in Araújo (2011), Araújo et al. (2007 and 2008) and Vilela Mendes et al. (2003). In Lopes et al. (2011) this technique is used to assess the clustering behavior implicit on sectoral gross output dynamics. In this paper we address the identification of strongly and weakly correlated regions, accordingly to the simultaneous evolution of their GDP *per capita* values along a certain time interval. In Araújo and Lopes (2013) a similar study was made for the period starting in 1995 and ending in 2008, the year before the start of the global financial and economic crisis. So, the main contribution of this paper is extending the data to 2012, in order to assess the effects of the macroeconomic shocks post-2008 on Iberian regional growth and convergence.

3.1 From a geometrical to a topological approach

The existence of a distance metric allows for the application of a topological approach in order to identify a network of regions associated to the regional space. From the matrix of distances $d_{k,l}$ computed in the reduced d-dimensional space, we apply the hierarchical clustering process to construct the minimal spanning tree (*MST*) that connects the N regions. Then the Boolean graph B is defined by setting

$$\begin{aligned} &b(k,l) = 1 \quad if \quad d(k,l) \le L \\ &b(k,l) = 0 \quad otherwise \end{aligned} \quad \textbf{(9)}$$

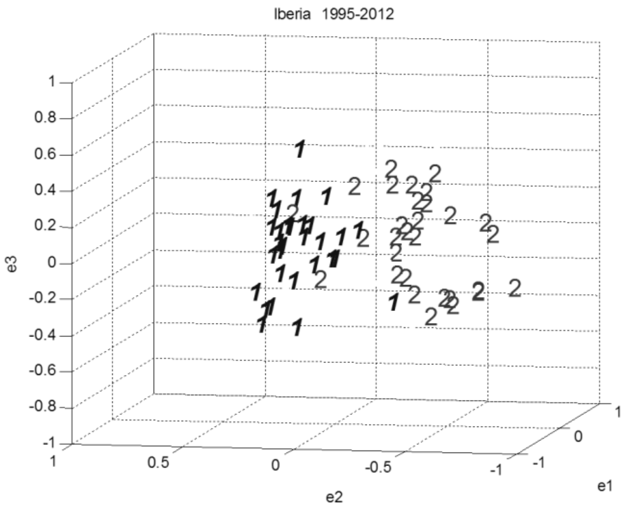
where L is the smallest threshold distance value that assures connectivity of the whole network in the hierarchical clustering process.

3.2 Regional spaces and their corresponding networks of regions

Results were computed using actual data, which consists in the set of yearly GDP *per capita* values of 81 regions with a time window of 18 years, from 1995 to 2012. We also compute results from surrogate data, i.e. data generated by permuting the GDP *per capita* values of each region randomly in time. As each region is independently permuted, time correlations among regions disappear, while the resulting surrogate data preserve the mean and the variance that characterize actual data.

Comparing results obtained from actual data with results computed from surrogate data has shown that the regional space has only three dimensions (the corresponding manifold can be contained in a 3-dimensional space). Figure 2 shows the projection of the coordinates of the set of 81 regions on these three characteristic directions. These directions are obtained from matrix T (see equation 7), whose diagonalization provides the set of normalized eigenvectors, conveying the structure of the deterministic correlations and economic trends that are driving the economic space.

Figure 2.The geometric space of the 81 Iberian regions by country



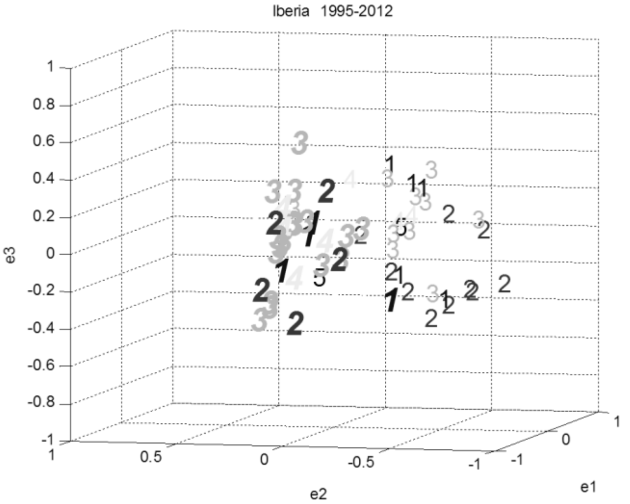
Note: 1- Portugal; 2 – Spain
Source: Eurostat and authors' calculations

In this figure the Portuguese regions are identified as "1" while the Spanish regions are identified as "2". It is clear that the two sets of regions (Portuguese and Spanish) seem to occupy different slots in the 3-dimensional space.

In the *3*-dimensional space presented in Figure 3, the 81 Portuguese and Spanish regions are represented according to the geographical and demographic classification described in section 2, according to the following legend: 1:Coastal, 2:Border, 3:Interior, 4:Metropolitan, 5:Peripheral. When the region is a Portuguese one it is represented in large, while Spanish regions have a smaller representation. Again, the observation of the 3-dimensional space of regions seems to lead to the identification of a tendency towards the occupation of different space slots depending on the country: Portuguese regions seem to be concentrated in the left side of the plot while the Spanish ones are mostly in the right. Moreover, the Interior regions seem to spread all over the *3*-dimensional space, while the Border regions are slightly less uniformly distributed on this space.

When the geometric distances are used to define the projected Boolean graph B (as in Equation *5*), it was empirically found that the set of 81 regions correspond to a highly connected network (the network average degree is around N/2) where the lack of sparseness makes unadvised the computation of typical to-

Figure 3.The geometric space of the 81 Iberian regions by type and country



Note: 1-Coastal, 2-Border, 3-Interior, 4-Metropolitan, 5-Peripheral, and Countries: Spain - small numbers, Portugal – large numbers.
Source: Eurostat and authors' calculations

pological coefficients as clustering and path length.

When the geometric distances are used to define the projected Boolean graph *B* (as in Equation *5*), it was empirically found that the set of 81 regions correspond to a highly connected network (the network average degree is around N/2) where the lack of sparseness makes unadvised the computation of typical topological coefficients as clustering and path length.

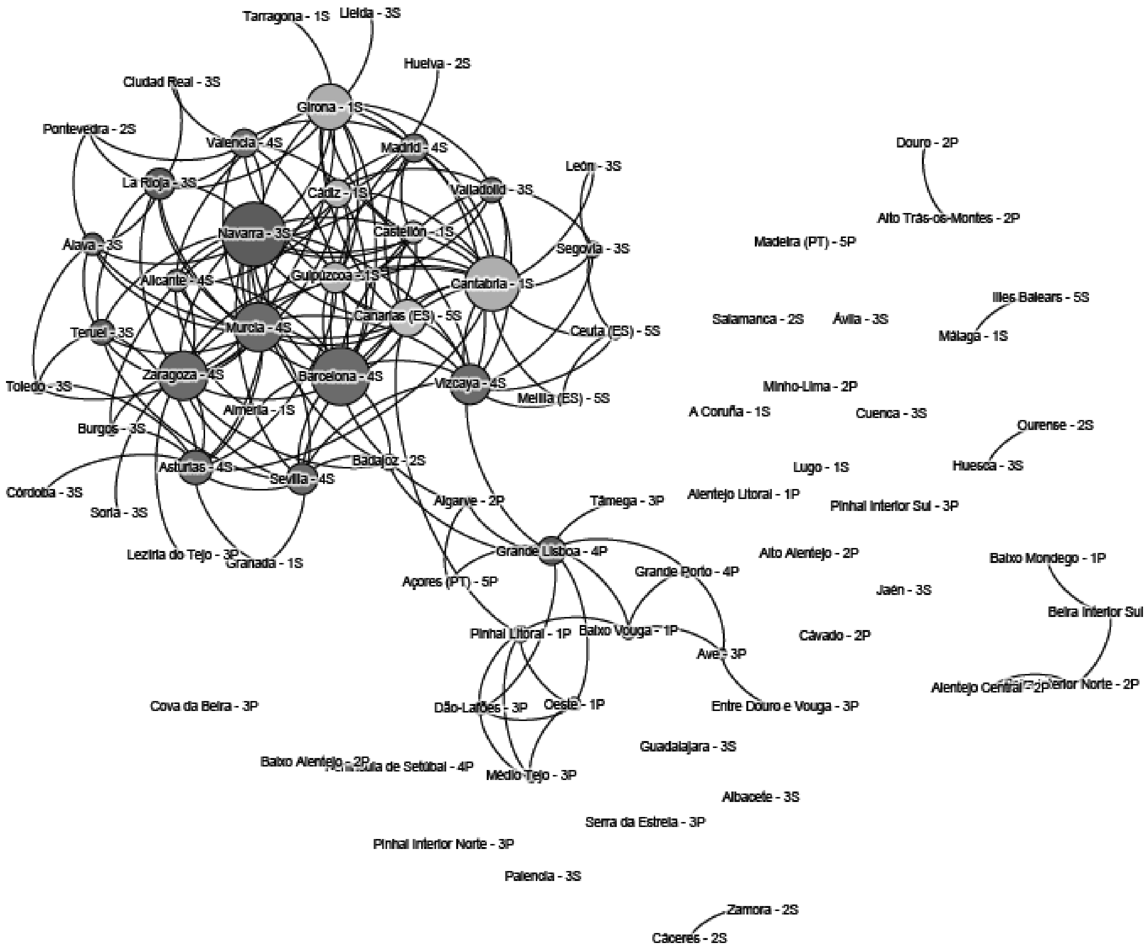
Due to the same reason, in graphically representing the derived network of regions we opt to sort the whole set of $\frac{N(N-1)}{2}$ distances in ascending order and to exclude the links between regions whose distance occupy a ranking position greater than *2N* in the sorted list. In so doing, the average degree of the network equals *2* and overloading the graph with a huge amount of links is avoided, allowing for the observation of some interesting patterns. Figure 4 shows the 81 Portuguese and Spanish regions represented according to the geographical and demographic classification described in section 2. Node labels end with a code for the region (1:Coastal, 2:Border, 3:Interior, 4:Metropolitan, 5:Peripheral) and "S" or "P" depending on the country to which the region belongs, Spain or Portugal, respectively. The size of each node in the network is proportional to its degree (the number of links). As such, large nodes are those highly connected ones while the small nodes are poorly connected.

The network presented in Figure 4 shows that almost every metropolitan region remains connected after the suppression of the less stronger links, showing that, in what concerns the simultaneous evolution of the GDP values, the group of Metropolitan regions is the most strongly correlated one. The degree (number of links) of the Metropolitan nodes (label 4) in the network is high, either considering the connections with regions that are inside or outside the Metropolitan group. Conversely, the Interior and the Border groups are very weakly connected ones. Among the Metropolitan group, Barcelona, Murcia and Zaragoza concentrate the highest connectivity values as their sizes show. Surprisingly, the most connected region (Navarra) belongs to the Interior group. There is also an important degree of connectivity characterizing Cantabria and Girona, both in the Coastal group. Together with the remarkable connectivity of the Metropolitan nodes, the second most important pattern coming out from the network in Figure 4 is probably the lack of connectivity of the Border regions (label 2).

Meanwhile, the most outstanding evidence that emerges from our approach is a significant "country effect", since the pattern of connectivity of the Spanish regions is largely greater than the connectivity of the Portuguese ones.

The observation that Spanish regions are more connected than the Portuguese ones shows that country matters when links are defined as functions of the correlation between regions. This result confirms the findings obtained when assessing the growth and convergence dynamics of the Iberia Peninsula regions (section 3). Another interesting result is that not only Spanish regions are more connected than the Portuguese ones but also that they tend to be strongly correlated with their national counterparts than with the Portuguese regions, independently of how similar are them in terms of their corresponding regional classification.

Figure 4: The network of Iberian regions



Note: 1-Coastal, 2-Border, 3-Interior, 4 Metropolitan, 5-Peripheral, and Countries: S-Spain P-Portugal.
Source: Eurostat and authors' calculations

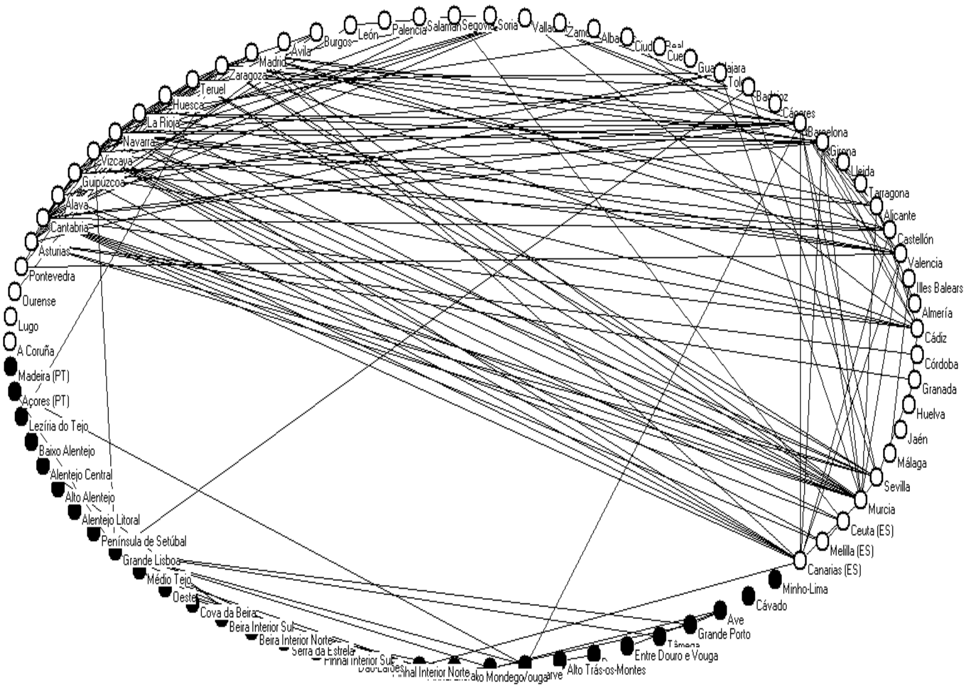
The ring network in Figure 5 confirms and emphasizes the dominance of connectivity pattern of the Spanish regions (white circles) when compared with the Portuguese ones (black circles).

3.3 The network of Spanish regions

To have an idea of the topological properties of each Iberian country we decide to repeat the computation for each country individually. In so doing one is able to isolate the "country effect" and to look for eventual topological patterns in each separated network of regions: the Spanish and the Portuguese networks.

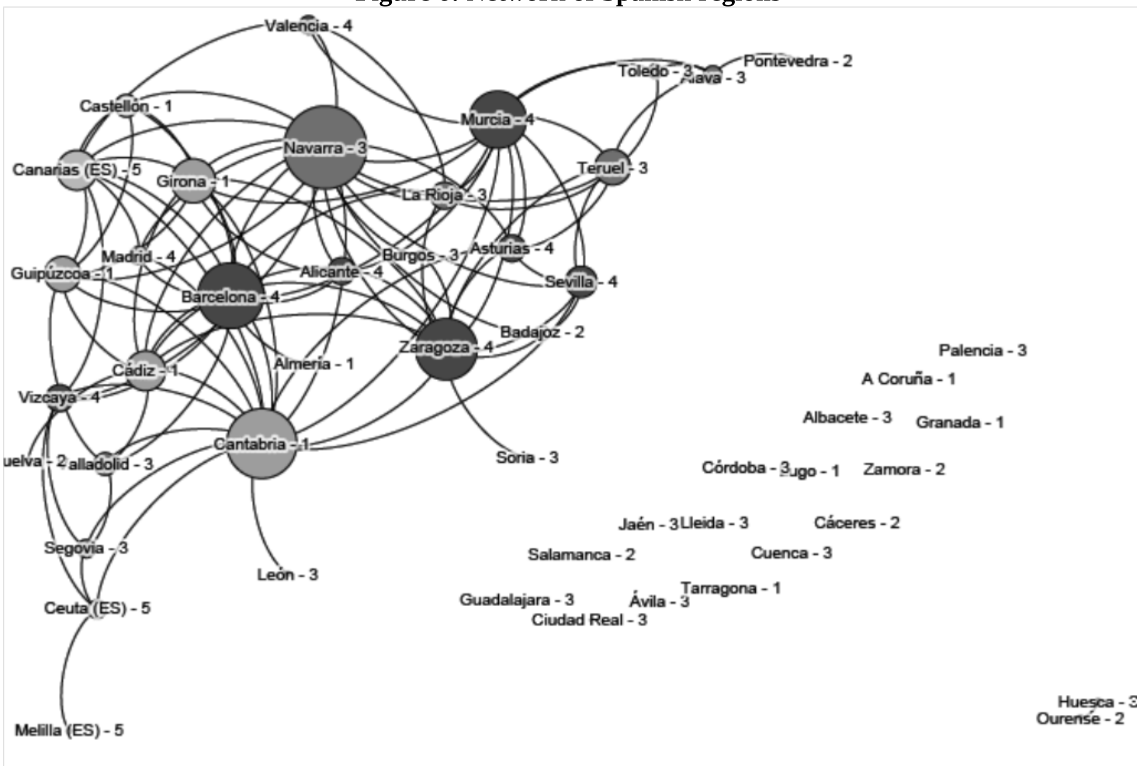
Figure 6 shows the network of Spanish regions computed with the same rules presented in the last section for the definition of the Iberian network.

Figure 5: The ring network of Iberian regions



Note: Spanish regions are represented by white circles and Portuguese regions are colored black.
Source: Eurostat and authors' calculations

Figure 6: N**etwork of Spanish regions**



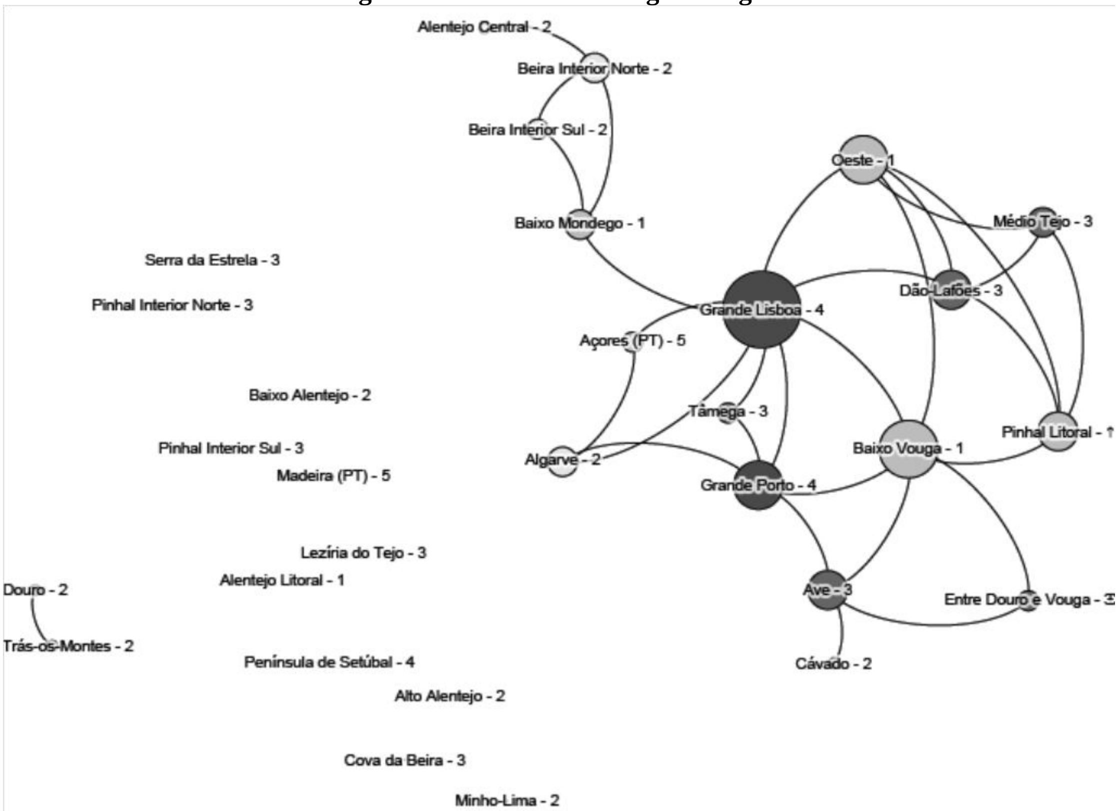
Note: 1-Coastal, 2-Border, 3-Interior, 4-Metropolitan, 5-Peripheral.
Source: Eurostat and authors' calculations

The pattern of connectivity in Figure 6 confirms the main findings observed in the network structure of the Iberian regions (Figures 4 and 5). When the "country effect" is removed, the Metropolitan Spanish regions (label 4) remain as the most connected regions. So doesthe Border group (label 2) that remains as the
less connected group of regions in the entire Spanish network. Not surprisingly, isolating the Spanish regions does not cause almost any change in the overall network structure and properties.

3.4 The network of Portuguese regions

When the same approach is applied to the Portuguese regions, some important outcomes emerge. Figure 7 shows the network of Portuguese regions, whose definition and representations aspects follow those of the previous networks herein presented.

Figure 7: Network of Portuguese regions



Note: 1-Coastal, 2-Border, 3-Interior, 4-Metropolitan, 5-Peripheral.
Source: Eurostat and authors' calculations

Besides the already observed connectivity of the Metropolitan regions (Grande Lisboa and Grande Porto), the first pattern to be highlighted in Figure 3 concerns the emergence of some enhanced connectivity in the Coastal group (label 1), being followed by the Interior group. However, unlikely in the previous networks, the Border group is no longer the poorest connected one, and the worst positioned in the connectivity ranking is now occupied by the Peripheral group (label 5).

4. CONCLUDING REMARKS

This paper examines the evolution of spatial similarities and disparities in the Iberian Peninsula, using data on GDP per capita of 81 NUTS 3 Portuguese and Spanish regions over the period 1995-2012. The main purpose is to assess the importance of geographic and demographic determinants of economic growth, namely in the following situations: whether or not the Iberian regions have a common border; whether they are coastal or inland; whether they have or not a large metropolitan area, and; if they have an ultra-peripheral location (by this meaning that they are islands or city enclaves in Africa).

A brief descriptive analysis of regional annual growth rates points to the advantage of economic backwardness, as most of the top ten regions are relatively low developed. The demographic and geographic factors appear not to be determinant, giving the mixed composition of regions, at both the top and the bottom level of the growth distribution.

The sigma convergence exercise indicates a very slight decrease of regional disparities in the Iberian case between 1995 and 2012, with two contradictory trends: an increasing one (divergence) until 2001, and a decreasing one (convergence) after this year. It is also worth mentioning that the dispersion of regional per capita GDP is much greater in Portugal than Spain, a result in accordance with other studies of this phenomenon.

A classical analysis of (absolute) beta convergence (the inverse relation between annual average growth and initial level of GDP per capita) concludes in favor of the convergence hypothesis (negative signal of the parameter beta estimated in all regressions), but only in the global (Iberian Peninsula) and the Portuguese cases, and with very low velocities of convergence (around or inferior to one percent). This result is also consistent with previous studies of regional convergence in Portugal and Spain.

The main contribution of this paper, adding value to the voluminous literature on regional growth and convergence, was the application of a stochastic geometry approach developing a geometric space built from the correlation coefficients between the log-difference of regional annual GDP. The most outstanding conclusion of this approach is a significant "country effect", since the pattern of connectivity of the Spanish regions is largely greater than the connectivity of the Portuguese ones.

Another important conclusion is that the group of Metropolitan regions is the most strongly correlated one, with a high number of links in the network, either considering the connections with regions that are inside or outside the Metropolitan group. There is also an important degree of connectivity characterizing some Coastal regions. Conversely, the Interior and the Border groups, as well as the Ultra-peripheral one, are very weakly connected. This is a worrying trend, confirmed in many other studies and approaches which, after several decades of regional policy and economic and social cohesion support, deserves great attention from political and economic decision-makers.

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APPENDIX

Portuguese and Spanish NUTS 3 level regions and classification

N	REGION	NUTS 3	CLA.
1	A Coruña	ES111	1-S
2	Lugo	ES112	1-S
3	Ourense	ES113	2-S
4	Pontevedra	ES114	2-S
5	Asturias	ES120	1-S
6	Cantabria	ES130	1-S
7	Álava	ES211	3-S
8	Guipúzcoa	ES212	1-S
9	Vizcaya	ES213	4-S
10	Navarra	ES220	3-S
11	La Rioja	ES230	3-S
12	Huesca	ES241	3-S
13	Teruel	ES242	3-S
14	Zaragoza	ES243	4-S
15	Madrid	ES300	4-S
16	Ávila	ES411	3-S
17	Burgos	ES412	3-S
18	León	ES413	3-S
19	Palencia	ES414	3-S
20	Salamanca	ES415	2-S
21	Segovia	ES416	3-S
22	Soria	ES417	3-S
23	Valladolid	ES418	3-S
24	Zamora	ES419	2-S
25	Albacete	ES421	3-S
26	Ciudad Real	ES422	3-S
27	Cuenca	ES423	3-S
28	Guadalajara	ES424	3-S
29	Toledo	ES425	3-S
30	Badajoz	ES431	2-S
31	Cáceres	ES432	2-S
32	Barcelona	ES511	4-S
33	Girona	ES512	1-S
34	Lleida	ES513	3-S
35	Tarragona	ES514	1-S
36	Alicante	ES521	4-S
37	Castellón	ES522	1-S
38	Valencia	ES523	4-S
39	Illes Balears	ES530	5-S
40	Almería	ES611	1-S
41	Cádiz	ES612	1-S

Portuguese and Spanish NUTS 3 level regions and classification (cont.)

N	REGION	NUTS 3	CLA.
42	Córdoba	ES613	3-S
43	Granada	ES614	1-S
44	Huelva	ES615	2-S
45	Jaén	ES616	3-S
46	Málaga	ES617	4-S
47	Sevilla	ES618	4-S
48	Murcia	ES620	1-S
49	Ceuta (ES)	ES630	5-S
50	Melilla (ES)	ES640	5-S
51	Canarias (ES)	ES700	5-S
52	Minho-Lima	PT111	2-P
53	Cávado	PT112	2-P
54	Ave	PT113	3-P
55	Grande Porto	PT114	4-P
56	Tâmega	PT115	3-P
57	Entre Douro e Vouga	PT116	3-P
58	Douro	PT117	2-P
59	Alto Trás-os-Montes	PT118	2-P
60	Algarve	PT150	2-P
61	Baixo Vouga	PT161	1-P
62	Baixo Mondego	PT162	1-P
63	Pinhal Litoral	PT163	1-P
64	Pinhal Interior Norte	PT164	3-P
65	Dão-Lafões	PT165	3-P
66	Pinhal Interior Sul	PT166	3-P
67	Serra da Estrela	PT167	3-P
68	Beira Interior Norte	PT168	2-P
69	Beira Interior Sul	PT169	2-P
70	Cova da Beira	PT16A	3-P
71	Oeste	PT16B	1-P
72	Médio Tejo	PT16C	3-P
73	Grande Lisboa	PT171	4-P
74	Península de Setúbal	PT172	4-P
75	Alentejo Litoral	PT181	1-P
76	Alto Alentejo	PT182	2-P
77	Alentejo Central	PT183	2-P
78	Baixo Alentejo	PT184	2-P
79	Lezíria do Tejo	PT185	3-P
80	Açores (PT)	PT200	5-P
81	Madeira (PT)	PT300	5-P

Classification: 1: Coastal, 2: Border, 3: Interior, 4: Metropolitan, 5: Peripheral;
S: Spanish; P: Portuguese