

CONVERGENCE AT LOCAL LEVEL: AN EXPLORATORY SPATIAL ANALYSIS APPLIED TO THE PORTUGUESE MUNICIPALITIES

CONVERGÊNCIA À ESCALA LOCAL: UMA ANÁLISE ESPACIAL EXPLORATÓRIA SOBRE OS MUNICÍPIOS PORTUGUESES

Miguel Viegas

mlbv@ua.pt

GOVCOPP, Universidade de Aveiro (DEGEI), Campus Universitário de Santiago, Aveiro

Micaela Antunes

micaela.antunes@ua.pt

GEMF, Universidade de Aveiro (DEGEI), Campus Universitário de Santiago, Aveiro

ABSTRACT/RESUMO

Following the enlargement process of the European Union that occurred from the 1980s onward, regional policies have been reinforced decreasing the disparities of GDP *per capita* among the European Union-15 Member States. However, this convergence trend is not observed at the intra-national level in which regional economic disparities are increasing.

In the present paper we proceed with an empirical exercise of convergence of continental Portuguese municipalities between 1998 and 2009. Differently from the common literature, we use a spatial econometric approach as a means to embody the role of space and geography, considering both spatial dependence and spatial heterogeneity.

The first conclusion points to the existence of a strong beta-convergence process during this period. The results also sustain the existence of two convergence clubs, a former composed by the inland municipalities with higher convergence velocity and a latter formed by the coastal municipalities with lower but still significant convergence velocity. The presence of spatial dependence on the convergence process of the coastal municipalities represents our third and final result.

Keywords: Agglomeration, Convergence, Portuguese Municipalities and Spatial Autocorrelation

JEL Codes: R11, R12 e O47.

Após o processo de alargamento da União Europeia, que ocorreu a partir da década de 1980, as políticas regionais foram reforçadas, fazendo com que as disparidades do PIB *per capita* entre Estados-membros diminuíssem. No entanto, esta tendência de convergência à escalada nacional não é observada ao nível das regiões de cada país, onde as disparidades regionais tendem a aumentar.

No presente trabalho, procedemos a um exercício empírico de convergência dos municípios portugueses continentais, entre 1998 e 2009. Diferentemente da literatura comum, usamos uma abordagem econométrica espacial como um meio para incorporar o papel do espaço e da geografia no desenvolvimento económico, considerando os efeitos de dependência e heterogeneidade espacial.

A primeira conclusão aponta para a existência de um forte processo de beta-convergência durante este período. Os resultados também sustentam a existência de dois clubes de convergência, um primeiro composto pelos municípios do interior com velocidade de convergência superior e um segundo, formado pelos municípios do litoral com uma velocidade de convergência menor, mas ainda assim significativa. A presença de dependência espacial no processo de convergência dos municípios costeiros representa o nosso terceiro e último resultado.

Palavras-chave: Aglomeração, Convergência, Municípios Portugueses e Autocorrelação Espacial.

Códigos JEL: R11, R12 e O47.

1. INTRODUCTION

The possibility of poor countries to grow faster than rich countries has been a key issue leading to many empirical works ([1, 2, 3, 4], among others). Romer [4] points three major reasons supporting the existence of such convergence processes. The first reason is based on the Solow model (5) and states that countries converge to their steady state level. Therefore, a poor country far from its balanced growth is expected to grow faster and, thus, catches up the richer. The second reason arises from incentives for capital to flow from rich to poor countries according to the law of decreasing returns on capital. The third and last reason points to the lags in the diffusion of knowledge and technology.

The enlargement processes of the European Union, namely those occurred from the 1980s onward, have increased significantly the regional disparities. As such, regional policies have been reinforced, namely through the associated “structural funds”. Empirical data show that, over the last decades, the disparities of GDP *per capita* have decreased between the European Union-15 Member States [6]. However, this convergence trend is not observed at the intra-national level in which regional economic disparities are increasing [6, 7]. Namely, it seems that economic integration policies and structural funds, most applied to transportation infrastructures, have contributed to concentrate productive activities in richer regions at the expense of the poor ones [8]. This increasing intra-national disparity is observed in practically all the European Union-27 Member States (except for France and Germany) [6].

Spatial economic theories, in particular, the New Economic Geography (following the work of Krugman [9, 10]), have gained relevance in trying to explore the insights of endogenous growth theories and increasing returns in order to explain the spatial distribution of economic activity. The New Economic Geography can be understood as a theory of divergence, where transportation costs, increasing returns to scale, knowledge spillovers and agglomeration externalities explain spatial concentration of economic activity in certain areas. In other lines of investigation, inspired by Myrdal [11] and Kaldor [12, 13], increased returns (both static and dynamic), acting in a circular and cumulative process in space, are captured by the “Verdoorn’s Law” according to which faster output growth leads to faster productivity growth. Nonetheless, it is only recently that this geographical dimension has been embodied in empirical growth studies [8, 14]. As such, most empirical studies about regional convergence do not include spatial economic variables [8].

Portugal is a small country that highly depends on trade relationships with the rest of the European Union. Following the discussion on Brühlhart [15], it is interesting to analyse whether in this specific case international trade (indirectly) promotes concentration or dispersion.

In fact, regarding the Portuguese economy, there are some examples of regional convergence studies at the

NUTS II and NUTS III level [16, 17, 18]. Crespo [19, 20] analyse, at the municipal (county) level, *per capita* income, physical and human capital, concluding that central areas display higher levels of *per capita* income and human capital. They also find that structural similarity among municipalities is thought to lead to real convergence. In the present paper we proceed with an empirical exercise of convergence of the 278 continental Portuguese municipalities between 1998 and 2009. Differently from the studies referred above, we use a spatial econometric approach as a means to embody the role of space and geography, assuming that economic performances of a particular region or municipality are not immune to its neighbourhood. Moreover we differentiate between inland and coastal municipalities, in order to check the presence of a convergence club effect. The notion of convergence club is based on the existence of a set of homogeneous economies that in the long run are driven to the same steady state with equalized *per capita* incomes. Chatterji [21] defends the existence of two mutually exclusive convergence clubs, one for the rich nations and the other for poor countries. His theory fits in the models of endogenous growth, favouring the idea of multiple equilibriums, i.e., different steady states. This differentiation is justified by the diversity in domestic productive processes, the distinct allocation of productive resources, the existence of non-decreasing returns and externalities linked to production. Additionally, Galor [22] argues that the inclusion of human capital, income distribution, fertility and capital market imperfections contribute favourably to the convergence club hypothesis. The remaining of this paper is organized as follows. In section 2 we describe the analytical framework, namely the convergence processes and the spatial effects. In section 3 we proceed with the exploratory spatial analysis and estimate the convergence process, and some final remarks are made in section 4.

2. THE ANALYTICAL FRAMEWORK

The convergence hypothesis is based on the neo-classical growth model implying, in the long run, the same income level and growth rate among all countries or regions, no matter how poor or rich is initially the country or region considered. This is the absolute beta-convergence concept [4], implying a negative and significant value of the convergence coefficient. The absolute beta-convergence was tested by Baumol [1] through the following equation:

$$\frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} = \alpha + \beta \ln y_{i,0} + \varepsilon_i \quad \varepsilon_i \rightarrow i.i.d(0, \sigma_\varepsilon^2) \quad (2.1)$$

Where $y_{i,t}$ corresponds to the *per capita* GDP of region i at time t , T is the time interval, α and β are the parameters to be estimated and ε the error term. From the estimation of β we obtain the velocity of convergence, $\theta = -\frac{\ln(1 + T\beta)}{T}$

and the time necessary to achieve half of the backwardness (half-life), $\tau = \frac{\ln 2}{\theta}$ (for details, see [23, 24]).

A second concept of convergence used in the literature is the sigma-convergence, which is related to the evolution of several measures of dispersion of *per capita* GDP. We are in the presence of sigma-convergence when, for instance, the standard deviation decreases throughout time. Note that the beta-convergence, in which a catching up mechanism is included, implies a sigma-convergence, but the reverse is not necessarily true.

Many convergence studies have been centred in cross-section analyses. However, several criticisms are pointed at these models, mostly related with the existence of multicollinearity, endogeneity, biasedness and the existence of specification errors. These problems may seriously affect the robustness of the convergence coefficient and produce misleading outcomes [25, 26 and 27]. Moreover, according to Anselin [28], LeSage [29], among others, the introduction of the geographical dimension, namely in the presence of spatial autocorrelation, allows not only to capture the spatial effect, but also to improve the estimation and prevision since spatial dependence violates some of the Gauss-Markov assumptions of the OLS estimation (cross section observations are no longer independent) producing inefficient estimators.

Two kinds of spatial effects are pointed out in the literature, namely: (i) spatial autocorrelation, revealing that contiguous regions may influence each other's performance through spillover effects and (ii) spatial heterogeneity, whenever the same functional form is erroneously considered for all regions (for comprehensive references about spatial econometric see for instance [28, 29 and 30]). Spatial autocorrelation, in turn, can be of two types: the spatial autoregressive dependence, in which the dependence is attached to contiguous economic variables and the spatial autocorrelation in the disturbance term, in which the spatial dependence is captured in the error term.

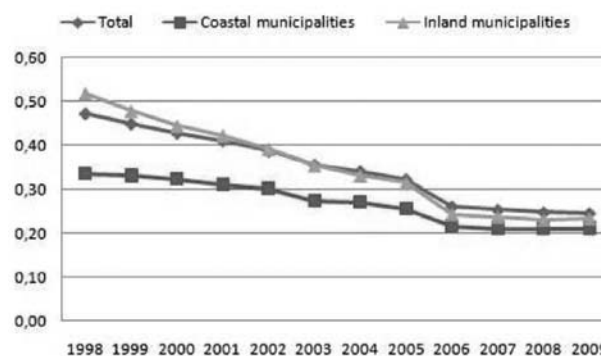
For our exploratory spatial analysis we use the firms' turnover disaggregated by municipality between 1998 and 2009, published by the Portuguese Official Statistics, deflated by a national GDP deflator (source: AMECO database) and divided by the respective population. The first Statistic Regional Guide was published in 1999 which determined the time interval. Gross Value Added (GVA) data was also available, but only for 2008 and 2009 (we estimated the GVA series for all economic sectors for the rest of the period, and obtained similar results). We only consider the 278 counties or municipalities of mainland Portugal leaving aside the Portuguese Islands, Azores and Madeira. After assessing the sigma-convergence, we estimate the presence of spatial autocorrelation, first, on the firms' turnover level, throughout the all period, and second, on the growth rate between 1998 and 2009, using the Moran's autocorrelation coefficient (Moran's I). Finally we estimate the beta-convergence process. We introduce the spatial heterogeneity through the distinction between inland and coastal mu-

nicipalities. We define a municipality as inland if the territory of the respective NUTSIII does not contact with sea. This specification allows us to estimate the possibility of two different convergence patterns and thus two clubs of convergence. All estimations are made through the general maximum likelihood method with Matlab. We use the LeSage Spatial Econometrics Toolbox functions available on the Internet at <http://www.econ.utoledo.edu>, where a comprehensive manual can also be found.

3. THE EXPLORATORY SPATIAL DATA ANALYSIS

Figure 1 illustrates the dispersion, measured by the coefficient of variation of the logarithm of the firms' turnover (*per capita*) and the spatial autocorrelation, during the 1998-2009 period in inland and coastal municipalities and also for all the 278 municipalities. Globally, the dispersion decreased steadily during the entire period, showing a sigma-convergence process. For the inland municipalities, the initial dispersion is much higher, relative to the coastal municipalities, but converges steadily and ends with a similar level.

FIGURE 1. SIGMA-CONVERGENCE: COEFFICIENT OF VARIATION BETWEEN 1998 AND 2009



Source: Portuguese Official Statistics.

The spatial autocorrelation is based on the Moran's statistic (Moran's I), which can be represented by the expression:

$$I_t = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} x_{it} x_{jt}}{\sum_{i=1}^n x_{it} x_{jt}} \quad (3.1)$$

in which w_{ij} represents the $\{i, j\}$ element of the spatial contiguity matrix, W , such as $w_{ij} = 1$ if municipalities i and j are neighbours and $w_{ij} = 0$ otherwise, x_{it} represents the logarithm of the turnover *per head* of population of municipality i at time t , and n corresponds to the number of observations.

Moran's I estimates the linear dependence between a variable in a specific location and the mean of the same

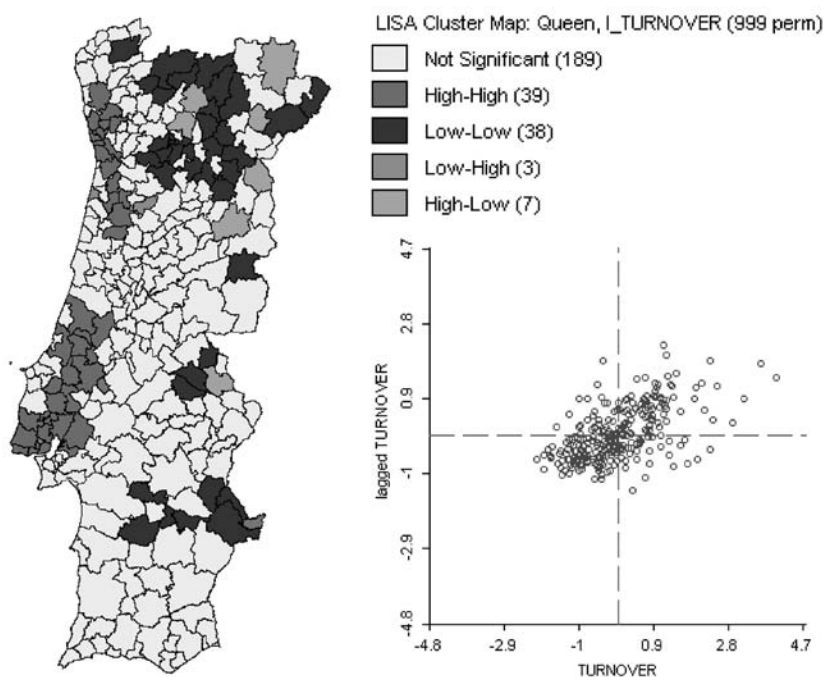
variable in the neighbourhood. The Moran's I-statistic and the respective Marginal Probability relative to the logarithm of the firms' turnover are shown in Table 1 revealing a positive and strong spatial dependence in all years. This means that richer municipalities tend to be located near other rich municipalities while poor municipalities tend to aggregate with other poor municipalities. However, Moran's I-statistic, although positive, decreased through-

out the 1998-2009 period, showing a similar path relative to the coefficient of variation. Comparing the inland and coastal municipalities, we observe the same decreasing paths, but the coastal municipalities exhibit a stronger pattern of spatial autocorrelation. This means that probably the stronger agglomerations of economic activities existing near the coast also affects strongly the contiguous or nearest municipalities.

TABLE1. MORAN'S I-STATISTIC: 1998-2009

Year	Total Municipalities		Inland Municipalities		Coastal Municipalities	
	Moran I	Mg. Prob.	Moran I	Mg. Prob.	Moran I	Mg. Prob.
1998	0.4649	0.0000	0.191	0.0000	0.4136	0.0000
1999	0.4545	0.0000	0.1698	0.0000	0.3928	0.0000
2000	0.4382	0.0000	0.163	0.0000	0.3607	0.0000
2001	0.4524	0.0000	0.1818	0.0000	0.3612	0.0000
2002	0.4367	0.0000	0.1842	0.0000	0.3602	0.0000
2003	0.4417	0.0000	0.1898	0.0000	0.3259	0.0000
2004	0.4372	0.0000	0.1745	0.0000	0.3198	0.0000
2005	0.4261	0.0000	0.1616	0.0000	0.3206	0.0000
2006	0.4057	0.0000	0.1385	0.0000	0.2779	0.0000
2007	0.3971	0.0000	0.1401	0.0000	0.2666	0.0000
2008	0.3853	0.0000	0.1455	0.0000	0.2487	0.0000
2009	0.3527	0.0000	0.1156	0.0000	0.2609	0.0000

FIGURE 2. FIRMS' PER CAPITA TURNOVER 2009 BY PORTUGUESE COUNTIES (LISA CLUSTER MAP, LEFT-HAND SIDE AND MORAN SCATTER PLOT, RIGHT-HAND SIDE)

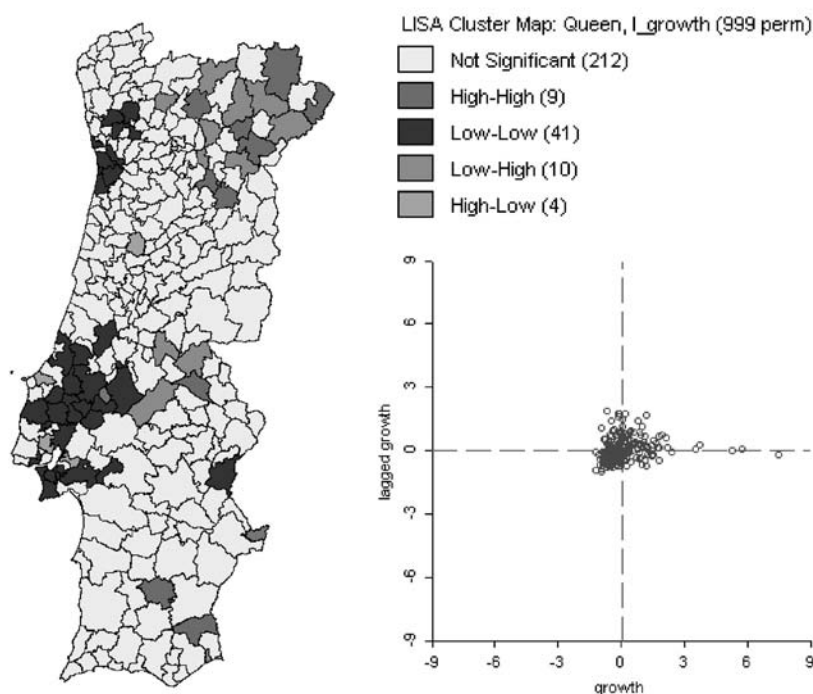


Source: Portuguese Official Statistics.

Figure 2 presents the LISA cluster map and the Moran scatter plot for the firms' *per capita* turnover in 2009 (the pattern is similar for the previous years). The Moran scatter plot depicts the firms' *per capita* turnover on the horizontal axis with the average values of the neighbouring municipalities on the vertical axis. The four quadrants in the scatter plot show, respectively, (i) the municipalities with high firms' turnovers associated with neighbouring municipalities also with high firms' turnovers, (ii) the municipalities with low firms' turnovers associated with neighbouring municipalities also with low firms' turnovers, (iii) the municipalities with low firms' turnovers associated with neighbouring municipalities with high firms' turnovers, (iv) the municipalities with high firms' turnovers associated with neighbouring municipalities with low firm's turnovers. The first and second (high-high and low-low) mean positive autocorrelation while the third and fourth mean negative autocorrelation. Therefore, the presence of a large number

of municipalities in the first and second quadrants (high-high and low-low) represents a clear symptom of positive spatial autocorrelation. The LISA cluster map shows the locations with significant local Moran statistics (the inference is based on a distribution generated by 999 permutations). The local Moran statistic is significant in 77 municipalities, 39 in the high-high quadrant, 38 in the low-low quadrant and 10 in the atypical quadrants. The map also shows that the first quadrant municipalities (high-high) tend to join together near the coast while the second quadrant municipalities (low-low) tend to aggregate inland. As for the atypical situation we can mention the municipality of Sines situated in the fourth quadrant (high-low) reflecting the distortion effect of the petroleum complex and the cargo port, or, the case of Moita, situated in the third quadrant (low-high), which represents a countryside municipality that remained mainly agricultural despite the proximity of large industrial complexes.

FIGURE 3. ANNUAL GROWTH OF FIRMS' PER CAPITA TURNOVER, 1998-2009, BY PORTUGUESE COUNTIES (LISA CLUSTER MAP, LEFT-HAND SIDE AND MORAN SCATTER PLOT, RIGHT-HAND SIDE).



Source: Portuguese official statistics.

Concerning the growth rate of the firms' turnover *per capita* between 1998 and 2009, we can observe in Figure 3 a weaker clustering effect of municipalities, still most of them being located in the first and second quadrants and suggesting a positive spatial autocorrelation. It is interesting to note that the colour pattern is reversed since the municipalities with higher growth rates tend to aggregate mostly in the countryside while the municipalities with low growth rates tend to be located on the coastal regions. The spatial autocorrelation is confirmed by the Moran's I estimation.

4. THE CONVERGENCE MODEL: RESULTS AND DISCUSSION

Finally we use the spatial econometric methodology to estimate a model of absolute beta-convergence for the Portuguese continental municipalities between 1998 and 2009. As a first step, we estimate the simple model of beta-convergence in which we add a dummy variable, *int*, for the inland municipalities and the same dummy variable associated with the initial level of output in order to detect an "inland-effect" on the convergence process, thus,

defining a convergence club. Note that by using this equation the eventual spatial effects will be the same among all municipalities.

$$\frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} = \alpha + \beta \ln y_{i,0} + \delta_1 \text{int}_i + \delta_2 \text{int}_i * \ln y_{i,0} + \varepsilon_i$$

$$\varepsilon_i \rightarrow i.i.d(0, \sigma_\varepsilon^2) \quad (4.1)$$

The next step consists in detecting the presence of spatial effects through several tests. These testes are crucial in order to adopt the correct model specification to fully integrate the spatial effects. Among several specifications we consider a model in which the spatial dependence is associated to the lagged dependent variable (equation 4.2); the spatial error model (equation 4.3), in which only disturbances (u_i) exhibit spatial dependence; and finally the gen-

eral version of the spatial model (equation 4.4), including both the spatial lagged term as well as the spatial correlated error term. W corresponds to the spatial contiguity matrix defined above and is common to all three specifications.

$$\frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} = \alpha + \rho W \frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} + \beta \ln y_{i,0} + \delta_1 \text{int}_i + \delta_2 \text{int}_i * \ln y_{i,0} + \varepsilon_i$$

$$\varepsilon_i \rightarrow i.i.d(0, \sigma_\varepsilon^2) \quad (4.2)$$

$$\frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} = \alpha + \beta \ln y_{i,0} + \delta_1 \text{int}_i + \delta_2 \text{int}_i * \ln y_{i,0} + u_i$$

$$\text{where } u_i = \lambda W u_i + \varepsilon_i \quad (4.3)$$

$$\frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} = \alpha + \rho W \frac{1}{T} \ln \frac{y_{i,T}}{y_{i,0}} + \beta \ln y_{i,0} + \delta_1 \text{int}_i + \delta_2 \text{int}_i * \ln y_{i,0} + u_i$$

$$\text{where } u_i = \lambda W u_i + \varepsilon_i \quad (4.4)$$

TABLE 2. ESTIMATIONS RESULTS AND TESTS: BETA-CONVERGENCE 1998-2009

Models	OLS (total)	OLS (inland)	OLS (coastal)	SAR (coastal)
ESTIMATION				
Obs	278	153	125	125
R ²	0.4753	0.4279	0.4011	0.4199
Constant	0.11868 (0.00000)	0.20318 (0.00000)	0.11868 (0.00000)	0.09975 (0.00000)
β	-0.04023 (0.00000)	-0.08486 (0.00000)	-0.04022 (0.00000)	-0.03479 (0.00000)
δ_1	0.08450 (0.00007)	-	-	-
δ_2	-0,04463 (0.00000)	-	-	-
ρ	-	-	-	0.25397 (0.02413)
AUTOCORRELATION TESTS				
I Moran	0.15412 (0.87750)	-0.14440 (0.88517)	1.33128 (0.18309)	-
M lag	0.04690 (0.82854)	0.43610 (0.50900)	4.75553 (0.02920)	-
LM error	0.00005 (0.99433)	0.08663 (0.76850)	1.21994 (0.26937)	1.01126 (0.31460)

Considering all municipalities and leaving aside the spatial heterogeneity, the results exhibited in the first column of Table 2 indicate that the specification of model 4.1 is adequate for the convergence process. The results of the three spatial autocorrelation tests can be seen at the bottom of the Table: the I Moran test detects the presence of spatial dependence but does not discriminate the type, while the LM lag and LM error tests [31] allow for the distinction of the two types of spatial correlation, respectively, in the lag dependent variable and in the residuals of the regression model. The three tests do not detect the presence of spatial autocorrelation, which is not a surprise consider-

ing the weak spatial dependence of the dependent variable, with a Moran's I relatively close to zero (Moran's I = 0.15). As such we validate the model represented by 4.1 and need no further estimations. The OLS results exhibit a strong beta-convergence process, which is even stronger in the inland municipalities $\delta_2 = -0.04463$ with $p = 0.00000$. As such, the significance of the δ_1 coefficient points to two distinct equilibriums between the two groups. Therefore, the results justify a separate estimation between inland and coastal municipalities considering the spatial heterogeneity.

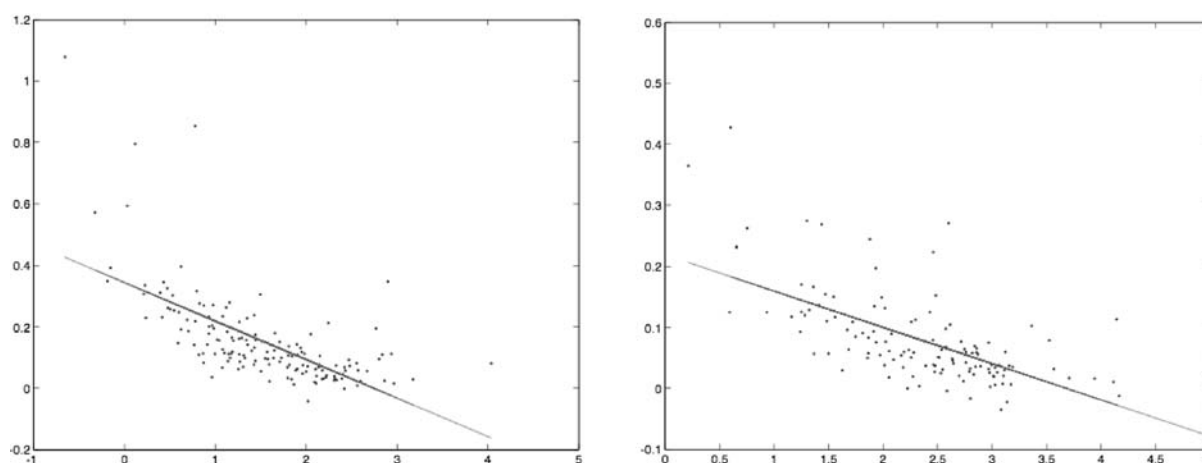
Columns (2) and (3) estimate by OLS the simple beta-convergence (equation 2.1) separately for the 153 in-

land municipalities and the 125 coastal municipalities. The three spatial autocorrelation tests are negative for the inland municipalities. Concerning the coastal municipalities the tests detect the presence of spatial autocorrelation in the lagged dependent variable. Therefore, we maintain the OLS estimation for the inland municipalities and use the spatial dependence model specification (equation 4.2) for the coastal municipalities¹. The results obtained by the maximum likelihood method are exhibited in column (4) of Table 2 in which we can confirm that the error continues to be uncorrelated.

According to those estimations, both municipality groups present beta-convergence, but the convergence

process remains faster in the inland municipalities. The β -coefficient values, namely the one associated with the inland municipalities, are unusually high relative to the ones commonly presented in the literature. Nonetheless, the velocity of convergence is 24.6% in the inland municipalities and 5.3% in the coastal municipalities while the half-life period is respectively 3 and 13 years – a result that may be controversial. However, we must recall that the proxy used for the GDP *per capita*, the firms' real turnover divided by population, may be somewhat inaccurate, presenting a large variability. Therefore, our interpretations must be prudent, avoiding any comparison with other previous similar studies.

FIGURE 4. BETA-CONVERGENCE: OLS AND SAR ESTIMATION (INLAND MUNICIPALITIES, LEFT-HAND SIDE, AND COASTAL MUNICIPALITIES, RIGHT-HAND SIDE)



Data source: Portuguese official statistics

The separate estimations exhibited in the last three columns confirm the different convergence paths between the two groups (Figure 4). Moreover the coastal municipalities, taking the presence of spatial dependence into account, present a smaller convergence velocity (4.4%) with a half-life period of 16 years relative to the OLS estimation. This spatial dependence pattern is probably related to the location of the main economic centres near the coast (Porto, Lisbon, Sines and the Algarve). Summing up, we first retain a significant absolute beta-convergence in the continental Portuguese municipalities between 1998 and 2009 which differs between inland and coastal municipalities, being the former higher than the latter. Secondly, and contrary to the inland municipalities, we find a significant spatial dependence in the coastal municipalities' convergence process.

¹ We tested for the presence of spatial dependence in the residual of both the spatial dependence (equation 3.3) and spatial error (equation 3.4) models for the coastal municipalities and confirmed that only the former eliminates the spatial dependence in the residuals. The results are available upon authors' request.

5. CONCLUSION

Using a spatial econometric approach we proceed with an empirical exercise of convergence of the Portuguese continental municipalities between 1998 and 2009. In order to overcome the lack of GDP data at the municipal level, we use the firms' turnover deflated and divided by population. We deal with spatial dependence and also with spatial heterogeneity by distinguishing inland from coastal municipalities.

Our first conclusion points to the existence of a strong beta-convergence process during the period. This convergence process, confirmed by the empirical reality, overshadows a wide spread idea according to which Portuguese development, supported by important flows of European structural funds, has been littoral-biased, or centred mainly in the capital. A second main result sustains the existence of two convergence clubs, a former composed by the inland municipalities with higher convergence velocity and a second club formed the coastal municipalities with lower but still significant convergence velocity. However, the inland municipalities converge to different steady state equilibrium relative to the coastal

and richer municipalities, which can lead to persistent inequalities in the long run.

The presence of spatial dependence on the convergence process of the coastal municipalities represents our third and final result. The spatial agglomeration of economic activities, or “clusters”, corresponds to various forms of geographic concentration and has been the subject of numerous theoretical and empirical investigations. The existence of such economic “clusters”, be that of the automobile, cork or shoe industries, predominantly located in coastal areas, probably contribute through its spillover effects to the spatial dependence detected. The assessment of these spatial agglomeration activities, and the related spatial dependence effects, represent a major line of investigation capable of providing important insight on regional development.

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