Regional Income Convergence in Portugal (1991-2002)

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ABSTRACT

Our research aims to address the problem of inequality in income distribution from a different perspective than the usual. We intend to verify if geography influences the pattern of inequality, that is, if the standard of living varies from region to region and if, in the process of growth, spatial units in Portugal have been converging in terms of most relevant variables, such as income. We search the answers to these questions by introducing the treatment of convergence between smaller territorial units, the municipalities as individuals. We intend to evaluate convergence or divergence in income growth and test empirically the theoretical hypothesis that β-convergence, although necessary, is not a sufficient condition for σ-convergence. To study convergence, we use information about GDP and wages for NUTS III regions, and wages for municipalities. We observe spatial dependence between municipalities, so we estimate spatial econometric models to test convergence. With regard to conditional convergence between municipalities, the model most appropriate is the one which includes in the explanatory variables the weight of primary sector employment, leading us to conclude that this variable distinguishes the "steady state" of the small economies. Variables like the activity rate and percentage of active population with higher education also reveal highly significant on the growth of wages, reflecting the different contexts of the labor market at regional level.

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1 Introduction

As mentioned in Guerreiro (2012), regional imbalances represent an intrinsic characteristic of the Portuguese economy and, as stated in Mateus et. al. (2000), the structural evolution of the European economy has shown a real convergence between countries and divergence between regions. Nowadays in European Union, the economic and social cohesion, namely the approach of the various territories in terms of standard of living is assumed to a primary objective of economic policy.

Our research aims to address the problem of inequality in income distribution from a different perspective than the traditional studies addressing inequality among individuals [see the studies of Rodrigues (1994, 1999 and 2008)]. We would like to answer questions such as if geography influences the pattern of inequality or if the Portuguese's standard of living depends on the place of residence and finally if, in the process of growth, the spatial units that make up the Portuguese territory have been converging in terms of income. We will search for answers to these questions by introducing the treatment of convergence between smaller territorial units, i.e. the municipalities.

Usually the economic literature examines, separately, the convergence of income, and the inequality in income and living conditions or welfare between people. For the study of economic convergence are used standard regional or national economic indicators such as Gross Domestic Product per capita (GDPpc) [considering the reference works of Barro and Sala-i-Martin (1992, 1995 and 1999), Barro (1991), Sala-i-Martin (1990, 1995, 1996a and 1996b) and about Portugal the applied studies of Soukiazis (2003), Soukiazis and Antunes (2004) and Soukiazis and Castro (2004)]. To study social inequalities, are usually used indicators like households (or individuals) income and / or consumption of households, or microeconomic data on households [consider the reference works of Atkinson (1975 and 1997), Atkinson et al. (1995), Cowell (2008a and 2008b), and in Portugal the recent studies of Rodrigues (1994, 1999 and 2008)]. In our research, using data for each region and municipality, we intend to study, at the same time, inequality and convergence, comparing results and linking these two areas of research.

Another interesting debate in economic literature and more particularly in convergence studies, regards the two concepts of convergence introduced by Sala-i-

Martin (1990): σ convergence[2] and β convergence[3]. In Sala-i-Martin (1995) is referred that the application of these concepts to real world data reveals that where σ convergence is observed, β convergence is also observed. But, Young et al. (2007), in an applied study to the Americans counties showed that β convergence is a necessary but not sufficient condition for σ convergence.

Following this discussion, another goal of our work is to test the hypothesis that β convergence is indeed necessary but not sufficient condition for the existence of σ convergence, through the application and analysis of the two concepts in our data set.

In Guerreiro (2012) we evaluated convergence or divergence in income growth using a static analysis, with conventional measures and other indicators, taking into account the regional differences in economic performance. We found a growing inequality between regional incomes over the period 1990-2006. We concluded that this distribution of earnings reflects the actual distribution of economic activity in Portugal, particularly concentrated in the coastal and metropolitan areas of Lisboa and Porto and differences on economic specialization and level of education among the population of each territorial unit.

In the present paper we propose to conclude about the convergence in wages per worker over the period 1991-2002, between the municipalities and between the NUTS III[4] regions of Portugal mainland. For NUTS III regions, we also intend to evaluate the convergence in the variable GDPpc (for which no information is available to the municipalities) over the same period.

To meet the objectives set out in this paper, after the introduction, we present a brief literature review and a description of methodology and sources of information. It follows the spatial autocorrelation analysis, and finally we evaluate and interpret the econometric results of estimated models. We conclude with a synthesis of results and possible future developments in the context of this work.

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[2] ***σ*** convergence occurs when a group of economies converge towards a decrease in the standard deviation, ie, when the dispersion in real GDPpc decreases over time $\sigma_{t+T} < \sigma_t$

[3] The concept of β convergence tells us that, when countries or regions are similar (tending to the same "steady state"), the rate of growth in the future will be as greater as the initial delay, i.e., poor economies tend to grow faster than rich economies.

[4] Nomenclature of Territorial Units for Statistics, 2002 (annex 1).

2 Literature review

In our research, as noted in the introduction, we performed two kinds of analysis that cross two research areas: first, the regional distribution of income inequality (treated in a previous paper) and secondly, regional convergence in income growth, treated in this paper.

The analysis of convergence as area of interest has emerged through the works of Barro and Sala-i-Martin (Barro and Sala-i-Martin, 1992, and Sala-i-Martin, 1996a, 1996b, among others) based on the neoclassical growth model of Solow (1956) and Swan (1956). These authors study the convergence between countries using international data.

In the last decade the convergence studies have proliferated, particularly those relating to the convergence between countries and / or regions of the European Union, following the successive changes in its composition in terms of member states, namely Marques and Soukiazis (1998), Pontes (2000), Silva and Silva (2000), Akbari and Farahmand (2002), Badinger et al. (2002), Beugelsdijk and Eijffinger (2003), Soukiazis and Castro (2004) and Paas et al. (2006), which evaluate the convergence based on gross domestic product per capita. Some of these studies come up with the aim of evaluating the effectiveness of EU policies, mainly the Structural Funds effects in narrowing the gap between member states (e.g. Beugelsdijk and Eijffinger, 2003).

We can also cite studies on convergence in sectorial productivity across countries and / or regions of the European Union, as Le Gallo and Dall'erba (2005).

Regarding the convergence between Portuguese regions, we synthesize several works published in Table 2.1.

Table 2.1: Key findings of empirical studies about income convergence in Portugal

Authors	Information and analysis units	Major Findings
Soukiazis, E. (2003)	GDPpc (Regio, Eurostat, 2001) by NUTS II regions for the period 1981-1996	The convergence process in GDPpc suggests that absolute convergence is slower than the conditional convergence, due to the reallocation of resources (employment by sector of activity) and the concentration of trade flows.
Soukiazis, E. and Antunes, M. (2004)	GDPpc and productivity by NUTS III regions (INE, National Accounts) for the period 1991-2000	Empirical analysis shows that the convergence is mainly conditional, rather than absolute, both in terms of GDPpc as in productivity.
Freitas, M. and Torres, F. (2005)[5]	GDPpc and GVA per employee (DGREGIO, Eurostat, 2003) by NUTS II regions for 1990 and 2001	The period 1995-2000 evidences a divergence between regions, both in terms of GDPpc, as Gross Value Added per employee. During this period, only the RA Madeira approached the national average in terms of GDPpc. In the extended time period 1990-2001, it is observed that only the Algarve and the North grow faster than the national average for both indicators.
Antunes, M. and Soukiazis, E. (2006)	GDPpc for NUTS III and later separation into only two major regions, interior and coastal	In the process of convergence it is important if the region belongs to the coast or inland. Coastal regions grow faster in terms of GDPpc. The regional distribution of structural funds reveals to benefit more developed regions of the coast in detriment of the interior regions. However, structural funds have contributed to the increased speed of convergence among all the regions. The regional convergence in terms of GDPpc is slightly higher in the inland regions, which means they become more homogeneous over time, converging to a different "steady state" than the one of coastal area.

In all the works mentioned in the table, the convergence analysis carried out is based on the regional GDPpc variable, which reflects the distribution of production between the territorial units making up the country, but tells us nothing about the distribution of income from production, between these regions.

In fact, the local of production can be not the same where the income of such production is allocated or distributed. Imagine the example of a small country or region "P", consisting of 10 factories and no housing, so no resident people. The workers of these plants daily moves of their residence country or region "R" to work in place "P". As such, part of the GDP generated in "P" is distributed in the form of salaries, to the residents in "R", so the regional distribution of production, does not coincide with the regional distribution of income, and in particular with respect to salaries.

[5] This paper analyzes the convergence between the regions of Portugal, based only on comparative statics, i.e., measuring the approach or not, of selected indicators across regions.

It is this phenomenon that we want to measure, the convergence (or not) in the regional distribution of income, and particularly in wages. For the chosen territorial units, i.e. NUTS III regions, we are to compare the analysis of convergence in the GDPpc growth with wages regional convergence. We propose to conduct a further study of convergence in income growth, via wages, between municipalities of Portugal mainland.

When convergence studies to small territorial units like regions are conducted, the location reveals itself as a key component that affects the growth patterns in a heterogeneous manner. According to Anselin (1988), the use of regional data implies considering the hypothesis that the observations are not independent, as a result of the interrelationships between neighboring regions. As referred by Ertur et al. (2006), Paas et al. (2006) and Bucellato (2007), the spatial component is not negligible. Hence the conventional estimates of convergence may prove to be biased towards the spatial dependence between observations, and many regional studies can be seriously compromised with bias and inefficiency of the estimates, because the space interdependence was not considered.

In fact, there are studies of convergence relative to other countries and their regions, which consider the spatial dependence (spatial autocorrelation), such as Arbia et al. (2005) who study the behavior of regional growth in Italy, Lundberg (2006) studying the growth at the municipal level in Sweden, and Buccellato (2007) who studies the convergence between the Russian regions.

Also some of the studies on the convergence between the regions of the European Union consider the spatial dependence between the territorial units under review, like Akbari and Farahmand (2002), Badinger et al. (2002), Le Gallo and Dall'erba (2005) and Paas et al. (2006).

In Portugal, papers like Martinho (2005) and Caleiro and Guerreiro (2005), demonstrate the existence of spatial dependence with regard to some observable variables for smaller territorial units. In the first case, it respects to the productivity per sector of activity at the level of NUTS III regions, and in the second one, the relation between election results and unemployment rate by municipality.

Caleiro and Guerreiro (2005), conclude that, despite a low geographical distance between the Portuguese municipalities, the same does not happen with the economic distance (measured by the purchasing power indicator). In fact Portugal is characterized by regional disparities pretty high. These authors suggest that the study of the distribution of wealth among families could enrich these results. So, in this context, we have developed this study.

3 Methodology and Information Sources

In the first phase of our work we will try to measure the convergence / divergence between the spatial units in the period of analysis, based on two alternative variables:

• Wages per capita for municipalities and for the NUTS III regions;

• Gross domestic product per capita (GDPpc) for the NUTS III regions.

In the literature on growth and convergence, we find systematically two concepts of convergence: the σ-convergence and the β-convergence, terminology introduced by Sala-i-Martin (1990).

In our study, the σ convergence means a convergence of regional economies via reduction of dispersion [standard deviation (σ)] in the variable under study (the GDPpc or wages) between regions, and over the period considered. This is the first convergence concept applied to our data, which is based on calculating the standard deviation of the $\ln(y_{it})$ along the data series.

The β convergence can be considered as absolute or conditional. The absolute β convergence states that poorer economies tend to grow faster than richer economies [(Sala-i-Martin (1995) and Barro and Sala-i-Martin (1995 and 1999)], which, in our work, means a higher growth rate of wages and / or of GDPpc in units of lower values in the initial year of the study (1991).

The concept of conditional β convergence states that the growth rate of an economy is inversely related to the distance that separates this economy from its steady-state, and that the steady-state differs from economy to economy. As such, only if all the economies under study converge to the same steady-state, we can speak of absolute convergence [(Sala-i-Martin (1995) and Barro and Sala-i-Martin (1995 and 1999)]. In this study, we begin by testing a model of absolute convergence, and, in a second stage, we include some explanatory variables in order to distinguish the steady state of small economies under study, to test the hypothesis of conditional convergence.

To obtain a first estimate of the absolute β convergence between the territorial units of our country, we follow the adjustment of Barro and Sala-i-Martin (1995 and 1999) to the Solow model (Solow, 1956):

$$\ln\left(\frac{y_{iT}}{y_{i0}}\right) = \alpha + \beta \ln(y_{i0}) + \varepsilon_{it} \qquad \textbf{(3.1)}$$

- $y_{i,0}$: Per capita variable for the territorial unit *i*, in the first year of the series (year 0);
- $y_{i,T}$: Per capita variable for the territorial unit i, in the last year of the series (year T);
- T is the size of the period (number of years, months, etc.);
- α, β: Parameters to be estimated by the model, where α is the constant and β is the coefficient of convergence;
- ε_{it}: Error term.

Our dependent variable is the growth (in GDPpc or in employees' compensations, depending on the model that we estimate), where we compare the initial and final years of the series, using the information of only these two years, and the independent variable is its value in the initial year of our data series.

For the employees' compensations we have information to the municipalities, but in the case of GDPpc (INE, National Accounts), we only have data for territorial units NUTS III. Therefore, in the case of employees' compensations we estimate the model for municipalities and for NUTS III regions, while in the case of variable GDPpc we only estimate the model for the NUTS III regions.

To the NUTS III regions, with both results we can compare the estimates using each of the variables (wages and GDPpc), one of our initial goals.

As for conditional β convergence, we again follow the linear model proposed by Barro and Sala-i-Martin (1995 and 1999):

$$\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta \ln(y_{i,0}) + \gamma X_i^{'} + \varepsilon_{it} \qquad \textbf{(3.2)}$$

- $\varepsilon \sim i.i.d.(0, \sigma^2 I_n)$
- $y_{i,T}$ is GDPpc / average wage of region i at time t;
- T is the size of the period (number of years, months, etc.);
- α is the constant;
- β is the coefficient of convergence;
- X is a matrix with additional explanatory variables, and γ the corresponding vector of coefficients.

After a first estimation of the model by the method of ordinary least squares (OLS), we must test the interdependence between spatial units of analysis (municipalities and NUTS III) and decide to what extent the original model should be amended to incorporate this spatial interdependence through a, so-called, neighbors matrix, which can be build up, for example, based on geographical contiguity.

Spatial dependence can occur when the value assumed by the dependent variable in a given location depends on the value given by the same variable in neighboring locations. This dependence arises from the existence of spatial autocorrelation, this is, spatial clusters with similar values to the explanatory variable. But the spatial dependence can also result from processes of spatial diffusion effects (explanatory variables) [Anselin (1988), Anselin (2002) and Caleiro (2008b)]. Spatial dependence can indeed take many forms, giving rise to different specifications (models) that include such dependence [see the multiplicity of models proposed in Le Sage (1998 and 1999)].

However, most applied work considers only two forms of spatial dependence, coupled with two types of models: spatial dependence in the explanatory variable, as synonymous with spatial diffusion, which translates into spatial autoregressive models, and spatial dependence in the errors / residues translated into spatial error models [see Anselin (2002, 2003a) and Caleiro (2008a).].

In any case, the application of spatial statistical techniques can be justified if [Le Sage (1998 and 1999)]:

• There is a theoretical model that supports the existence of that kind of spatial dependence;

• Spatial autocorrelation, detected at the level of clusters in space, is confirmed by specific tests.

To test the spatial interdependence (autocorrelation), we can calculate different statistical tests of spatial correlation, and the Moran's I test is the one with wider use (Moran, 1950).

In algebraic terms, the global Moran's I statistic is calculated with the following expression (Moran, 1950):

$$I = \frac{n}{\sum_i \sum_j v_{ij}} \frac{\sum_i \sum_j v_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \qquad \textbf{(3.3)}$$

where n represents the number of units / spatial locations, indexed by *j*, v_{ij} represents the spatial weights, *x* the variable of interest, and $\bar{x}$ their average. When I statistic assumes a high value and positive, it means that there is positive autocorrelation. If there is no spatial dependence, we have I=-[1/(n-1)].

The same statistics can be calculated for each site [Local Moran's I (I_i)]**:**

$$I_i = \frac{(x_i - \bar{x})\sum_{i=1}^{n}(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2 / n} \qquad \textbf{(3.4)}$$

$I_i < 0$, indicates a negative local spatial autocorrelation; $I_i = 0$, indicates the absence of spatial location and $I_i > 0$, indicates positive spatial location.

Plainly in calculating the levels of spatial correlation is determinant the definition of neighborhood relations. Neighborly relations are usually translated by a matrix, the spatial weights matrix (W matrix), which is subsequently introduced into the models specification. The construction of the W matrix can be based on contiguity, or neighborhood, between the territorial units under study, or alternatively, on the geographical distance (Euclidean distance) [Le Sage (1999) and Anselin (2003b)], or even other concepts of distance, such as the distance measured in terms of time between the units [concept followed, for example, in the applied study of Paas et al. (2006)].

In the present work, following Buccellato (2007), Akbari and Farahmand (2002), Lundberg (2006) and others, we choose a matrix of spatial weights based on spatial contiguity. In our study, especially with regard to municipalities, such option is fully justified by the small size of spatial units and simultaneously the number of neighborhoods of each unit. In fact, although the municipalities are small spatial units, are also surrounded by other small units, verifying that each municipality has always more than one neighbor (some of them have 8 or 9 neighbors). As such, the spatial contiguity matrix covers a large net of relationships which we believe cover the economic reality of these small units.

The W matrix based on contiguity, and used in spatial econometric models, results of standardization[6] of a neighborhoods matrix V which can take many forms. Its simplest form, can be defined by: $V = \lfloor v_{ij} \rfloor$, where $v_{ij} = o$ if j localization is not nearby of i (and if j=i) and $v_{ij} = 1$if localization j is nearby i. The fact of considering the locations, neighboring or not, depends on the previously established criteria, because there are different ways of defining the contiguity.

Of the five different ways suggested by Le Sage (1999) to define the presence or absence of contiguity between regions, we highlight those applied by Anselin (2003b):

• Queen contiguity: provided that the territorial units have one point in common in their boundaries, we consider they are neighbors;

• Rook contiguity: to be considered neighbors, the territorial units have an entire limit or boundary, in common.

As such, the spatial weights matrix based on queen contiguity has always a denser structure of connectivity; this is, for each land unit, the number of neighbors is greater than in the concept of rook contiguity. Therefore, in the present study, we choose the matrix of queen neighborhoods[7].

As for the statistical tests of spatial correlation, Moran's I test compares the value of global variable in any location, with its value at all other locations. It is based on a statistical calculation that is roughly the correlation coefficient between the variable values by location, and the average values of this variable presented in neighboring locations (spatial lags), i.e., for all $j \neq i$ where $v_{ij} = 1$.

Another alternative and similar test is the Geary, or C Geary test. The C statistic is obtained as follows [Geary (1954)]:

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[6] According to Anselin (1988) and Le Sage (1999), standardization or normalization of V matrix is advisable to guarantee that the sum of its columns to each row is equal to 1 ($\sum w_i = 1$) and that the new matrix is not symmetric.

[7] We have constructed the rook matrix of neighborhoods and found that the results do not change significantly.

$$C = \frac{\left[(n-1) \sum_i \sum_j v_{ij} \left(x_i - x_j \right)^2 \right]}{2 \sum_i \sum_j v_{ij} (x_i - \bar{x})^2} \qquad \textbf{\textit{(3.5)}}$$

Both Moran's I test, as Geary test, are diffuse tests, indicating the existence (or not) of spatial dependence, not giving indication of possible alternative solutions [(Florax and Graaf (2004)]. The alternative hypothesis of these tests is that there is spatial correlation, but, if so, do not indicate what kind of correlation exists, and hence which model specification is advised: Spatial Autoregressive Model (SAR) or Spatial Error Model (SEM).

Alternatively and (or) to complement those tests, Florax and Graaf (2004) present more specific tests developed in a maximum likelihood context, that usually take the form of Lagrange Multipliers (LM) tests, rather than Wald or LR (asymptotically equivalent but which calculation is more difficult): LM test for spatial error model (LM-ERR) and LM test for spatial lag model (LM-LAG). If both statistics prove significant, the proposed solutions are varied. Some studies show an ad hoc decision resulting in the LM statistic associated with the option of greater value and greater significance, others argue the calculation of robust LM statistics which come into consideration with a possible incomplete specification of the model: LM - lag robust (RLM-lag) is the test of spatial dependence in the form of spatial autocorrelation in the dependent variable, robust to the presence of spatial autocorrelation in the error term; LM - error robust (RLM-Err) is the test of spatial dependence in form of spatial autocorrelation of the error term, robust to the presence of spatial dependence in the form of spatial lag of the dependent variable [Anselin and Florax (1995)].

We can also apply other LM tests for other types of models with higher-order spatial correlation. The LM statistics follow asymptotically a χ^2 distribution.

If the tests point to the presence of spatial interdependence among territorial units it is usual to estimate two types of models by the method of maximum likelihood: the model of spatial lag and spatial error model [Anselin (1988) and Le Sage (1998 and 1999)], and we must always bear in mind the LM test results, because they can immediately indicate the best model specification that includes the spatial dependence [Anselin and Florax (1995)].

With regard to the absolute convergence with spatial dependence, we estimate the following models [specification adapted to the existence of spatial autocorrelation, suggested by Anselin (1988)]:

- Spatial *lag* model

$$\ln\left(\frac{y_{iT}}{y_{i0}}\right) = \alpha + \rho\left[W.\ln\left(\frac{y_{iT}}{y_{i0}}\right)\right] + \beta\ln(y_{i0}) + \varepsilon_i \qquad \textbf{\textit{(3.6)}}$$

- Spatial Error Model

$$\ln\left(\frac{y_{iT}}{y_{i0}}\right) = \alpha + \beta\ln(y_{i0}) + \varepsilon_i \text{ and } \varepsilon_i = \lambda[W.\varepsilon]_i + u_i \qquad \textbf{\textit{(3.7)}}$$

where: ρ and λ are coefficients of spatial autocorrelation and W is the regional weight matrix (standardized neighborhood matrix).

In models of spatial error, spatial dependence is restricted to the error term and it is not possible to distinguish the causes of the dependence.

Considering also the spatial dependence, we estimate the following models of conditional convergence [specification adapted to the existence of spatial autocorrelation, suggested by Anselin (1988)], depending on the type of autocorrelation:

- Spatial *lag* model:

$$\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta\ln(y_{i,0}) + \gamma X_i^{'} + \rho W\left[\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)\right] + \varepsilon_i \qquad \textbf{\textit{(3.8)}}$$

$\varepsilon \sim i.i.d.(0, \sigma^2 I_n)$

- Spatial Error Model:

$$\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta\ln(y_{i,0}) + \gamma X_i^{'} + u_i \qquad \textbf{\textit{(3.9)}}$$

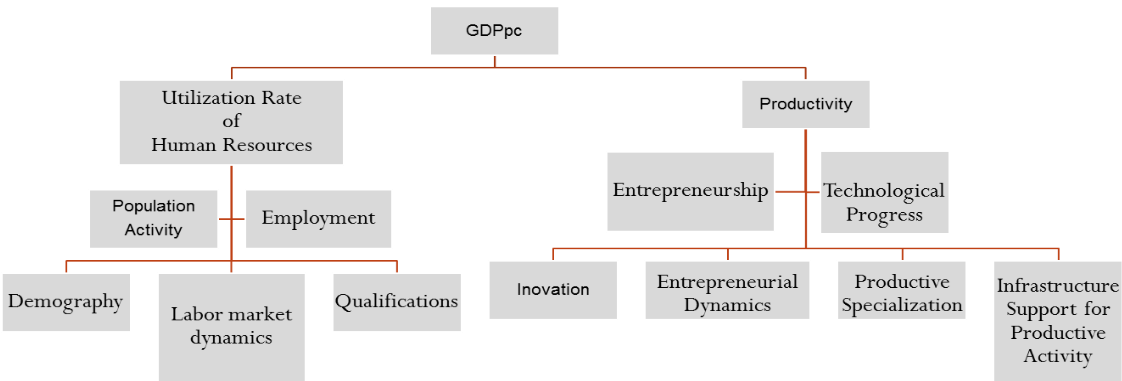
$u_i = \lambda W u_i + \varepsilon_i \qquad \varepsilon_i \sim i.i.d.(0, \sigma^2 I_n)$

where: ρ and λ are coefficients of spatial autocorrelation and *W* are the regional weight matrix (standardized neighborhood matrix).

According to Le Sage (1998) and Anselin (1988), in the estimation of spatial models, the maximum likelihood method must be applied. In fact, in the spatial lag model, the presence of space lagged dependent variable as explanatory variable implies the correlation with the error term, which makes the OLS estimators biased and inconsistent, requiring the use of the maximum likelihood method to estimate the model. On other hand, the coefficient λ of the spatial error model measures the degree of spatial autocorrelation among the error terms of neighboring areas, which makes the OLS estimators inefficient and once again we must use the maximum likelihood method. As such, in the present study, we estimated these models using the maximum likelihood method.

To select the additional explanatory variables to include in the matrix X, with which we intend to describe and distinguish the economic base of each territorial unit, we use the same criterion adopted by Guerreiro and Rego (2005). We follow the Territorial Competitiveness Pyramid proposed by Mateus, A. et al. (2000) [Figure 3.1], in an attempt to distinguish territorial units based on their competitive conditions, which can be grouped in several areas (the pyramid basis): demographics, labor market dynamics, skills, innovation, business dynamics, productive specialization and infrastructure support to productive activity.

Figure 3.1: Territorial Competitiveness Pyramid



Source: Mateus, A. et al. (2000)

In Table 3.2 we present the selection of variables by theme, and their choice was subject to the availability of information in official sources (INE, 2008b) for the spatial units of analysis.

Table 3.2: Explanatory variables selected

Base of territorial competitiveness pyramid	Explanatory variables (proxy) *Source: National Statistics Institute, Census of Population, 1991*
Demography	• Ageing ratio
Labor market dynamics	• Activity rate • Unemployment rate
Qualification	• Percentage of labor force with higher education • Illiteracy rate
Inovation	Not available for base year (1991)
Entrepreneunerial dynamics	Not available for base year (1991)
Productive specialization	Employment structure by sector of activity: • Percentage of population employed in sector I • Percentage of population employed in sector II • Percentage of population employed in sector III
Infrastructure Support for Productive Activity	Information not collected because we did not consider it relevant in the distinction of spatial units

The information collected for the variables listed in Table 3.2, refers to the initial year of our data series, namely the 1991[8] in an attempt to incorporate in the model, the structural differences that distinguish the territorial units at the base of departure for the analysis of convergence.

For data analysis and estimation of the models we use the following software: GeoDa (developed by Luc Anselin) and STATA.

In collecting information, we privilege the official (institutional) sources. As such, we used information from two distinct sources:

• National Statistics Institute (INE): National Accounts, Consumer Price Index (IPC) and also the whole economic-social information available to the municipalities of Portugal and compiled annually in electronic publishing Portugal in Numbers;

• Ministry of Labour and Social Solidarity - Office of Strategy and Planning (DGEEP): information relating to the employees' compensations, by municipality and industry.

The time period chosen for our analysis is basically the 90's, 1991/2002 to the dependent variable employees' compensations and 1990/2003 for the variable GDPpc.

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[8] Although the data series relating to GDPpc for NUTS III begin in 1990, the 1991 data are more reliable, since it is a year of Population Census.

With regard to the spatial disaggregation of information, whenever possible, we choose to collect it for the territorial unity municipality. To avoid biasing the analysis, we excluded the Autonomous Regions (Azores and Madeira), which do not have a spatial relationship of contiguity with other regions. As such, we will only collect information for all municipalities in Portugal mainland.

But when we choose the municipality as the spatial unit of analysis, it raises the problems of changes in territorial nomenclature, because during this period were created new administrative units at this level (new municipalities). Thus, for our annual results to be comparable, we will be based on the Nomenclature of Territorial Units for Statistics of 1990 (Annex A), and for subsequent years, we convert the data into the same classification of municipalities.

The employees' compensations for the final year of the series (2002) were deflated, i.e. recalculated at constant prices of the initial year of the series (1991). Since we are working under the income approach and not by the production approach, the deflator used was the Consumer Price Index (IPC). The IPC is calculated by INE only at the level of disaggregation of NUTS II regions (level II of the Nomenclature of Territorial Units for Statistics), so to each municipality the values were deflated by the IPC's NUTS II region in which each one belongs.

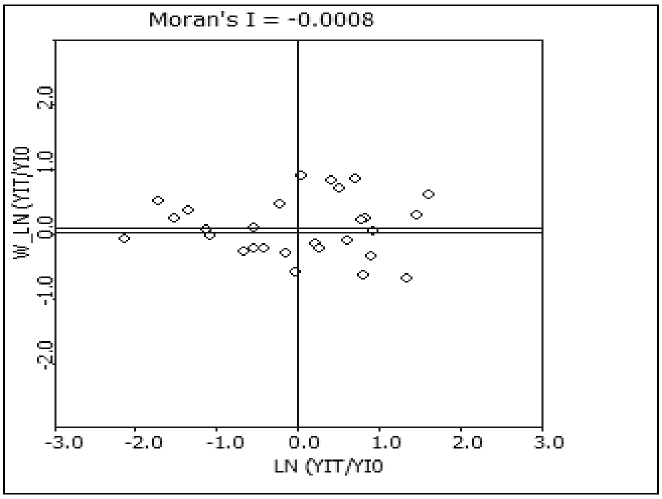
4 Analysis of spatial autocorrelation

Between NUTS III regions: regional growth of GDPpc

Figure 4.1 denotes the absence of spatial autocorrelation in the growth of regional GDPpc. In fact, Moran's I test for the dependent variable assumes a value close to zero[9]. As such, there is no need to estimate the spatial lag models and spatial error for the growth of GDPpc among the NUTS III regions.

[9] This conclusion is confirmed by diagnostic tests of spatial dependence, presented in the tables of results in section 6.

Figure 4.1: Moran's I in the growth of regional GDPpc



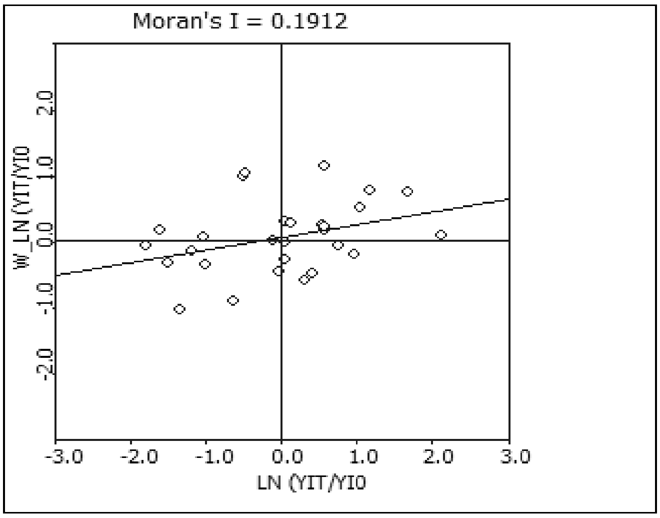
Notes: W_ln(y_{it}/y_{io}) is the growth in the spatially lagged GDPpc and ln (yit / yio) is the growth in GDPpc.

The GeoDa allows us to perform an analysis of local spatial autocorrelation (LISA), which allows us to have an indicator of spatial autocorrelation for each location individually [Anselin (2003b)]. Among the 28 NUTS III regions, only five showed Local Moran I test statistically significant: Tâmega, Médio Tejo and Alentejo with a significance level of 5%, and Pinhal Interior Norte and Pinhal Litoral, with a significance level of 1%.

Between NUTS III regions: regional growth of average monthly earnings per worker

In Figure 4.2 we analyze spatial autocorrelation of regional wage growth by the Moran's I test for dependent variable.

Figure 4.2: Moran's I in regional wage growth



The Moran's I test for dependent variable assumes a low value near zero, but it does not denote a complete absence of spatial correlation, as was the case for the

GDPpc. However, if we analyze the tests LM-Lag and LM-ERR (Table 6.5), we find that both are not significant and therefore, according to our decision rule, we consider the absence of autocorrelation.

Once again, between the 28 NUTS III regions, only five of them (but not the same ones identified for GDPpc) present Local Moran's I tests statistically significant. The regions of Grande Porto, Entre Douro e Vouga, Oeste and Baixo Alentejo have a local Moran's I statistic with a significance level of 5%, and Baixo Vouga with a significance level of 1%.

Between municipalities

Figure 4.3 presents Moran's I statistic for wage's growth between municipalities and shows us that there is autocorrelation between these spatial units.

This is confirmed in figure 4.4, where we repeat the analysis of local spatial autocorrelation (LISA) in terms of compensation per municipality.

Figure 4.3: Moran's I for salaries growth between municipalities

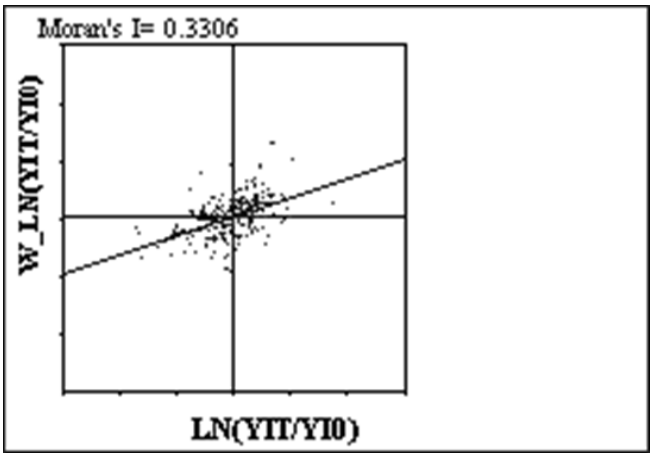
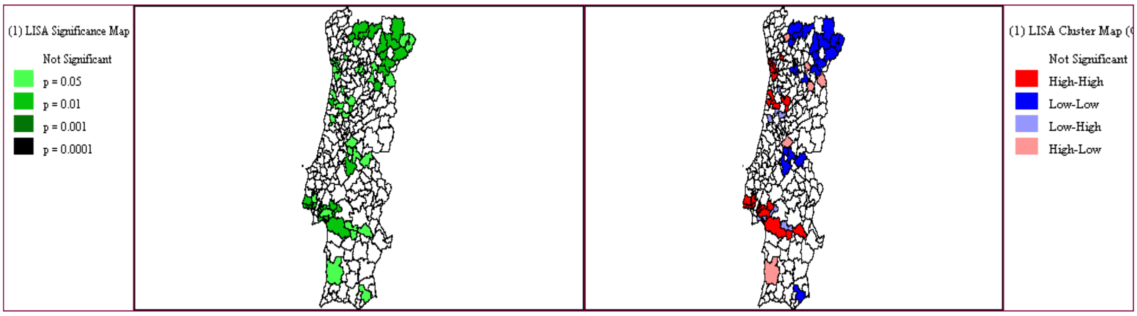


Figure 4.4: Significance and clusters maps of local spatial autocorrelation for remuneration by municipality



We identify three "clusters" of municipalities with very different characteristics:

- Municipalities in the interior north, near the border with Spain (Montalegre, Cabeceiras de Basto, Boticas, Chaves, Bragança, Vimioso, Miranda do Douro, Mogadouro, Macedo de Cavaleiros, Mirandela, Vila Flor, Torre de Moncorvo), with a significant local spatial autocorrelation, forming a low-low cluster, with low values for both variables (the dependent variable and lagged dependent variable) and spatially correlated;
- Municipalities of northern and central coastline, with an extension to the inner center, with a significant local spatial autocorrelation, but forming two types of cluster: high-high cluster for the coastal municipalities (Maia, Matosinhos, Porto Gondomar, Vila Nova de Gaia and Santa Maria da Feira in northern, and Vagos, Aveiro, Oliveira de Barro, Anadia, Tondela and Santa Comba Dão in center), with high values for the dependent variable and lagged dependent variable; and low-low cluster for the municipalities of inside center (Nisa, Mação, Vila de Rei and Abrantes);
- Municipalities that form a track from Lisbon (almost) until the border with Spain (Cascais, Sintra, Loures, Lisboa, Palmela, Montijo, Alcochete, Alcácer do Sal, Alvito and Portel), except the municipality of Moura, with significant local spatial autocorrelation forming a high-high cluster, with high values for the dependent variable and lagged dependent.

5 σ convergence

We studied the σ convergence between NUTSIII regions in GDPpc growth and employees' compensation growth (Figure 5.1).

We observe a slight decrease in GDPpc dispersion along the period ($\sigma = 0.28$ in 1990, $\sigma = 0.25$ in 2002 and $\sigma = 0.26$ in 2003), but in employees 'compensation there is a slight increase in the dispersion (σ = 0.11 in 1991 and σ = 0.13 in 2002[10]). It follows that, although the GDPpc distribution has become less unequal between NUTS III regions, the same was not true for the employees' compensation.

Figure 5.1: Dispersion (σ convergence) of GDPpc and average earnings per worker among NUTS III regions of mainland Portugal

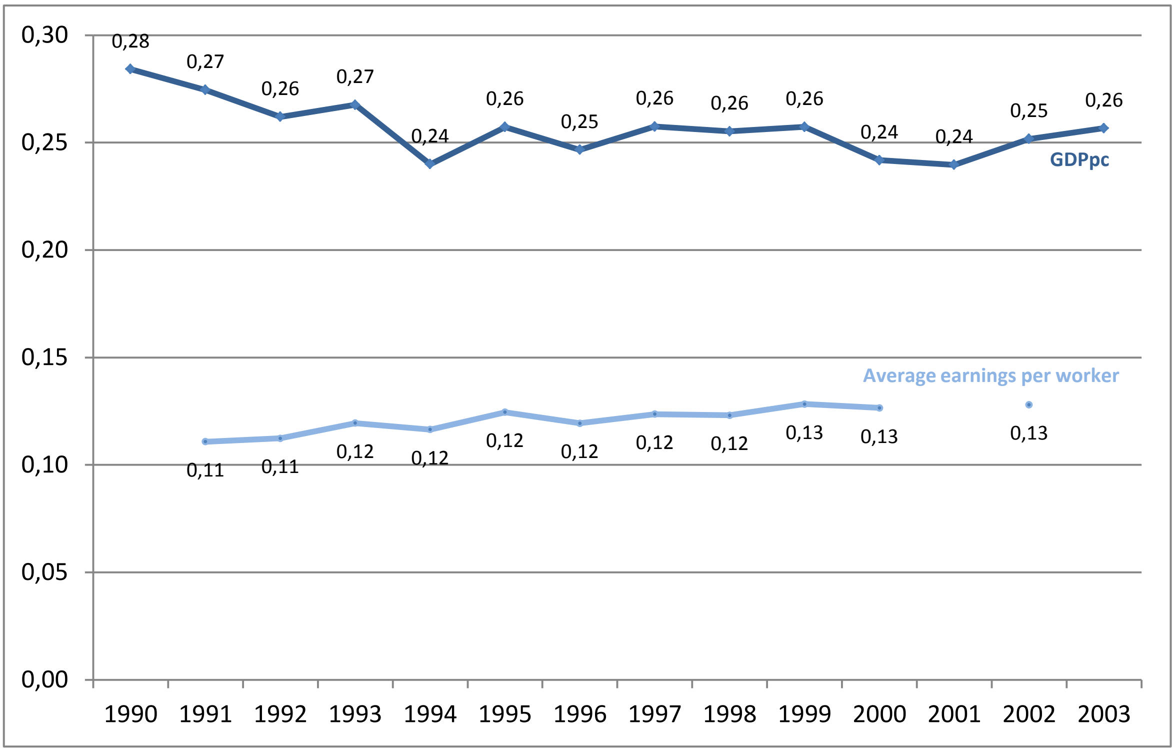
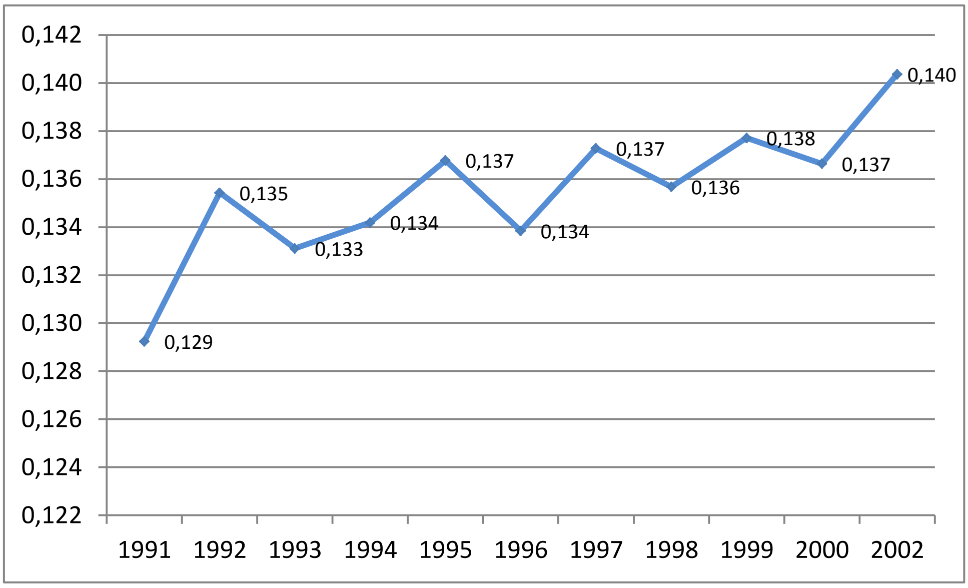


Figure 5.2 presents the dispersion in average wages per worker (or employees' compensation) among the municipalities of mainland and we observe a clear increase in dispersion over the period under review, in 1991 we note σ = 0.129 and in 2002, σ = 0.140.

In Guerreiro (2012), we concluded that we were facing a spatial distribution of employees' compensations moderately uneven, but with a tendency to become increasingly unequal, since indicators, both weighted variation coefficient and weighted Gini coefficient, increased over the period between 1991 and 2002. This conclusion is here confirmed by the increase of the dispersion during this period. We do not register σ convergence.

[10] Note that, in employees' compensation, there is a series break in 2001 alien to the author. In fact, the DGEEP, entity supplying this information, has no data for this year, due to methodological reasons.

Figure 5.2: Dispersion (σ convergence) in average earnings per worker between the municipalities of Portuguese mainland



In next section we check β convergence in the spatial data series of GDPpc and wages.

6 *β* convergence: econometric results

Among NUTS III regions of mainland Portugal in GDPpc growth

Figure 6.1 examines the existence of β convergence among regions NUTSIII of mainland Portugal in GDPpc growth between 1990 and 2003. The horizontal axis represents the logarithm of GDPpc in the initial year of our series, 1990, and the vertical axis represents the growth rate of GDPpc between 1990 and 2003.

Figure 6.1: Convergence among NUTS III regions in GDPpc growth between 1990 and 2003

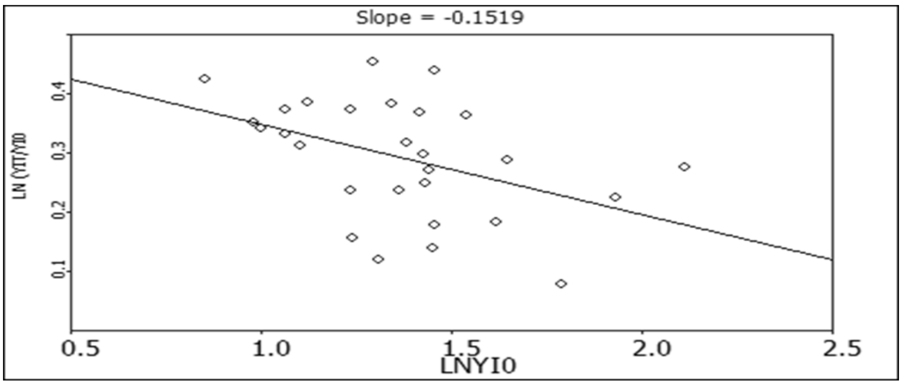


Figure 6.1 shows the inverse relationship between growth and initial value of GDPpc, by indicating the existence of convergence. But let us see in more detail the estimation results of absolute and conditional convergence models in the growth of GDPpc for NUTS III, in the period 1990-2003, using the method of ordinary least squares (OLS), in Table 6.1.

Table 6.1: Estimation of absolute and conditional β convergence models, applied to GDPpc growth among NUTS III regions[11]

Dependent variable: *Growth of GDPpc among NUTS III regions (1990-2003)*		
Explanatory variables	$\ln\left(\frac{y_{iT}}{y_{i0}}\right)=\alpha+\beta\ln(y_{i0})+\varepsilon_i$	$\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i^{'}+\varepsilon_i$
Constant	**0,498** (5,698) (*)	**0,445** (0,840)
GDPpc (1990)	**-0,152** (-2,430) (**)	**-0,259** (-2.265)(**)
Ageing ratio		**0,001** (0,979)
Activity rate		**0,008** (0,764)
Unemployment rate		**-0,012** (-1,200)
Employment in sector I		**-0,002** (-0,532)
Employment in sector II		**-0,003** (-,0,868)
Labor force with higher education		**0,003** (0,202)
R^2	0,185	0,325
F statistic	5,907 *(p= 0,022)*	1,377 *(p= 0,268)*
n	28	28
Breuch-Pagan test	0,519 *(p=0,471)*	3,342 *(p=0,852)*
Notes: - Figures in brackets mean statistic t; (*) indicates that the estimated coefficient is statistically significant for a significance level of 1%; (**) significant at 5% and (***) significant at 10%.		

We observe that the β estimated value is negative and statistically significant in both models, indicating that there is convergence between the regions with regard to GDPpc. In the conditional convergence model all other estimated coefficients are not statistically significant.

Therefore, contrary to Soukiazis and Antunes (2004) conclusions for the period 1995-2000, and bearing in mind that the studies differ with regard to methodology and

[11] We present the results of the more complete conditional convergence model, although other models have been tested with different compositions of the matrix X.

sample[12], there are indications allowing to conclude that the model of absolute convergence seems more appropriate for modeling growth in GDPpc between NUTS III regions for the period 1990-2003, in a sectional view.

Table 6.2: Diagnostics on the spatial dependence in the model of GDPpc absolute convergence for the NUTS III regions

FOR WEIGHT MATRIX : NutsIII_Queen.GAL (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	0.006994	0.4616159	0.6443568
Lagrange Multiplier (lag)	1	0.0527534	0.8183396
Robust LM (lag)	1	0.6647234	0.4148973
Lagrange Multiplier (error)	1	0.0027654	0.9580613
Robust LM (error)	1	0.6147354	0.4330104
Lagrange Multiplier (SARMA)	2	0.6674888	0.7162368

Tables 6.2 and 6.3 present the tests related to the spatial dependence in models of absolute and conditional convergence, respectively. The tests confirm the results in section 4, i.e. the absence of spatial autocorrelation in the regional GDPpc growth. In fact, the Moran's I test statistic, assumes in each case a value very close to zero, and all tests are no significant. As such, we did not estimate the spatial lag or spatial error models for the GDPpc growth among the NUTS III regions.

Table 6.3: Diagnostics on the spatial dependence in the model of GDPpc conditional convergence for the NUTS III regions

FOR WEIGHT MATRIX : **NutsIII_Queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	-0.002326	0.7799318	0.4354309
Lagrange Multiplier (lag)	1	0.0539210	0.8163757
Robust LM (lag)	1	0.3870649	0.5338463
Lagrange Multiplier (error)	1	0.0003058	0.9860489
Robust LM (error)	1	0.3334496	0.5636349
Lagrange Multiplier (SARMA)	2	0.3873706	0.8239171

Among NUTS III regions of mainland Portugal in employees' compensation growth

Figure 6.2 shows that, during the period from 1991 to 2002, there was no absolute β convergence on the growth of compensation per employee between the

[12] Soukiazis and Antunes (2004) carry out the estimation of panel data, and the composition of the matrix X is not exactly the same one that we consider in our work, and these authors do not exclude the autonomous regions of Azores and Madeira.

NUTS III regions, and these spatial units moved away from each other's in terms of this indicator.

Figure 6.2: Convergence among NUTS III regions in employees' compensation growth between 1991 and 2002

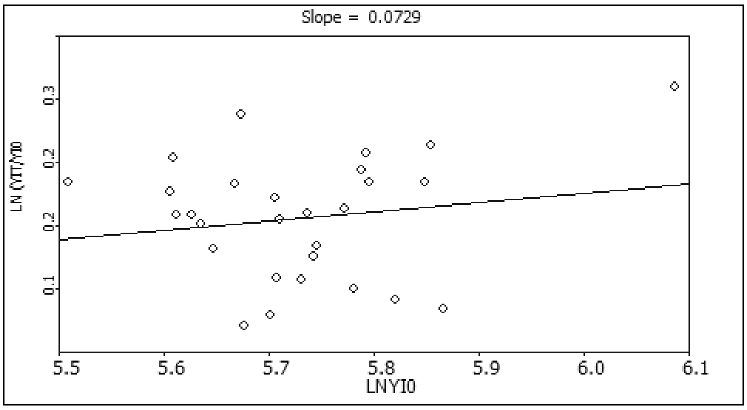


Table 6.4 presents the estimation results of absolute and conditional β convergence models in employees' compensation growth for the NUTS III regions in the period 1991-2002, using the estimation method of ordinary least squares (OLS).

For the conditional convergence, we tested four alternative models: Model A, which includes like explanatory variables, among others, the proportion of people employed in sectors I and II; Models B, C and D where, in terms of employment sectorial structure we include separately the percentage of employed population in each sector, I, II and III, respectively. In our view, models B and D appear more appropriate in terms of convergence between the salaries of the NUTS III regions. In both the estimated β is negative and statistically significant, which demonstrates (conditional) convergence in regional employees' compensation levels.

Table 6.4: Estimation results of absolute and conditional β convergence models among the NUTS III regions, applied to the growth in compensation per employee

Dependent variable: *Growth in average earnings on NUTS III regions (1991-2002)*					
Explanatory variables	$\ln\left(\frac{y_{iT}}{y_{i0}}\right)=\alpha+\beta\ln(y_{i0})+\varepsilon_i$	Model A (I e II) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i^{'}+\varepsilon_i$	Model B (I) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i^{'}+\varepsilon_i$	Model C (II) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i^{'}+\varepsilon_i$	Model D (III) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i^{'}+\varepsilon_i$
Constant	**-0,262** (-0.542)	**0,875** (1,483)	**1,354** (2,806) (*)	**0,847** (1,601)	**1,254** (2,281) (**)
Average earnings (1991)	**0,073** (0,087)	**-0,167** (-1,569)	**-0,237** (-2,487) (**)	**-0,165** (-1,615)	**-0,245** (-2,305) (**)
Ageing ratio		**0,000002** (0,007)	**-0,00006** (-0,225)	**0,000011** (0,041)	**0,0000098** (0,327)
Activity rate		**0,002** (0,714)	**0,003** (1,083)	**0,002** (0,777)	**0,006** (2,598) (**)
Unemployment rate		**0,003** (0,840)	**0,0003** (0,125)	**0,003** (0,969)	**0,001** (0,414)
Employment in sector I		**-0,0002** (-0,118)	**-0,002** (-1,683)(***)		
Employment in sector II		**0,002** (1,358)		**0,002** (2,239) (**)	
Employment in sector III					**-0,001** (-0,816)
Labor force with higher education		**0,017** (3,548)(*)	**0,014** (3,267)(*)	**0,018** (4,577) (*)	**0,005** (3,631)(*)
R^2	0,028	0,725	0,7	0,725	0,670
F	0,749 *(p= 0,395)*	7,546 *(p= 0,000)*	8,168 *(p=0,0001)*	9,235 *(p=0,000)*	7,108 *(p= 0,000)*
n	28	28	28	28	28
Breuch-Pagan test	1,589 *(p=0,208)*	3,343 *(p=0,765)*	8,136 *(p=0,228)*	6,776 *(p=0,342)*	3,343 *(p=0,765)*
Notes: - Figures in brackets mean statistic t; (*) indicates that the estimated coefficient is statistically significant for a significance level of 1%; (**) significant at 5% and (***) significant at 10%.					

Table 6.5: Diagnostics on the spatial dependence in the model of employees' compensation absolute convergence for the NUTS III regions

FOR WEIGHT MATRIX : **NutsIII_Queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	0.193156	2.0617815	0.0392284
Lagrange Multiplier (lag)	1	2.0935855	0.1479186
Robust LM (lag)	1	0.0035406	0.9525516
Lagrange Multiplier (error)	1	2.1089436	0.1464404
Robust LM (error)	1	0.0188986	0.8906575
Lagrange Multiplier (SARMA)	2	2.1124842	0.3477602

Table 6.6: Diagnostics on the spatial dependence in the B model of employees' compensation conditional convergence for the NUTS III regions

FOR WEIGHT MATRIX : **NutsIII_Queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	-0.011585	0.8312386	0.4058387
Lagrange Multiplier (lag)	1	0.8946076	0.3442317
Robust LM (lag)	1	2.3025882	0.1291586
Lagrange Multiplier (error)	1	0.0075868	0.9305903
Robust LM (error)	1	1.4155673	0.2341344
Lagrange Multiplier (SARMA)	2	2.3101749	0.3150300

Table 6.7: Diagnostics on the spatial dependence in the D model of employees' compensation conditional convergence for the NUTS III regions

FOR WEIGHT MATRIX : **NutsIII_Queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	-0.019431	0.6506070	0.5153001
Lagrange Multiplier (lag)	1	0.0023195	0.9615876
Robust LM (lag)	1	0.0102032	0.9195420
Lagrange Multiplier (error)	1	0.0213420	0.8838511
Robust LM (error)	1	0.0292257	0.8642591
Lagrange Multiplier (SARMA)	2	0.0315452	0.9843511

In absolute β convergence model Moran's I test for dependent variable assumes a low value, near zero, although not denotes a complete absence of spatial correlation, as was the case for the GDPpc. However, if we analyze the LM-Lag and LM-ERR tests (Table 6.5), we find that both are not significant and therefore, according to our decision rule, we consider the absence of spatial autocorrelation.

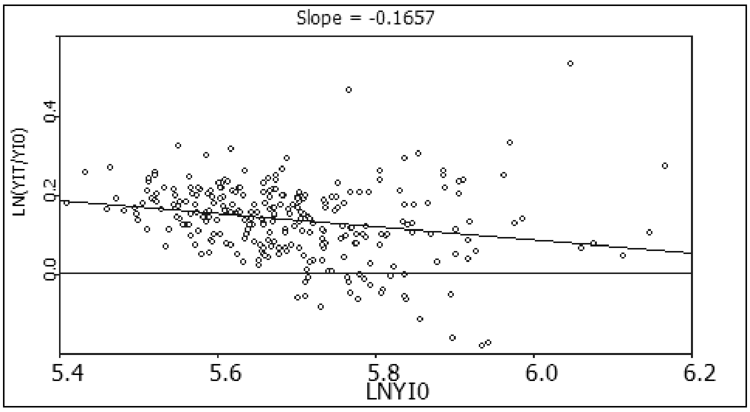
All estimated models for conditional β convergence reveal tests of spatial autocorrelation not significant (see the calculated tests for models B and D in Tables 6.6 and 6.7, respectively).

As such we did not estimate the spatial lag and / or spatial error models, for the growth of wages among the NUTS III regions, both in terms of absolute convergence and in terms of conditional convergence.

Among the municipalities of Portugal and in employees' compensation growth

Figure 6.3 reveals an evidence of absolute β convergence in compensation per employee growth to the period 1991-2002. In fact, there is an inverse relationship between the initial level of remuneration of each municipality and their growth over this period, with a $\hat{\beta}$ = -0.1657.

Figure 6.3: Convergence between the municipalities in compensation per employee growth between 1991 and 2002



Furthermore let us consider table 6.8, where we describe the estimation results of absolute and conditional convergence models applied to wages growth among municipalities in the period 1991-2002. We present the results of four alternative conditional convergence models. The difference between the models lies only in respect of the employment structure by sector of activity for the municipality. In model A, we include the percentage of employment in sectors I and II as explanatory variables, and models B, C and D, include each sector separately, respectively, sector I, sector II and sector III.

All estimated models reveal the existence of convergence between municipalities in employees' compensation throughout the period under review (1991-2002), with $\hat{\beta} < 0$ statistically significant.

When evaluated separately, the coefficients value of employed population in each sector (keeping all other variables in the model) is very close to zero and in the case of the tertiary sector is hardly statistically significant.

The estimated coefficient for the ageing ratio is not significant in any model, while the estimated coefficients for the activity rate and labor force with higher education are significant in all models.

Table 6.8: Estimation results of absolute and conditional β convergence models among municipalities, applied to the growth in compensation per employee

Dependent variable: *Growth in average earnings on municipalities (1991-2002)*					
Explanatory variables	$\ln\left(\frac{y_{iT}}{y_{i0}}\right)=\alpha+\beta\ln(y_{i0})+\varepsilon_i$	Model A (I and II) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i'+\varepsilon_i$	Model B (I) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i'+\varepsilon_i$	Model C (II) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i'+\varepsilon_i$	Model D (III) $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta\ln(y_{i,0})+\gamma X_i'+\varepsilon_i$
Constant	**1,077** (3,19)(*)	**1,951** (6,96)(*)	**2,015** (7,58) (*)	**1,884** (6,97)(*)	**1,920** (6,82)(*)
Average earnings (1991)	**-0,166** (-2,77)(*)	**-0,373** (-7,82)(*)	**-0,340** (-8,11) (*)	**-0,367** (-7,74)(*)	**-0,375** (-7,59)(*)
Ageing ratio		**0,0002** (1,19)	**0,0001** (1,10)	**0,0002** (1,32)	**0,0002** (1,21)
Activity rate		**0,005** (4,92)(*)	**0,005** (5,12) (*)	**0,005** (5,11)(*)	**0,006** (6,48)(*)
Unemployment rate		**0,003** (2,20)**(**)**	**0,002** (2,00) (**)	**0,003** (2,47)(*)	**0,003** (1,93) **(**)**
Employment in sector I		**-0,0004** (-0,81)	**-0,001** (-2,25) (**)		
Employment in sector II		**0,0004** (0,92)		**0,001** (2,39)(**)	
Employment in sector III					**0,00001**(0,03)
Labor force with higher education		**0,017** (4,46) (*)	**0,015** (4,60) (*)	**0,018** (6,04)(*)	**0,017** (4,62)(*)
R^2	0,053	0,445	0,444	0,444	0,433
F	7,65 *(p= 0,006)*	24,51 *(p= 0,000)*	28,72 *(p=0,000)*	27,29 *(p=0,000)*	24,26 *(p= 0,000)*
n	275	275	275	275	275
Breuch-Pagan test	86,95 *(p=0,000)*	3,85 *(p=0,05)*	4,47 (*p=0,035*)	3,75 *(p=0,05)*	6,55 *(p=0,011)*
Notes: - Figures in brackets mean statistic t; (*) indicates that the estimated coefficient is statistically significant for a significance level of 1%; (**) significant at 5% and (***) significant at 10%.					

To verify the existence of spatial autocorrelation we consider Moran's I test for dependent variable (Figure 4.3) and we complete it with a diagnosis related to spatial dependence in models of absolute convergence (Tables 6.9 and 6.10) and conditional convergence (Tables 6.11 and 6.12).

Table 6.9: Global spatial autocorrelation in the model of absolute convergence

Moran's I					
Variables	I	E(I)	sd(I)	z	p-value*
lnyityi0	0.331	-0.004	0.038	8.796	0.000
Geary's c					
Variables	c	E(c)	sd(c)	z	p-value*
lnyityi0	0.673	1.000	0.044	-7.466	0.000
*1-tail test					

Table 6.10: Diagnostics on the spatial dependence in the model of employees' compensation absolute convergence for municipalities

FOR WEIGHT MATRIX : **Concelhos_queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	0.393727	10.4767078	0.0000000
Lagrange Multiplier (lag)	1	85.7583148	0.0000000
Robust LM (lag)	1	17.4543783	0.0000294
Lagrange Multiplier (error)	1	104.5604200	0.0000000
Robust LM (error)	1	36.2564835	0.0000000

Table 6.11: Diagnostics on the spatial dependence in the A model of employees' compensation conditional convergence for municipalities

FOR WEIGHT MATRIX : **Concelhos_queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	0.141562	4.2382280	0.0000225
Lagrange Multiplier (lag)	1	16.4534060	0.0000499
Robust LM (lag)	1	3.1793973	0.0745722
Lagrange Multiplier (error)	1	13.5166646	0.0002365
Robust LM (error)	1	0.2426558	0.6222945

Table 6.12: Diagnostics on the spatial dependence in the D model of employees' compensation conditional convergence for municipalities

FOR WEIGHT MATRIX : **Concelhos_queen.GAL** (row-standardized weights)			
TEST	**MI/DF**	**VALUE**	**PROB**
Moran's I (error)	0.149109	4.3660465	0.0000127
Lagrange Multiplier (lag)	1	19.7341473	0.0000089
Robust LM (lag)	1	4.8048815	0.0283792
Lagrange Multiplier (error)	1	14.9963563	0.0001077
Robust LM (error)	1	0.0670905	0.7956211

Through the analysis of previous tables and figures, is easily concluded that there is spatial autocorrelation in the growth of wages among municipalities, because in all models Moran's I test assumes a nonzero and significant value and the same applies to the Geary's C test, which we only apply in the absolute convergence model.

The spatial autocorrelation is confirmed through the LM tests. In the absolute convergence model all LM tests are statistically significant, giving us no indication of the best model to estimate spatial autocorrelation (spatial lag or spatial error). In the conditional convergence models both LM tests are significant, and LM-lag presents a higher value, but in the robust LM tests, only the RLM-lag is significant.

Thus, following the adopted decision rule, in absolute convergence model, we proceeded to the estimation of two types of spatial autocorrelation models - lag and error – and in conditional convergence model we chose the spatial lag model.

Table 6.13 presents the estimation results to the spatial lag and the spatial error absolute convergence models.

Table 6.13: Estimation results to the absolute β convergence models between municipalities and applied to the growth in compensation per employee

Dependent variable: *Growth in average earnings on municipalities (1991-2002)*			
Explanatory variables	$\ln\left(\frac{y_{iT}}{y_{i0}}\right)=\alpha+\beta\ln(y_{i0})+\varepsilon_i$	Spatial lag model $\ln\left(\frac{y_{iT}}{y_{i0}}\right)=\alpha+\rho\left[W.\ln\left(\frac{y_{iT}}{y_{i0}}\right)\right]+\beta\ln(y_{i0})+\varepsilon_i$	Spatial error model $\ln\left(\frac{y_{iT}}{y_{i0}}\right)=\alpha+\beta\ln(y_{i0})+\varepsilon_i$ $\varepsilon_i=\lambda[W.\varepsilon]_i+u_i$
Constant *Average earnings (1991)*	**1,077** (3,19) (*) **-0,166** (-2,77) (*)	**1,130** (4,13)(*) **-0,188** (-3,90) (*)	**1,705** (5,96) (*) **-0,277** (-5,41) (*)
	-	**ρ=0,542** (8,70) (*)	**λ=0,598** (9,33) (*)
	-	Log likelihood=301,993	Log likelihood=310,114
	R^2=0,053	**AIC**= -597,986	**AIC**=-616,227
n	275	275	275
Notes: - Figures in brackets mean t-value (OLS) and z-value (spatial autocorrelation models) ; (*) indicates that the estimated coefficient is statistically significant for a significance level of 1%; (**) significant at 5% and (***) significant at 10%.			

When spatial autocorrelation is included, the convergence in earnings growth becomes more evident (larger and more significant in absolute terms). Furthermore, both ρ as λ, assume significant estimated values, probably indicating the existence of spatial correlation, both in the independent variable as in the error term, which implies the use of a mixed spatial autocorrelation model, as suggested by Le Sage (1998 and 1999).

For conditional convergence spatial-lag model we obtained the results listed in Table 6.14.

Table 6.14: Estimation results of spatial-lag conditional β convergence models for municipalities and applied to employees' compensation growth

Dependent variable: *Growth in average earnings on municipalities (1991-2002)*				
Spatial-lag model: $\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta \ln(y_{i,0}) + \gamma X_i^{'} + \rho W\left[\ln\left(\frac{y_{i,T}}{y_{i,0}}\right)\right] + \varepsilon_i$				
Explanatory variables	Model A (I and II)	Model B (I)	Model C (II)	Model D (III)
Constant	**1,936** (6,95)$^{(*)}$	**1,951** (7,51)$^{(*)}$	**1,852** (6,91)$^{(*)}$	**1,887** (6,82)$^{(*)}$
Average earnings (1991)	**-0,362** (-7,66)$^{(*)}$	**-0,363** (-7,91)$^{(*)}$	**-0,355** (-7,56)$^{(*)}$	**-0,362** (-7,46)$^{(*)}$
Ageing ratio	**0,00009** (0,73)	**0,00009** (0,72)	**0,0001** (0,89)	**0,00009** (0,71)
Activity rate	**0,003** (3,81)$^{(*)}$	**0,004** (3,81)$^{(*)}$	**0,004** (4,03)$^{(*)}$	**0,004** (4,61)$^{(*)}$
Unemployment rate	**0,002** (1,42)	**0,002** (1,41)	**0,002** (1,74)$^{(***)}$	**0,002** ((1,18)
Employment in sector I	**-0,001** (-1,07)	**-0,001** (-1,86)$^{(***)}$		
Employment in sector II	**0,0001** (0,24)		**0,001** (1,59)	
Employment in sector III				**0,0003** (0,53)
Labor force with higher education	**0,014** (3,94)$^{(*)}$	**0,014** (4,35)$^{(*)}$	**0,016** (5,51)$^{(*)}$	**0,014** (3,98)$^{(*)}$
ρ	**0,266** (3,94)$^{(*)}$	**0,269** (4,10)$^{(*)}$	**0,262** (3,85)$^{(*)}$	**0,287** (4,32)$^{(*)}$
Log likelihood	351,423	351,400	350,870	349,827
n	275	275	275	275
Notes: - Figures in brackets mean z-value; (*) indicates that the estimated coefficient is statistically significant for a significance level of 1%; (**) significant at 5% and (***) significant at 10%.				

All estimated models still show presence of convergence between the salaries of municipalities throughout the period under review (1991-2002), with $\hat{\beta} < 0$ statistically significant.

ρ is always positive (positive spatial autocorrelation) and statistically significant, confirming the existence of spatial dependence.

We highlight that, when evaluated separately, the contribution of employed population in each sector (keeping all other variables in the model), reveals coefficients very close to zero and not statistically significant[13].

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[13] We have estimated all conditional convergence spatial-lag models (A to D), replacing the variable *Labor force with higher education* by the variable *Illiteracy rate*, and in these models the sectorial structure of employment already has a significant contribution to the growth of wages.

The estimated coefficient of ageing rate is not significant in any model, while the estimated coefficients of activity rate and labor force with higher education are significant and positive in all models.

We can say that in terms of earnings growth, the municipalities of Portugal have been converging, although to different 'steady-states' (conditional convergence). The main determinants of growth differences between those territorial units, according to our models, are the characteristics of the resident population, both in terms of activity rate and in terms of the active population academic degree (labor force with higher education).

On the other hand, if we replace the labor force with higher education by the variable that gives us an indication of school education lack (illiteracy, which estimated coefficient is always negative, as expected, although not statistically significant in model A), the sectorial structure of employment appears as a determinant of wages growth, with statistically significant estimated coefficients, in sectors I and II appear with a negative contribution, while the tertiary sector has a positive coefficient.

The fact that, when we vary the composition of matrix X, the significance of estimated coefficients for the different variables changes, also due to the correlation between these variables (Table 6.15).

Table 6.15: Correlations table between matrix X variables to the municipalities

	A.rate	Activ r.	Unemp r.	empi	empii	empiii	Illiter.	LFHEduc
Ageing rate	1.0000							
Activity rate	-0.7076	1.0000						
Unemploym. r.	0.1777	-0.1321	1.0000					
empi	0.3390	-0.5503	0.0121	1.0000				
empii	-0.4003	0.5098	-0.2608	-0.6510	1.0000			
empiii	0.0395	0.0966	0.2843	-0.4915	-0.3411	1.0000		
Illiteracy r.	0.7362	-0.6962	0.2827	0.6589	-0.5146	-0.2256	1.0000	
LF hig. educ.	-0.2026	0.3321	0.0170	-0.4960	-0.0512	0.6730	-0.4977	1.0000

The aging rate shows a high correlation with the activity rate and the illiteracy rate, negative in the first case and positive in the second. The activity rate is also negatively correlated with the illiteracy rate and the employment in the primary sector. This last variable in turn is even more highly correlated with two variables, a negative correlation with the employment in the secondary sector, and positively with the illiteracy rate. On the other hand the share of employment in the tertiary sector shows a high correlation with the percentage of labor force with higher education.

7 Conclusions

In this applied investigation, we cannot confirm the spatial correlation in GDP and wages growth between NUTS III regions, but it is confirmed (in wages growth) for smaller territorial units - municipalities. This could mean that spatial correlation applies particularly in intra-regional level and not in inter-regional level.

Between NUTS III regions, we observed σ convergence in GDPpc growth, but this has not been confirmed in wages growth (at the end of period the wages register a greater dispersion). Indeed, when we tested the existence of absolute β convergence (necessary but not sufficient for σ convergence) we conclude that it occurs only in the growth of GDPpc. We tested further alternative models of conditional β convergence on the growth of compensation between the regions, and it appears to be significant in models B and D, which includes the sectorial employment structure, to sectors I and III, respectively, together with other variables related to workforce and education level. It may indeed be decisive for the different regional "steady-state", the weight that these sectors play in the economy, partly because, during the period under review, there was a net transfer of jobs from sector I to sector III, especially in regions where the first one has assumed major importance in 1991. It is important to note the high significance of the estimated coefficient for the variable labor force with higher education, demonstrating the importance of this variable as a determinant of growth and convergence of wages.

As regards municipalities, we conclude that there is not σ convergence in earnings over the period of our study, which confirms, the results obtained in Guerreiro (2012) when observing the evolution of inequality indexes, as well as the results obtained for NUTS III regions. We therefore conclude that there was an increased dispersion of earnings per worker between the municipalities of Portugal, but this does not invalidate the verification of β convergence, which is confirmed by the significance of $\hat{\beta}$ in all estimated models. After confirming the existence of spatial autocorrelation, the models that consider it turn out to be the best, both in terms of absolute and conditional convergence.

With regard to conditional convergence, we follow the same methodology as in the case of NUTS III regions and we have estimated four alternative models. The model that considers the weight of primary sector employment as a determinant of growth and convergence reveals itself more appropriate, leading us once again to conclude that this variable distinguishes the "steady state" of our small economies. The variables activity rate and labor force with higher education also reveal highly significant on the growth of salaries, reflecting the different contexts of the labor market at regional level.

In this paper we have achieved the proposed objective to reveal the spatial convergence or divergence in income growth in Portugal and we have proved empirically (with our data) the theoretical hypothesis that β convergence is indeed a necessary but not a sufficient condition for the existence of σ convergence.

However we are aware of limitations of this paper. The first limitation regards the lack of available statistical information on small territorial units, preventing the processing of Gross Disposable Income (GDI) of Families with this spatial disaggregation. The analysis of regional GDI would give a better picture of the spatial distribution and convergence of income levels by region and municipality. Another possible limitation and possible clue to future developments regards to the explanation for the inequality found on the spatial distribution of income. We have pointed out some differences in the demographic, economic and social indicators between the spatial units, particularly in respect of economic activity spatial concentration, trying to differentiate the regions or municipalities in terms of "steady state", but there is still much more to explore.

From those limitations arise the tracks for future developments with regard to the study of spatial pattern of inequality and eventual regional convergence of income. Since we have no information on disposable income, we can find an approach to this aggregate if we consider the employees' compensation together with social benefits, which take important values in regions and municipalities with a large aging population.

In terms of econometric analysis of convergence, the data processing can be improved, through:

- Models estimation with panel data (every year), which represents a greater volume of information to be processed, and could reveal more robust results;

- Inclusion in the specification of conditional convergence models, other variables that could better distinguish local economies, allowing a better definition of the various steady-states;
- Exploration of dichotomy between interior and coastal spatial units, which reveals important in the most of indicators, by including a dummy variable in the models specification to distinguish between municipalities located on the coast or inland.

Despite the limitations and future developments that may arise in this area of research, we believe that this work represents an important contribution to the knowledge of the spatial distribution of income in Portugal, allowing a better understanding of regional realities and contributing to support the implementation of possible regional and local policies.

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<u>Annex A:</u> Nomenclature of Territorial Units for Statistics (2002):

NUTS II, NUTS III and Municipalities