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DETERMINANTS OF REGIONAL GROWTH IN PORTUGAL: AN EMPIRICAL ANALYSIS

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ABSTRACT. This paper aims to define the determinants of regional growth in Portugal, at the NUTS III level, in a time span between 1999 and 2010. A panel data approach is used as well as the fixed, random and pooled effects models, all of them with and without trend.
The results from the panel data and the Hausman test show that the model that best portrays the reality under study is the panel data with random effects model. The performed analysis allowed us to confirm that employment, sectorial GVA, electricity consumption, number of museums and landline phone accesses have a positive association with the regional per capita GDP. Surprisingly, the number of residents, population density, number of medical doctors and technical progress presents a negative correlation instead.

JEL Classification: O47, R58

Keywords: Growth, determinants of regional development, panel data, random effects model, fixed effects model.

Introduction

Regional growth or development[1] result not from a single factor, condition or agent, but from their joint action although in different ways. Is has been analyzed by several classical authors that advocated the theories of growth poles (Perroux, 1950) and cumulative causation (Myrdall, 1957) and emphasized the importance of transaction costs (Krugman, 1989; Scott, 1998). Regional growth occurs as a result of the interaction of multiple economic, social, cultural, institutional and environmental dimensions which, in turn, are also

[1] Economic growth is an increase of the national product and allows us to evaluate the performance of an economy. However, the resulting conclusions are not particularly illuminating since the social, organization and institutional aspects were not analyzed. However, it becomes necessary to use the, often ill-defined or misused as synonym, concept of development that, in addition to the quantitative component (increase of the national income), implies qualitative changes in the well-being. Development is an innovative process of creative rupture/destruction that must consider as the absolute priority in a long term perspective.

multifaceted, thence the intensity and form of development of each region being shaped by their depth and level of articulation (Becker and Wittemann, 2008).

Among other factors, national and regional growth are determined by innovation, competitiveness, technology, human capital, tourism, infrastructures and equipments, as documented by Bronzini and Piselli (2008), Shapiro (2006), Rutten and Boekema (2007) and Jackson and Murphy (2006). Technology arises as an essential but not sufficient or exclusive condition to explain regional economic growth (Rutten and Boekema, 2007). The interaction between innovation, social networks and tangible and intangible assets of the region, such as knowledge and technology, are also factors of economic growth (Cooke, 2002; Teece, 2000).

Since the reduction of economic and social inequalities between member countries and regions is one of the central objectives of the European Regional Policy, many researchers have chosen to study this subject (e.g. Goletsis and Chletsos, 2011). Authors such as Campo *et al.* (2008) proposed a classification of European regions adjusted to the different axis of socio-economic development, while Goletsis and Chletsos (2011) measured the development and regional disparities on the Greek periphery.

Several authors studied the relationship between human capital and economic development (Barro, 1991; Barro, 2001; Barro and Sala-i-Martin, 1995; Benhabib and Spiegel, 1994; Gemmell, 1996; Bils and Klenow, 2000; Tamura, 2006) while Barrios and Strobl (2009) analyzed the relationship between regional inequality and per capita GDP in the 12 european countries[2].

Regional social capital and innovation networks are important elements of regions economic growth for Rutten and Boekema (2006), while technology and knowledge are crucial factors for Teece (2000) and Cooke (2002) and Liberto (2008) mentions education as a key factor for regional development in Italy.

At the same time, Tuan and Ng (2007) focused on foreign direct investment (FDI) and regional development in China and Fu and Gabriel (2012) analyzed the contribution of migration and human capital for the regional development of this same country.

At a national level, Ramos (2009) analyzed regional development and sustainability indicators, Crespo and Fontoura (2006; 2009) studied regional convergence at the municipal level, Antunes and Soukiazis (2006) highlighted the important role of European Structural Funds for convergence at the NUTS III level and Soukiazis and Proenca (2008), based on empirical evidence, considered tourism as a factor of regional convergence.

This study aims to identify the main determinants of regional (NUT III) growth in Portugal. In terms of specific goals we can mention the following: (i) deepen the concepts, similarities and differences between growth and development; (ii) identify the key determinants that explain growth of Portuguese regions, considering them as defined in NUT III; (iii) identify the direction (positive or negative) of this influences; and (iv) assess whether the panel data approach is appropriate or suitable for this study.

This research tests the following hypotheses:

- ***Hypothesis 1***: There is a positive association between per capita GDP and the following individual variables: population density, natural growth rate, resident population, employment, GVA, exports, electricity consumption, number of doctors, hospitals and health centers, number of museums and publications, number of higher education institutions, expenditure on culture, financial transfers from public administration[3], number of landline phone accesses and hotel accommodation capacity;

[2] Namely, Austria, Belgium, Finland, France, Germany, Greece, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom and Bulgaria.

[3] Or financial transfers from the state budget.

- ***Hypothesis 2***: There is a negative association between per capita GDP and the following individual variables: aging index, pension amount paid by Social Security, imports and crime rate;
- ***Hypothesis 3***: The panel data methodology is appropriate and has some advantages over other methodologies in order to analyze the economic regional growth.

In terms of methodology, taking into account the characteristics of the economic and social tissue of the country, the lack of administrative regions (the autonomous regions of the Azores and Madeira are the exception) and the heterogeneity of the national territory, we adopted a panel data approach developed from a set of economic, social and demographic observations of the country's regions (NUT III). The geographic area covered by this research includes mainland Portugal and the islands of Madeira and the Azores. The time span considered for the collection of statistical information, from the INE and DGO databases, covers the 12 year period from 1999 to 2010.

This study also considers variables that have not yet been used in previous studies, such as the number of museums per thousand inhabitants, the number of periodicals per thousand habitants or the financial transfers from Central to Local Public Administration.

In addition to this introduction, this article is structured into four sections: (i) section one presents the theoretical framework; (ii) section two exposes the methodological framework of the case study, provides a brief description of the variables and presents some descriptive statistics and the correlation matrix of variables used; (iii) section three presents the parameter estimates and the results of the statistical tests for determining the errors' autocorrelation and heteroscedasticity and multicollinearity between explanatory variables, as well as the discussion of the results; finally, (iv) the fourth section presents a synthesis of the main conclusions of the study.

1. Growth and Regional Development: a theoretical approach

It is generally accepted, that economic growth exists when there are positive changes in the Gross Domestic Product (GDP) supported by an increase of per capita GDP, in most cases accompanied by an increase in population and/or on structural changes (Acemoglu, 2009; Barro and Sala-i-Martin, 2004; Kuznets, 1966). There was a time when growth was defined as a set of quantitative changes in the product and yield variables, following a functionalist and productivist approach, in which space arises as the physical basis of economic activities (Aydalot, 1985). However, the modern concept does a rupture with the functionalist perspective and suggests a return to territorial view that values endogenous resources and the participation of local actors (Aydalot, 1985).

On another hand, development is defined as an upward movement of an entire social system, expressed by a set of endogenous (economic and non-economic) and exogenous factors (Myrdal, 1974). Regional development integrates the variable space, trough the specific spatial reference (the region) into the clearly functionalist and deterritorialized or no spatial economic and social development, in other words a development where the factor territory is innocuous or irrelevant.

Regional development fits into two paradigms: (i) the endogenous, based on the specific or internal resources of the region that values the acquirement of skills by its human resources and (ii) the exogenous, based on external resources of the region, that emphasizes the free operation of markets and the participation of regional companies in trade flows (Dinis and Gerry, 2005).

Regional growth is determined, among other factors, by innovation, competitiveness, technology, human capital, tourism and infrastructure and collective equipments (Bronzini and Piselli, 2008; Rutten and Boekema, 2007; Jackson and Murphy, 2006; Shapiro, 2006) with the technology being a necessary but not sufficient condition for regional economic growth (Rutten and Boekema, 2007). Several authors argued that in the last decades knowledge and technology have increased rapidly, as well as their availability and accessibility, providing a high level of production (Gibbons *et al.*, 1994; Piore and Sabel, 1984; Storper, 1993) but they did not analyze the regional system with its requirements and the factors that influence company's behavior, which are indeed essential for understanding the territorial differences in terms of growth.

Currently, technology has become so ubiquitous that it is no longer a sufficient condition for competitive advantage over competitors (Maskell *et al.*, 1998). The consumer, surrounded by innovations, are more interested in products and services that make their lives more convenient and are attached to the values, fashions and lifestyles they desire. Although it can be argued that technology is just one of the combinations of different types of knowledge that innovation requires (Hertog *et al.*, 1997; Porter, 1998; Rutten, 2003), the increasing availability and integration of knowledge and technology into production and the capital gains that arise to society from it are not territorially homogeneous, which led the EU to promote the competitiveness of regional firms/businesses through the regional development policy (Morgan, 2004).

Historically, it is from the 1950's that regional economy wins its own status as a scientific discipline. For Perroux (1950), regional development results from the creation of growth poles while Myrdall (1957) uses the theory of cumulative causation to explain regional differences in economic development (McGovern, 2003).

Nelson and Winter (1982) extended the notion of creative destruction or innovation being stimulus for economic growth (Schumpeter, 1943) to regional development. According to the authors, the regional actors type of action, i.e. their values, routines and norms that affect the behavior of territories and their agents leading to uneven regional development and hence the creation and deepening of regional disparities.

The theory of regional development is the theoretical support of the "new economic geography", whereby, geographic concentrations of activity can be explained by transaction costs, efficiency and commercial and economical specializations (Krugman, 1989 and Scott, 1998).

Regional network theories define regional development as the result of the interaction of agents within and between networks (Lundvall, 1992; Porter, 1990; Rutten and Boekema, 2007). The number, density of networks and interaction between them, lead each region to specialize and to have a particular economic and social structure. Regional economic growth thus results from the interaction between innovation, social networks and the tangible and intangible assets, such as knowledge and technology of a given region (Cooke, 2002; Teece, 2000).

Reich (1991) drew the attention to the role of the level of education of the labor force (i.e. the human capital), which according to the author, is the basis of production. The regional intangible assets, like for instance a social capital, assuming a determinant role, are themselves part of a dynamic process of social relations (Granovetter, 1985). The social capital, by Putnam (2000), comprises the social organization and the institutions. Morgan (2004) reported other intangible actives such as social and cultural proximity of actors whose role is to facilitate cooperation between network partners.

Additionally, regions with high productivity have a greater ability to attract qualified human resources thus increasing their population (Glaeser *et al.*, 1995; Simon, 1998; Simon, 2004; Simon and Nardinelli, 2002; Waldorf, 2009), which in turn leads to more expensive housing (Rauch, 1993; Shapiro, 2006). It can also be argued that a high human capital stock stimulates the region or location to provide a better quality of life for its residents and Shapiro

(2006) estimated that up to 40% of the effects of an increase in human capital are directly related to an increase in quality of life.

The existence of colleges and universities in a given region seems to be a key determinant of the level of human capital (Winters, 2011) which increased significantly not only by the resident population that has access to higher education, but also by students from other regions that converge and settle in. (Alm and Winters, 2009; Blackwell *et al.*, 2002; Card, 1995; Hickman, 2009; Groen, 2004; Groen and White, 2004; Huffman and Quigley, 2002; Winter, 2011). A significant growth proportion of the so-called "smart cities" is due to former students whom are rooted in the region after completing their higher education. Additionally, residents with higher education lead to increase the diversity and density of consumer services (Glaeser *et al.*, 2001; Milligan *et al.*, 2004; Waldfogel, 2008) and are less prone to commit crimes (Lochner and Moretti, 2004).

The infrastructures and collective equipments that support economic activity and households are regarded as a crucial factor for regional development strategies as they help to improve productivity (Munnell, 1992). A positive relationship between the effectiveness of infrastructures/collective equipments and productivity has been established (Arrow and Kurtz, 1970; Holtz-Eakin and Lovely, 1995) as a substantial positive impact of effectiveness of infrastructures on public capital has been argued by Aschauer (1989; 1990) too.

Although this view was questioned by some authors that documented opposite causality between productivity and public capital and the non-stationarity of the data (Holtz-Eakin; 1994; Garcia-Mila *et al.*, 1996), their position was subsequently refuted by several studies that documented a positive relationship between public capital and productivity of regional productive systems (Bonaglia *et al.*, 2000; Canning, 1999; Canning and Pedroni, 2004; Destefanis and Sena, 2005; Everaert and Heylen, 2001; Fernald, 1999).

Thus, the public capital of a region contributes to increase its comparative advantage, enabling it to capture factors of production from other territories that will see their production or productivity decrease (Boarnet, 1998). The discussion leaves, however, one question unanswered: to what extent does the public capital invested in a given region contribute to increase the productivity in the neighboring regions? Although there are no conclusive answers, given the limited published research, it is nevertheless arguable that, for example, the construction of a highway in a given region has an impact on the neighboring regions by reducing the transport costs of the enterprises that use this infrastructure.

According to Jackson and Murphy (2006), tourism is an important factor for the promotion of regional economic development. Tourism may replace jobs that will be lost in other productive sectors caused by the increasing use of technology or the migration of young people to big cities or more developed regions. Thus, tourism may prove to be a key agent for the economic recovery of certain regions, especially the most isolated and sparsely populated, when these hold a vast natural, patrimonial and cultural heritage. It should however be noted that, like other economic sectors, tourism cannot be the only solution for regional development (Tisdell, 1998). The energy industry, for instance, may also constitute a key sector for the sustainable economic and social development of a region (Ramachandra, 2007).

In short, we can say that regional development results not from a single factor, condition, or agent, but from their interaction though different forms and rates, depending on the specific circumstances of the region.

2. Economic growth in Portugal at the regional level: an empirical approach

2.1. Methodological framework

Based on the analysis of the conceptual framework and several published empirical studies (Field *et al.*, 2008; Goletsis and Chletsos, 2011; Potts, 2010; Soukiazis and Antunes, 2011; Sterlacchini, 2008). This study follows a new research line where new vectors, namely the application of panel data and the introduction of new variables which hitherto had not been used in other empirical studies to Portugal or another countries, as is the case of the variables number of museums per thousand of inhabitants, number of periodicals per thousand inhabitants and financial transfers from central to local government.

The panel consists of a set of statistical observations of the Portuguese NUT III regions during the 1999-2010 timeframe, except for the variables employment, GVA, exports, imports and consumption of electrical energy, for which data was only available for the 1999-2009 period. The use of data for 1999, allows extend the period under review giving more hardiness to the results and establishing the link with the twentieth century. Note also that the values of per capita GDP for 2010 are estimates. The raw data was retrieved from the INE database, the Portuguese Regional Statistical Yearbooks, Regional Accounts, and DGO databases.

The application of panel data models allows taking into account the existing differences among regions, the heterogeneity of the group and the estimation of econometric models that describe the behavior of regions over a year. For the data treatment we took into account the assumptions that affect the random errors of the model, as well as the assumptions of if, when and how to change the settings between individuals and between different periods (Hill, 2012).

According to Hsiao (2003) and Klevmarken (1989), panel data allows to: (i) control the heterogeneity and differences between regions; (ii) process the information with much more variability, less multicollinearity between the explanatory variables, more degrees of freedom and efficiency; (iii) study the dynamic adjustment of the variables over time; (iv) build and test more sophisticated behavioral models than the sectional or pure temporal; and (v) reduce or eliminate the bias resulting from data aggregation.

However, the use of panel data also has some limitations and disadvantages due to the process of data collection and the measurement of error bias, as well as problems of selectivity of the timeframe (which in some cases is short) and of the dependence between the regions.

This panel data approach integrates several general linear models (multiple regressions) that were estimated using the GLS-General Least Squares method of estimation (Naceur, 2003). The values of these models were obtained using Eviews 7. It is assumed that the errors are randomly distributed, homoscedastic and are not self-correlated which, if true, would mean that the obtained estimators are unbiased and consistent.

The complete and unfolded model that we will estimate can be formalized as:

$$y_{it} = \alpha_i + \beta_1 x_{1it} + \beta_2 x_{2it} + \cdots + \beta_k x_{kit} + u_{it}$$

where i (i = 1, 2 ... 30) identifies the region; t (t = 1999 ... 2010) or trend identifies the year; y_{it} is the dependent variable; x_{jit} (j = 1,2,. .., k) are the independent variables or explanatory factors and u_{it} are the random errors of the models, assumed to have zero mean, constant variance and show no contemporaneous correlation.

The panel data analysis was conducted using the fixed effects (FEM) and the random effects (REM) models. The choice of the most appropriate model was supported by specification tests formulated by Hausman (1978). To contrast the results, we used a third model of linear regression: the pooled or accumulated model.

As usual in this type of studies, we chose to convert into natural logarithms all the variables, except those that presented negative values or rates, and the trend in order to minimize the eventual presence of multicollinearity between the explanatory variables (x_{jit}) and reduce the variability of the values (homogenization of variance).

The operationalization of the method was performed using the per capita GDP (y_{it}), as the dependent variable while as explanatory variables or factors (x_{jit}) were used: (x_1) population density (number of inhabitants per km^2); (x_2) natural growth rate in percentage; (x_3) aging index; (x_4) primary employment; (x_5) secondary employment; (x_6) tertiary employment; (x_7) number of medical doctors per 1000 inhabitants; (x_8) primary GVA per job; (x_9) secondary GVA per job; (x_{10}) tertiary per job; (x_{11}) value of pensions paid by the social security per capita; (x_{13}) exports per job; (x_{15}) imports per job; (x_{16}) consumption of electricity (in kWh) per capita; (x_{17}) number of hospitals and health centers; (x_{18}), number of museums; (x_{19}) number of periodicals per 1000 inhabitants; (x_{20}) expenditures of municipalities in culture and sport per capita; (x_{21}) number of higher education institutions; (x_{22}) transfers from general government per capita; (x_{23}) resident population; (x_{24}) number of landline phone accesses per 1000 inhabitants; (x_{25}) accommodation capacity; (x_{26}) crime rate (‰) and the proxy trend (t). The variables x4, x5, x6, x7, x17, x18, x19, x21, x24, and x25 are measured in 1000 inhabitants, while the variables x8, x9, x10, x11x13, x22, x23 are measured in thousand euro.

All the monetary variables were deflated using 2006 as base-year. Since the correlation of regional indices with the national CPI was of 99%, GDP per capita, GVA, value of Social Security pensions, expenditures of municipalities in culture and sport, spending on public administration and value of taxes transfers were deflated using the CPI (100), while imports and exports were deflated using the respective deflators.

The variables used in this study were selected based on the publications cited above and the authors own experience in this field. It should however be noted that the availability and reliability of the raw data used in each regional category (population, social protection, labor market, productivity, education, tourism, energy, technology, health and public administration), were also factors that played a key role in the selection of the variables set.

The dependent or explained variable is per capita GDP in constant 2006 prices. The literature review showed that this variable is usually used in applications with several countries to explain regional development (Soukiazis and Antunes, 2011). According Goletsis and Chletsos (2011), the per capita GDP that is used by European authorities to assess the level of development of each region.

The independent or explanatory variables representing the population are: (x_1) population density (hab./km^2); (x_2) natural growth rate (%); (x_3) aging index and (x_{23}) resident. Population density was used as a variable in several previous studies (Campo and Soares, 2008; Wei and Hao, 2010) and is expected to present a positive association with GDP per capita (Sterlacchini, 2008). Since the natural growth rate[4] (in %) is related to the death rate and the birth rate, it is not clear if whether it will present a positive or negative correlation with GDP per capita. The relation between resident population ratio expressed in thousands of people[5] and GDP per capita is unclear in terms of the signal, due to the enormous variability

[4] Defined as the natural balance observed during a given period of time, usually a calendar year, referring to the average population in that period expressed in 10^3 inhabitants (INE, 2012); TCN = [SN(0,t) / [(P(0) + P(t)/2]] * 10^n where: SN(0,t) is the natural balance between the moments 0 and t; P(0) is the population in the moment 0; P(t) is the population in the moment t.

[5] Set of people that, regardless of being present or absent in a given accommodation at the time of observation, have lived in their place/site of usual residence for a continuous period of at least 12 months preceding the time of observation, or that have arrived to their place/site of usual residence during the period corresponding to the 12 months preceding the time of observation, with the intention to staying for a minimum period of one year (INE, 2012).

of characteristics that it may present. Finally, the aging index[6] is essential to verify the effect of the older population on regional growth since it has been reported that the number of elderly inhabitants has a negative association with growth (Wei and Hao, 2010).

The variable pensions paid by Social Security in thousands of Euros per capita[7] (x_{11}) is associated to social protection. According to Campos and Soares (2008), this variable represents the retired of each region and it is expected to present a negative association (Wei and Hao, 2010).

The explanatory variables that characterize culture are: (x_{20}) expenses of municipalities in culture and sport per capita; (x19) number of museums and (x_{18}) number of journals. The variable costs of municipalities in cultural activities per capita includes spending on maintenance of zoological and botanical gardens, beaches, public parks, grants to artists and arts companies and construction of sports stadiums, public swimming pools, theaters, operas and national museums (Bucci and Segre, 2011). Bucci and Segre (2011) also mention that there is a positive association between spending on culture and sport and the GDP per capita. The introduction of the variable number of museums[8] is due to the fact that it has not been used in other studies although it has been established that the cultural level increase contributes to increase the GDP per capita (Bucci and Segre, 2010). Empirically, one notices that the countries with higher GDP have more people involved in cultural and artistic activities. Although the variable number of periodicals[9], to the best of our knowledge, has not yet been used in any study directly. However we think it is positive for regional growth and is also positive the association with per capita GDP and culture (Bucci and Segre, 2010).

The independent variable that represents the labor market (x_4–x_6) is given by employment per sector of activity[10] and is expected to have a positive association with per capita GDP. Campo *et al.* (2008) found evidence of a positive relationship with GDP and tertiary employment while Soukiazis and Antunes (2011) showed that employment in the primary and secondary sector present a negative association with regional growth.

The explanatory variable that represents productivity (x_8–x_{10}) is GVA by sector of activity[11]. The GVA has a economic significance both for the institutional sectors and the branches of productive activity, due to which it is often used (Barrios and Strobl, 2009; Chi, 2007). Additionally, an increase in productivity leads to an increase in GDP, so we expect it to present an association with per capita GDP.

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[6] Relationship between the elderly and young population, as the ratio between the number of people aged 65 years or more and the number of people with ages between 0 and 14 years, defined as IE = $[(P(65,+) / P(0,14)] * 10^n$ where: P(65,+) is the population aged 65 or over and P(0,14) is the population aged up to 14 years (INE, 2012).

[7] Monthly cash benefit granted to Portuguese citizens resident in Portugal and exceptionally in foreign territory, with 18 or more years of age when incapacitated for all and any profession and the elderly with 65 or more years. In both cases, the beneficiaries may not maintain any professional activity, be covered by other Social Security schemes and have gross monthly incomes exceeding 30% (or 50% per couple) of the minimum national wage (INE, 2012).

[8] Permanent NPO devoted to the service of society and its development; open to the public; promoting research about the material evidence of man and his environment, acquiring, preserving, divulgating and exposing it for study, education and leisure (INE, 2012).

[9] Number of publications edited in continuous series with the same title, on paper and/or electronic, at regular or irregular intervals, for an indefinite period with the different elements of the series being consecutively numbered and/or with each of them being dated (INE, 2012).

[10] The employment includes all the people with a productive activity within the definition of production (INE, 2012).

[11] Balance of production account which includes, in resources, the production and, in employment, the intermediate consumption before the deduction of the consumption of fixed capital. The GVA is calculated at basic prices, i.e., not including the liquid taxes of subsidies on products (INE, 2012).

The independent variables that characterize international trade (x_{13} and x_{15}) are, respectively, exports and imports. These variables were used in several studies such as Hao and Wei (2010) and Kuo and Yang (2008). We expect to find a strong relationship between regional growth and international trade (Soukiazis and Antunes, 2011). While a positive association is expected for exports (Kuo and Yang, 2008), it is unknown what kind of association will have imports with per capita GDP.

The explanatory variable that represents education (x_{21}) is the number of higher education institutions per 1000 inhabitants. It is expected to have a positive association with GDP per capita (Chi, 2007) since several studies report that education is key to development and regional growth (Campo *et al.*, 2008; Goletsis and Chletsos, 2011; Liberto, 2008; Sterlacchini, 2008)

The independent variables that characterize health are: (x_7) the number of physicians[12] and (x_{17}) number of hospitals and health centers[13]. These variables proved to be important to measure regional growth given that an increase in these variables leads to increased GDP (Goletsis and Chletsos, 2011). Thus, it is expected that the variables that represent health will have a positive association with per capita GDP.

The explanatory variable that represents tourism is (x_{25}) the accommodation capacity per[14]. It is expected to have a positive association with GDP per capita since an increase in tourism leads to increased GDP (Goletsis and Chletsos, 2011).

The independent variable that characterizes energy is (x_{16}) the electricity consumption (kWh) per capita[15], which seems to be fundamental to regional growth (Ramachandra, 2007) and is expected to present a positive association with per capita GDP.

The explanatory variable that represents technology is (x_{24}) the number of landline phone accesses. Like the previous, this variable was also proved useful to growth (OCDE, 1992) and is expected to have a positive association with GDP.

The information about the variables used, notation, unit of measure and the expected signal is summarized in *Table 1*.

Table 1. Variables used in the study, their notation in this paper, unit of measurement used to express them and relevant/supporting publications

Variables	Notation	Unit of measurement	Expected signal	Author, Year
1	2	3	4	5
Dependent variable				
* GDP per capita	Y_1	Thousands of Euros per capita		
Independent variables:				
* Constant	C			

[12] Qualified professional with Medical education and legally authorized to practice medicine (INE, 2012).
[13] Hospitals are health establishments equipped with inpatient and outpatient units and diagnostic and therapeutic means, with the goal of providing curative and rehabilitation medical care to the population, having to also assist in the preservation of the disease, in education and scientific research. Health centers are public health establishments, with or without inpatient units, aimed at health promotion, disease prevention and care giving by intervening in the first line of action of the National Health Service, and ensuring continuity of care, when is need to resort to other services and specialized care (INE, 2012).
[14] Maximum number of individuals that the establishments can accommodate in a given time and that in hotel industry is determined by the number of individual beds (double beds count as two) per 1000 inhabitants (INE, 2012).
[15] Sum of power consumption attributable to production, services not pertaining to exploration and, if any, to consumption in pumping and synchronous compensation (INE, 2012).

1	2	3	4	5
Population:				
* Population density	X_1	Inh./Km^2	Positive	Sterlacchini, 2008[1]
* Natural growth rate	X_2	%	?	
* Aging index	X_3	Number	Positive	Wel and Hao, 2010[2]
* Resident population	X_{23}	Thousands of people		
Labor market:				
* Primary employment	X_4	Per 1000 inhabitants	?	
* Secondary employment	X_5	Per 1000 inhabitants	?	
* Tertiary employment	X_6	Per 1000 inhabitants	Positive	Campo *et al.*, 2008
Productivity:				
* Primary GDP	X_8	Thousands of Euros per job	Positive	Chi, 2007
* Secondary GDP	X_9	Thousands of Euros per job	Positive	Chi, 2007
* Tertiary GDP	X_{10}	Thousands of Euros per job	Positive	Chi, 2007
Social protection:				
* Pensions paid by Social Security	X_{11}	Thousands of Euros per capita	Negative	Wei and Hao, 2010
International trade:				
* Exports	X_{13}	Thousands of Euros per job	Positive	Soukiazis and Antunes, 2011
* Imports	X_{15}	Thousands of Euros per job	?	
Energy:				
* Electricity consumption	X_{16}	kWh per capita	Positive	Rachamandra, 2003
Health:				
* Medical doctors	X_7	Number per 1000 inhabitants	Positive	Goletsis and Chletsos, 2011
* Hospitals e Health Centers	X_{17}	Number per 1000 inhabitants	Positive	Goletsis and Chletsos, 2011
Culture:				
* Periodical publications	X_{18}	Number per 1000 inhabitants	Positive	Bucci and Segre, 2010
* Museums	X_{19}	Number per 1000 inhabitants	Positive	Bucci and Segre, 2010
* Municipalities expenses in culture and sport	X_{20}	Thousands of Euros per capita	Positive	Bucci and Segre, 2010
Education:				
* Higher education establishments	X_{21}	Number per 1000 inhabitants	Positive	Chi, 2007
Public administration:				
* Transfers from Central Administration	X_{22}	Thousands of Euros per capita	Positive	Reich, 1991
Technology:				
* Landline phone accesses	X_{24}	Number per 1000 inhabitants	Positive	OCDE, 1992

1	2	3	4	5
Tourism:				
* Accommodation capacity	X_{25}	Number per 1000 inhabitants	Positive	Goletsis and Chletsos, 2011
Justice:				
* Criminality rate	X_{26}	%	Negative	Winters, 2011

Legend:
1 – The author refer regional economic growth; 2 – the author refer growth.

The explanatory variable that represents justice is (x_{26}) the crime rate (‰). It has been used by some authors and, in particular, Winters (2011) found a negative association with GDP per capita as it contributes to reduce the quality of life.

The independent variable that represents the public administration is (x_{22}) transfers from central government to Local Administration[16], which is expected to have a positive association with per capita GDP (Reich, 1991).

The t variable, or trend, is used to establish the effect of time on regional growth.

2.3. Descriptive statistics and correlation matrix

The variables were first treated in order to estimate the following measures: average, median, maximum and minimum, standard deviation, skewness, kurtosis, results of the Jarque-Bera normality test, sum of all values, sum of squared deviations, number of observations and number of sections or regions (cross section) for each of them (*Table 2*).

Table 2. Descriptive statistics

	LNY1	LNX1	X2	LNX3	LNX4	LNX5	LNX6	LNX7
1	2	3	4	5	6	7	8	9
Mean	2.520723	4.646444	-0.201179	4.854327	2.821088	3.516874	4.074742	0.695779
Median	2.522759	4.605670	-0.230000	4.933394	2.737217	3.570083	4.032756	0.641854
Maximum	3.252585	7.364420	0.660000	5.467216	3.996456	5.448400	6.933109	2.476538
Minimum	1.941401	2.681022	-1.090000	4.036009	1,675787	1.426476	2.028937	-0.510826
Std. Dev.	0.264561	0.413838	0.413838	0.382535	0.623206	0.984603	0.938878	0.558815
Skewness	0.492330	-0.093058	-0.093058	-0.413442	0.225024	0.069395	0.801578	0.998005
Kurtosis	3.416448	1.945365	1.945365	2.109993	1.997361	2.068231	4.538253	4.686274
Jarque -Bera	13.33480	13.38042	13.38042	17.21824	14.09132	10.35364	57.59050	79.65504
Probability	0.001272	0.009801	0.001243	0.000182	0.000871	0.005646	0.000000	0.000000
Sum	705.8023	1301.004	-56.33000	1359.212	789.9046	984.7248	1140.928	194.8162
Sum Sq. Dev	19.52793	430.5081	47.78211	40.82693	108.3597	270.4747	245.9365	87.12465
Observations	280	280	280	280	280	280	280	280

	LNX8	LNX9	LNX10	LNX11	LNX13	LNX15	LNX16	LNX17
Mean	1.860190	3.139584	3.405384	1.197917	919.4885	944.2654	8.289797	-2.778709
Median	1.475648	3.117201	3.393507	1.211003	687.7653	469.5796	8.287889	-2.792171
Maximum	3.589124	4.586419	3.784458	3.711197	8607.886	34169.12	9.458747	-1.795876
Minimum	0.619034	2.554057	2.060914	-1.430398	-15935.03	-34672.11	7.482767	-3.847781

[16] Include all direct and indirect taxes, except income tax, regarding the business activity generally calculated as a function of consumption, production and sales (INE, 2012).

1	2	3	4	5	6	7	8	9
Std. Dev.	0.879883	0.318547	0.120766	0.363080	1421.063	3195.598	0.351772	0.452031
Skewness	0.487800	1.686974	-4.219811	-1.920334	-5.083507	-0.763165	0.531090	0.053641
Kurtosis	1.721001	8.461758	57.39165	28.77753	75.02423	97.89944	3.909904	2.249481
Jarque -Bera	30.18903	480.8338	35346.25	7924.372	61726.67	105096.0	22.82177	6.705858
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000011	0.034982
Sum	520.8533	879.0836	953.5076	335.4167	257456.8	264391.8	2321.143	-778.0385
Sum Sq. Dev	216.0001	28.31069	4.069063	36.77972	5.63E+09	2.85E+09	34.52442	57.00872
Observations	280	280	280	280	280	280	280	280

	LNX18	LNX19	LNX20	LNX21	LNX22	LNX23	LNX24	LNX25	LNX26
Mean	-3.639478	-2.061309	-2.452532	-3.786777	-1.252798	5.549448	3.463190	2.588219	3.430226
Median	-3.635630	-2.102410	-2.507308	-3.869752	-1321.397	5.517402	3.503604	2.561118	3.387774
Maximum	-2.085279	-0.699550	-1.400647	-2.265065	2.487816	7.617640	4.088326	5.480026	4.304065
Minimum	-5.208847	-3.198745	-3.418358	-5.607514	-3.929732	3.849488	2.729159	0.779769	2.821379
Std. Dev.	0.582035	0.449650	0.427621	0.651428	0.732241	0.803250	0.226137	0.925747	0.270594
Skewness	0.025633	0.541125	0.168958	0.095079	0.382348	0.386491	-0.576396	0.901184	0.663947
Kurtosis	0.025533	3.655640	2.262360	2.365338	6.372535	3.347271	3.940014	5.138103	3.527657
Jarque -Bera	0.037660	10.67982	7.680166	5.121147	139.5188	8.377815	25.81315	91.99425	23.82013
Probability	0.981346	0.000088	0.021492	0.077260	0.000000	0.015163	0.000002	0.000000	0.000007
Sum	-1019.054	-577.1665	-686.7090	-1060.298	-350.7834	1553.845	969.6933	719.1013	960.4634
Sum Sq. Dev	94.51537	56.40954	51.01785	118.3959	149.5931	180.0139	14.26746	239.1053	20.42876
Observations	280	280	280	280	280	280	280	280	280

Source: Authors own calculations using E-Views v. 7.

The results of applying the Jarque Bera normality test show that, except for the variables (lnx_{18}) number of periodicals and (lnx_{21}) higher education institutions, all other variables reject the null hypothesis of normality at the usual significance levels. The variables are positively skewed, except (lnx_2) growth rate, (lnx_3) aging index, (lnx_{10}) tertiary GVA, (lnx_{11}) pensions paid by Social Security, (lnx_{15}) imports and (lnx_{24}) number of landline phones.

There are about 15 variables that have a kurtosis coefficient less than the normal, the default value (normal distribution) being 3.

Eighteen of the variables are positively related (skewness) the rest (six) being negatively associated.

The relation between each pair of the variables using a correlation matrix can be seen in *Table 3*. Using this matrix to study the collinearity or multicollinearity between the variables, we are in a situation where none of the independent variables is perfectly correlated with any other independent variable, which allows us to consider the coefficients and respective signs correct. In general terms, the matrix showed that there is no linear combination of the independent variables except (lnx_3) aging index and (lnx_2) rate of natural growth with the value -0.939 and between the (lnx_{23}) resident population and (lnx_6) tertiary employment with a value near unity (0.964).

Table 3. Correlation Matrix

	LNY1	LNX1	X2	LNX3	LNX4	LNX5	LNX6	LNX7	LNX8	LNX9	LNX10	LNX11	X13	X15	LNX16	LNX17	LNX18	LNX19	LNX20	LNX21	LNX22	LNX23	LNX24	LNX25	LNX26
LNY1	1																								
LNX1	0,307	1																							
X2	0,285	0,835	1																						
LNX3	-0,152	-0,767	-0,939	1																					
LNX4	-0,375	-0,078	0,027	-0,028	1																				
LNX5	0,310	0,897	0,895	-0,789	0,065	1																			
LNX6	0,570	0,800	0,719	-0,576	-0,080	0,845	1																		
LNX7	0,487	0,338	0,074	0,053	-0,098	0,219	0,539	1																	
LNX8	0,579	-0,098	0,043	0,017	-0,603	-0,019	0,288	0,175	1																
LNX9	0,649	-0,138	-0,141	0,271	-0,269	-0,121	0,165	0,246	0,535	1															
LNX10	0,604	0,226	0,162	-0,420	-0,134	0,123	0,262	0,272	0,229	0,379	1														
LNX11	0,117	0,323	0,177	-0,097	-0,071	0,301	0,300	0,187	-0,040	0,062	-0,015	1													
X13	0,165	0,246	0,213	-0,170	-0,089	0,280	0,163	0,034	-0,028	0,073	-0,008	0,125	1												
X15	0,200	0,217	0,155	-0,104	-0,123	0,211	0,230	0,085	0,076	0,128	0,096	0,118	0,804	1											
LNX16	0,607	0,140	0,116	0,051	-0,233	0,184	0,221	0,264	0,308	0,650	0,222	0,289	0,256	0,133	1										
LNX17	-0,089	-0,674	-0,698	0,579	0,027	-0,693	-0,433	0,079	0,161	0,089	-0,030	-0,333	-0,269	-0,151	-0,307	1									
LNX18	0,251	-0,420	-0,550	0,469	-0,273	-0,545	-0,242	0,218	0,279	0,295	0,168	-0,083	-0,128	-0,052	0,060	0,613	1								
LNX19	0,189	0,254	-0,049	0,051	-0,176	0,067	0,234	0,535	-0,150	-0,111	0,195	0,074	-0,069	0,104	-0,208	0,265	0,236	1							
LNX20	-0,080	-0,660	-0,604	0,586	-0,152	-0,583	-0,376	0,037	0,319	0,160	-0,193	-0,143	-0,175	-0,114	-0,039	0,607	0,436	-0,010	1						
LNX21	0,218	-0,160	-0,368	0,440	0,074	-0,224	0,097	0,682	0,113	0,227	0,199	-0,062	-0,156	-0,030	0,021	0,294	0,285	0,357	0,271	1					
LNX22	-0,368	-0,638	-0,592	0,478	0,120	-0,610	-0,575	-0,224	-0,122	-0,090	-0,192	-0,244	-0,181	-0,175	-0,270	0,546	0,248	-0,053	0,374	0,095	1				
LNX23	0,402	0,854	0,804	-0,679	0,022	0,927	0,964	0,394	0,156	0,057	0,214	0,304	0,190	0,222	0,152	-0,549	-0,411	0,136	-0,472	-0,030	-0,585	1			
LNX24	0,375	-0,137	-0,178	0,278	-0,132	-0,147	0,107	0,345	0,365	0,217	0,221	-0,186	-0,142	0,067	-0,026	0,371	0,138	0,328	0,254	0,486	0,018	-0,030	1		
LNX25	0,491	-0,111	-0,108	0,154	-0,055	-0,191	0,135	0,352	0,288	0,259	0,423	-0,068	-0,228	-0,026	0,149	0,298	0,406	0,266	0,239	0,331	0,024	-0,045	0,432	1	
LNX26	0,650	0,414	0,408	-0,277	-0,256	0,407	0,657	0,484	0,525	0,288	0,406	0,235	-0,002	0,119	0,367	-0,235	0,086	0,103	-0,040	0,200	-0,386	0,543	0,261	0,486	1

Source: Authors calculations using E-Views v. 7.

3. Estimates of the parameters, tests and other statistical results

3.1. Results

The results of the six estimations obtained running each of the three models (fixed effects, random effects and pooled models) with and without trend are summarized in *Table 4*. Some indicators related to the quality of the regression (F test), the autocorrelation between errors (Durbin-Watson test) and the redundancy tests for the fixed effects model can also be seen.

The redundancy test shows whether there are significant differences between regions (NUT III) and the Hausman test allows to appreciate the occurrence of correlations between the coefficients and the residuals or errors of the models, while identifying which is the best panel data model (fixed or random effects) to explain wealth growth in the Portuguese mainland and insular regions.

Table 4. Results of estimations using different models

Variable or parameter	Fixed effects Model		Random Effects Model		Pooled Model	
	Without trend	With trend	Without trend	With trend	Without trend	With trend
C		-1.221594*	0.537140*	0.673537*	0.956724*	0.929528*
x1	-0,3246*	-0.306937*		-0.022730**	-0.024337*	-0.038038*
x2						
x3				-0.030984***	-0.061123*	-0.070387*
x4	0.042115*		0.022935**			-0.015825*
x5	0.227384*	0.197116*	0.248665*	0.207804*	0.286518*	0.256583*
x6	0.571622*	0.646074*	0.592405*	0.586001*	0.696901*	0.723020*
X7			-0.025190**		-0.041039*	-0.048023*
X8	0.077597*	0.049604*	0.062595*	0.042332*	0.018476*	
X9	0.266120*	0.273117*	0.265879*	0.252299*	0.328518*	0.297978*
X10	0.590616*	0.658943*	0.616937*	0.602886*	0.739415*	0.761580*
x11		0.004032***				
x13					1.45E-05*	1.56E-05*
x15					-4.65E-06*	-5.14E-06*
x16	0.040869**	0.082444*	0.026849**	0.060995*		0.038457*
x17				-0.027653***		
x18				0.007035***	0.010858**	0.018215*
x19						
x20						
x21					0.015092*	0.015284*
x22						
x23	-0.387962*	-0.356971*	-0.844501*	-0.783868*	-0.986047*	-0.962256*
x24	0.032234*		0.017481***	-0.031026**	0.043910*	
x25					-0.008223**	-0.008414**
x26						
Trend		-0.006798*		-0.006441*		-0.005791*
R-squared, R^2	0.995625	0.995787	0.916800	0.900202	0.986244	0.987041
F-statistic	1692.218	1757.743	351.5154	196.3628	1266.604	1256.761
Prob (F-statistic)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Durbin-Watson stat	1.369205	1.450526	1.333561	1.225499	0.656262	0.690825
Qui-squared	436.557023	462.210591				
Degrees of freedom	28	28				
Prob	0.000000	0.000000				
F stat	1692.218	1757.743				
Prob	0.000000	0.000000				
Qui-squared			157.509611	192.700305		
Degrees of freedom			24	25		
Prob			0.0000	0.0000		

Legend:
*, **, *** statistically significant value at 1%, 5% and 10% levels of significance, respectively.
Source: Authors own calculations using E-Views v. 7.

3.2. Discussion of the results

By analyzing the main results of the panel data estimations using the: i) fixed effects model (FEM); ii) random effects (REM); and iii) pooled model (PM) (*Table 4*), one verifies that there is a convergence of the independent significant variables that are capable to explain regional growth in mainland and insular Portugal (NUT III). Additionally, the dependent and independent variables seem to present the same relation throughout the different models, as the coefficients present 'roughly' the same signs and are very close to each other in terms of absolute values

In summary, the Hausman test indicates that the REM is the most suitable model for studying regional growth. There are high concordance in terms of the signs obtained, by the six tested models, and most of the coefficients estimated for the used variables being significant in all three models. Nevertheless although the global regressions are significant (Prob=0 in F test) in all three models, there is a possibility of autocorrelation between the errors in 3 variables, a normal situation with panel data. The fact that there are still some non significant variables alerts us to a possible association between some of the explanatory variables, i.e., to the hypothesis that there may be multicollinearity between some of the possible determinants of regional growth, reason why some of them the value of coefficients is insignificant.

The per capita GDP reacts positively to positive variations in (x_5) secondary employment, (x_6) tertiary employment, (x_9) secondary GVA and (x_{10}) tertiary GVA only in the pooled and fixed effects models, in (x_4) primary employment in fixed effects model without trend, in (x_8) primary GVA in pooled model with trend, and in, both in the FEM (with and without trend), in (x_{11}) pensions paid by Social Security only in the FEM with trend, in (x_{13}) exports of goods and services only in the PM, in (x_{19}) number of museums in the PM, in (x_{18}) number of higher education institutions only in the PM, in (x_{24}) landline phone accesses and in PM and FEM without trend.

These results are in accordance with those presented by Chi (2007), Campo *et al.*, (2008), Soukiazis and Antunes (2011), Loerincik and Shruthi (2006), Bucci and Segre (2010) and OECD (1992), among others. The results of the pensions paid by Social Security (x11) are in accordance with those presented by Wei and Hao (2010).

The GDP per capita reacts negatively to positive changes in (x_1) population density and (x_{23}) resident population in both the FEM and PM but it only reacts negatively to positive changes in the (x3) aging index, (x_7) number of medical doctors, (x_{15}) imports and (x_{25}) accommodation capacity in the PM and only reacts negatively to positive changes in the (x_4) primary employment in the PM with trend. Some of these results, in particular the negative association of wealth creation in the regions with the (x_7) number of medical doctors and (X_{25}) tourist accommodation capacity although unexpected, can be explained by a possible multicollinearity between some of the variables and even by the errors autocorrelation. These results are not in accordance with those presented by Goletsis and Chletsos (2011).

The negative relation between (x_1) population density and (x_{23}) resident population with per capita GDP may also have the same explanation. Also the increase of employment does not always translate into economic growth where the regions are facing underemployment.

The effect of technical progress on regional growth and development, measured by a proxy, the trend (t), is negative. This result, contradict some macroeconomic models, may possibly be explained by the creation of unqualified unemployment or the exodus of manpower to more competitive regions.

The redundancy test applied to the FEM with and without trend ensures that there are significant differences between the growth models of Portuguese regions (NUTS II), what is not surprising given the disparities between them. In turn, the Hausman test, by rejecting the hypothesis of correlation between the coefficients or parameters and the errors, assures us that the best explanatory model for regional growth (measured by GDP per capita) is the random effects model.

According to the results of the REM without trend it can also be argued that, assuming the ceteris paribus condition: an 1% increase in (x_4) primary employment causes a positive increase of 0.023% in per capita GDP; an 1% increase of 1% in (x_5) secondary employment causes a positive increase of 0.249% in pc GDP and, finally, an increase of 1% in (x_6) tertiary employment causes a positive 0.592% increase of 0.592% in pc GDP. In terms of the elasticity of GDP in reaction to employment, the values are, respectively, 0.023%, 0.249% and 0.592% thus demonstrating that GDP is more responsive to inputs from tertiary than from secondary employment and to inputs from secondary than from primary employment, in agreement with Campo *et al.* (2008).

The empirical results also show that, assuming the ceteris paribus hypothesis: a unitary increase in (x_8) primary GVA causes a positive increase of 0.063% in pc GDP; a 1% increase in (x_9) secondary GVA causes a positive increase of 0.266% in GDP per capita and a 1% increase in (x_{10}) tertiary GVA causes a positive increase of 0.617% in pc GDP. In terms of elasticity of GDP in reaction to sectorial GVA, the values are, respectively 0.063%, 0.266% and 0.617%. As occurs with employment, the tertiary sector GVA has the greatest impact on regional growth. The same results are presented by Chi (2007).

Furthermore, assuming the ceteris paribus hypothesis: a 1% increase in (x_{16}) electricity consumption causes a positive 0.061% increase of 0.061% in GDP (in the REM with trend); a 1% increase in the number of museums (x_{18}) causes a positive increase of 0.007% in GDP per capita (in the REM with trend) and a 1% increase in (x_{24}) landline phone access causes a positive increase of 0.017% in GDP per capita (in the REM without trend). In terms of elasticity of GDP in reaction to variations on these variables, the values are, respectively, 0.061%, 0.007% and 0.017%, which is in accordance with the results reported by the OECD (1992).

On another hand, assuming the ceteris paribus hypothesis: a 1% increase in (x_1) population density causes a decrease of 0.023% in pc GDP (REM with trend); a 1% increase in (x_3) aging rate causes a decrease of 0.03% in pc GDP (REM with trend), a 1% increase in the (x_{23}) number of residents causes a decrease of 0.845% in pc GDP (REM without trend) and a 1% increase in the (x_7) number of medical doctors causes a decrease of 0.025% in pc GDP (REM without trend). Additionally, a 1% increase in (x_{24}) landline phone access increases the pc GDP by 0.032%, in the FEM and by 0.017%, in the REM, both without trend.

Our results are in accordance with those presented by Goletsis and Chletsos (2011), except for the value of elasticity (-0.031%) in the REF with trend. It should also be noted that, from one year to the next, the technical progress measured by its proxy (t) causes a 0.004% reduction in the GDP per capita growth rate, which was not expected/expectable as mentioned above.

Conclusion

The concept of regional development has evolved over the years mainly through the introduction of various dimensions such as the local, cultural, institutional and that of sustainability and citizenship. The economic growth t of a given territory results from a multiplicity of aspects ranging from economic to social, cultural, institutional and environment which, in turn, are also multifaceted. Thus, the intensity and form of regional development are shaped by the aspects/characteristics mentioned above (Becker and Wittemann, 2008).

Our results show that the best panel data model to be used in this study is the random effects model, as shown by the Hausman test. The study also show, that there is good agreement in terms of the signals obtained using the six models considered: fixed effects model (FEM), random-effects model (REM) and pooled model (PM), with and without trend. The coefficients estimated for the variables are mostly significant in all the models and the global regressions are significant (Prob = 0 in F test).

The results of the estimation of the random effects model, which proved to be the best of the three considered models to conclude that factors such as (x_4 to x_6) employment, (x_8 to x_{10}) setorial GVA, (x_{16}) electricity consumption (model with trend), (x_{19}) number of museums (model with trend) and (x_{24}) number of landline phone accesses (model without trend), have a positive association with the regions pc GDP, as expected. However, the same model show that the (x_{23}) number of residents, (x_1) population density, (x_7) number of medical doctors and (x_{24}) number of landline phone accesses react negatively to the regional pc GDP. These results were surprising as these variables were expected to present a positive association, suggesting the need for further studies. The evolution of GDP per capita reacts negatively to positive changes in the aging index, as expected.

Finally, the hypothesis tested was confirmed. Regarding the first hypothesis, it was confirmed that there is a positive association between pc GDP and employment by sector, sectorial GVA, electricity consumption and number of publications. However, this association could not be verified for some of the explanatory variables considered in this study (number of residents, population density, number of medical doctors and technical progress) given, the possibility of occurrence of multicollinearity between some of the explanatory variables and possible autocorrelation between the errors in the various models used in this study.

Regarding the second hypothesis, the study shows that there is a negative association between pc GDP and the aging rate while the other variables have negligible values or contradict the formulated hypothesis.

Regarding the third hypothesis, it was also confirmed that the panel data methodology is appropriate and presents advantages over other methodologies used to assess the explanatory factors of wealth creation of the Portuguese regions. In fact, the panel data model allows the consideration of the differences between the regions and the heterogeneity of the group, as well as its control. On the other hand, still allows the study of the dynamic adjustment over time and reduce or eliminate the skew resulting from the aggregation of data.

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