SPATIAL EXTERNALITIES AND REGIONAL INEQUALITIES: THE CASE OF RIO GRANDE DO SUL

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Abstract

Rio Grande do Sul is the fourth richest Brazilian State. But, like the most places in the world, the activities are spatially concentrated. Using the recent data sourced by Fundação de Economia e Estatística (FEE) covering state comparable areas on the 1970-2000 period, this paper does a spatial exploratory analysis of cities economic growth and studies the traditional state division, the South-North division. The economic growth of both regions is analyzed using the spatial panel model with fixed effects using maximum likelihood estimation methodology. The main result of the paper is that externalities may help to explain the differences on economic growth of these regions. In the model, three literature recognized types of externalities effects in the cities economic growth are studied: knowledge, localization and urbanization. The findings show that the North region experimented knowledge spillovers and localization economies. However, the South region, only experimented urbanization economies without a city spillover effect and didn't experiment other types of positive externalities, which helps to explain its low economic growth in the period. The cities convergence hypothesis is also tested, the results show that there are conditional convergence in both regions.

Keywords: Externalities, Economic Growth, Spatial Panel Model.

JEL Classification: O47, O18, R11, R23.

Resumo

O Rio Grande do Sul é o quarto Estado mais rico do Brasil. Entretanto, tal como na maioria dos lugares no mundo, as atividades econômicas são espacialmente concentradas. Utilizando dados recentemente disponibilizados pela Fundação de Economia e Estatística (FEE) cobrindo o período 1970-2000 com áreas comparáveis, este artigo faz uma análise exploratória espacial do crescimento econômico das cidades e estuda a divisão tradicional do Estado em metades Sul e Norte. O crescimento econômico de ambas as regiões é analisado utilizando um modelo de painel espacial com efeitos fixos estimado através da metodologia da máxima verossimilhança. O principal resultado do artigo é o de mostrar que externalidades podem ajudar a explicar as diferenças de crescimento econômico apresentadas por estas regiões. No modelo, três tipos de externalidades reconhecidas pela literatura são estudados: conhecimento, localização e urbanização. Os resultados mostram a existência de externalidades de conhecimento e economias de localização na região Norte. Entretanto, estas externalidades positivas não são verificadas na região Sul, que somente apresentou a atuação de economias de urbanização sem a presença de efeitos da vizinhança, o que ajuda a explicar o seu baixo crescimento econômico no período. A hipótese de convergência dos municípios também é testada e os resultados mostram a existência de convergência condicional em ambas as regiões.

Palavras chave: Externalidades, Crescimento Econômico, Modelo de Painel Espacial.

Classificação JEL: O47, O18, R11, R23.

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1. Introduction

The economic growth of cities differs from the economic growth of countries in many aspects that make pure neoclassical models inappropriate. The existence of factors mobility, like labor and capital, let saving rates and capital accumulation at a second plan. In the economic growth of cities context is more important to understand how the space and the costs to moving things over it (transport costs) can take to an agglomeration of activities and people in some spatial units. Authors like Myrdal (1957) and Hirschman (1958) had observed a half century ago that there are agglomerative forces that create a circular causality which makes rich regions attract more economic activities and, for consequence, creating inequalities in the economic growth of spatial units like cities.

In the economic growth of cities the role of externalities became evident since New Economic Geography authors recover Marshall (1890) ideas and try to explain the activities distribution trough the action of contrary forces. There are agglomerative (centripetal) forces and disagglomerative forces (centrifugal), where some types of positive and negative externalities can represent these forces. Since the economic growth of cities is dependent of how these forces act, theorical and empirical studies about them are necessary. However, externalities are so difficulty to model and to evidence. Some authors like Jacobs (1969) and Lucas (1988) suggested that their best evidence are in cities. It is certainly a starting point where the spatial econometrics tools can be helpful to determine their extension and dimensions. Factors mobility can generate spillovers effects that affect not only one city but also many neighbor cities, which in spatial econometric language means that there is some spatial dependence (autocorrelation) in the economic growth of cities generated by some type of externality.

In this paper, the most known externality types are studied and discussed, however an alternative classification with three externalities types is proposed. There are localization economies which refer to relationships that can be inter-firms and inter-sectors that specially occur in the industrial activity. As pointed by Marshall (1890), they can exist due the existence of non-traded local inputs, thick labor market and information spillovers. There are urbanization economies which refer to people agglomeration phenomena. They exist due the positive effects that urban environment creates to frequent exchange and interactions across workers. Different from localization economies, urbanization economies are essentially a non-market interaction. The last type of externality is the knowledge spillover. This is the external effect of human capital accumulation. Better educated people benefits the whole economy since it make the ideas generation easier and make people more capable to generate innovations which will improve city productivity.

The paper presents an empirical study about the role of these externalities on the explanation of regional inequalities in Rio Grande do Sul, a Brazilian State. For this goal is used a spatial panel data model covering a thirty years period (1970-2000) using the econometric estimation methodology proposed by Elhorst (2003). The Rio Grande do Sul is the fourth richest state of the country and is responsible for approximately 8% of country GDP and 9% of country industrial production. However, 64% of State's industrial production, 48% of service production and 42% of population is concentrated in only 5,24% of its area. So, like the most part of the world, there are a great people and activities concentration and, as consequence, great regional inequalities. The activities are concentrated at the North of the State and it is very common to do a North-South division, where there are a rich part, the North, and a poor part, the South. There is a common sense that these differences are explained trough differences in colonization, since the North was colonized by Germans and Italians and the South by Portugueses, even tough, the colonization process was finished almost a century. Certainly, the economics can give a contribution to better understanding de State regional inequality and the present study analyses the factors that can determining the economic growth of Rio Grande do Sul cities and how they act in the two different regions, North and South. The paper is organized in the following manner. In the next section will be presented a discussion about externalities and their role in the economic growth of cities. In this section, an alternative classification to externalities is presented and justified. The third section presents the estimation procedure of economic growth with a spatial panel data model. This section presents the maximum likelihood estimation method proposed by Elhorst (2003), the data sources, an exploratory analysis of the growth data, the estimation results and their interpretation in the light of existent literature. The last section of the paper presents some conclusions.

2. The externalities classification and their role on the economic growth of cities

Once that capitals can flow freely inside a country or a State, the economic growth of cities does not depend of saving rates differences. However, this mobility can agglomerate investments in a few cities or regions. The New Economic Geography (NGE) central point is the possibility of activities agglomerate due to existence of some source of increasing returns of scale. This may be either external to the firms or internal. If they are internal, so the traditional microeconomics is the appropriate tool and the relate subject is the firm's optimal size. Which in terms of activities space distribution implies that is better to firms to have a larger plant in a single place than have a fragmentation in many plants in several places. This means that the firms tend to have a few big plants instead of many small plants. However, this doesn't explain the reason why several firms from a same sector or from different sectors are located so closely to each other.

To answer this question the NEG authors recovered the Marshall (1890) ideas of positive externalities. Marshall (1890) was the first to got the attention for the externalities importance, in his known statement, p. 225: "*...so great are the advantages which people following the same skilled trade get from near neighborhood to one another. The mysteries of trade become no mysteries; but they are as it were in the air...*". His three externalities types are considered by the NEG literature as the centripetal forces which are responsible for activities agglomeration: Non-traded local inputs, thick labor market and information spillovers.

Non-traded local inputs externality refers to a decrease on the production costs due to the existence of scale returns in a common intermediate input supply. A large local market supports the local production of intermediate goods, lowering costs for downstream producers. Many firms from a specific sector can be beneficed by an existence of this intermediated input firm. So, these firms will locate near each other to internalize this benefit. However, this agglomeration process depends on two conditions which should be satisfied:

a) The demand for the input is not enough to one firm could explore the scale economies in the intermediary input production.
b) The transport costs are relatively high. If buyer and supplier interact in the designing or in the production of the intermediate input, the direct contact between buyer and seller is necessary, so the proximity to the input supplier is important. Likewise, if the intermediate input is so big, fragile or it should be delivered quickly, the proximity is also important.

Local thick market externality refers to the increase in the job market efficiency. This occurs because many workers located at same place allow workers from different firms to change their jobs at a low cost, because they don't need to change of city, area or state. In this case, the employers are also benefited, because they can hire workers trained by other firms. It means, in a more modern terms, that this Marshallian externality in the job market is nothing else than an increase of the efficiency in the job-matching, where workers and firms are benefited by the proximity, since it reduces the hiring and training costs for the firms and the search cost for the workers (Gordon and McCann, 2000).

Information spillovers externality refers to the information exchange between workers and firms. They can discuss formally or informally about new products or new technologies. McCann (2005) consider that this contacts help to have a better picture of the market. For example, information spillovers can arise with neighboring firms; by observing them and learning about what they are doing, firms learn about technological developments, whom to buy from and sell to, whom to hire, what product lines are selling. This kind of information is essential for many firms and helps them to improve their knowledge about the market. Romer (1986) also give a great importance to this type of externality, the author, p.1003, said that: "*the creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms because knowledge cannot be perfectly patented or kept secret*". So, as Marshall argued, like this knowledge is acquired without any payment, this could be considered an externality.

In spite of the limitations of Marshall's assumptions of perfect competition and constant returns of scale his contributions are far relevant and most of the literature about externalities is based on his ideas. Later, Scitovsky (1954) gives a new classification to externalities that are divided in two types: pecuniary and technological (pure) externalities. The former refers to externalities in which firm's output decision is altered by other agents' decisions. This externality is introduced by market relationships and price mechanisms. The Non-traded local inputs and thick labor market are examples of this type of externality. The later, also known as spillovers, refers the externalities that don't depend from market interactions, but they are inserted as arguments in the consumers' utility functions and/or in the production functions of the firms. In this case, the agents are affected by actions of other agents without a control of that. Informational spillover is an example of that one.

Pecuniary externalities are easier to model and to observe. Fujita and Thisse (2002), p. 9, states that: "*...their impact can be traced back to the values of fundamental microeconomic parameters such as the intensity of the returns of scale, the strength of firms' market power, the level of barriers to goods, and factor mobility.*". Pecuniary externalities are essential for the NEG literature because they arise from market interactions with imperfect competition which generates the increasing returns to scale which takes activities to agglomerate. However, NEG explain cities without addressing non-market interactions which became the big challenge to economists. To explain and identify how the flow of ideas occurs through face-to-face interaction may be an important topic in the cities growth studies. Since non-market interactions are so determined by space, and the spatial organization of economic activities is so determined by non-market interactions, this should be better studied.

A good start point is to consider information as a public good and consider that the value of information is not necessarily diminished when it is used by many agents. Hence information exchanges can generate positive externalities. If their exchanges are less easy and more costly when distance increases, than the cities are the better place to evidence that. Lucas (1988) paper discusses the role of cities in the transfer of knowledge. The author argued that the investment in human capital has at least two results: the first is an individual productivity increase and the second, and most important, all agents are benefited with better educated people, because they are capable to generate innovations which will improve all agents' productivity. Lucas (1988) brought to growth economics the idea that cities may be playing a major role in facilitating the accumulation of knowledge spillovers in the growth process, the disembodied knowledge as called by him. Being in a city where the general level of skills (human capital) is high may result in an even faster accumulation of skills (Lucas 1988, Rauch 1991) and ideas, which, certainly, move quickly in cities. These knowledge spillovers, following the author, would be the economic growth engine. In fact, Lucas followed Jacobs (1969) and Marshall (1890) and argued that cities play a central role in human capital, knowledge, and growth. However, knowledge spillovers are difficulty to measure. Krugman (1991), for example, recognized their importance, but the author states that "*knowledge flows are invisible; they leave no paper trail by which they may be measured and tracked.*" In spite of these difficulties, much of cities economic growth depends on how these pure positive externalities work.

At empirical point of view, the literature brings back the Hoover (1948) classification of externalities. There are localization economies and urbanization economies. Localization economies occur when the concentration of an industry sector in a city facilitates inter-firm formal and informal interactions and, therefore, growth of the industry and city. These interactions generate the same externalities cited by Marshall's seminal work. They are sometimes referred to as MAR externalities after Arrow (1962) and Romer (1986) formalization of Marshall's ideas. Urbanization economies occur when many industry sectors locates near each other. They differ from localization economies because it refers to inter-industry sectors interactions and that proximity benefits all sectors. These externalities are sometimes referred to as Jacob's externalities because her support to the view that sector diversity is beneficial to city growth. In spite of their differences it could be stated that both types of externalities could be considered an industrial phenomenon and that they are indistinguishable in many situations. Both refer to industrial localization phenomena and the main difference is which is an inter-firm or an inter-sector interaction.

Perhaps is not correct to call urbanization economies an industrial phenomenon. Urbanization is the process of people movement from rural areas to cities, later called urban areas. Many authors believe that this process per se could generates spillovers and, for consequence, city growth. Jacobs (1969) was the first to argue that urban environment improve knowledge transference. She emphasized that the role of urban diversity in the formation of new ideas trough many examples of how it works. After her, many authors argue that urban agglomeration is an improver on the knowledge transferences and technologies diffusion (Henderson, 1988; Henderson 1999a,b; Henderson, Shalizi e Venables, 2003). Furthermore, the urban environment promotes frequent exchange and interactions across workers and therefore may speed up the learning of useful skills over time (Glaeser and Mare, 1994). Spatial proximity (and hence urban agglomeration) facilitates non-market interactions and makes relationships easier to start and maintain. These relationships create the face-to-face interactions that are fundamental to generate the knowledge spillovers. As Lucas (1988) pointed, p. 38: "*most of what we know we learn from other people*". Who was never benefited from a good partnership to exchange experiences? The urban environment can speed's up this process with a greater number of experiences lived by individual which make them more experienced more learning prone. Maybe these are the real urbanization externalities. They are more based on non-market interactions than the traditional localization and urbanization economies classification. Henceforward, this paper calls localization economies both inter-firm economies and inter-sectors economies and calls urbanization economies the externalities provided by people agglomeration in urban environments.

This paper uses spatial panel data approach to study three externalities types (localization economies, urbanization economies and knowledge spillovers) and their effects in the economic growth of cites. The next section presents the econometric procedures used for this goal.

3. Estimating cities economic growth model with spatial panels

3.1. Econometric procedures

Panel data studies have been impulsed by recent data availability. The panel data approach advantages and limitations are much known. According to Hsiao (1986) and Baltagi (2001), panel data give more informative data, more variability, less collinearity among the variables, more degrees of freedom, and more efficiency. Panel data also allow the specification of more complicated behavioral hypotheses, including effects that cannot be addressed using pure cross-sectional or time-series data. However, Elhorst (2003) argues that when a panel data have a locational component a spatial dependence problem may exist between the observations at each point in time. The main reason is that one observation associated with a spatial unit may depend on observations at other spatial units and, so, that distance affects economic behavior. A general spatial panel model can be expressed as:

$$Y_{it} = \rho W_1 Y_{it} + X_{it}\beta + \mu_i + \phi_{it} \text{ to } i = 1,...,N \quad ; \; t = 1,...,T \qquad (1)$$

where $\phi_{it} = \lambda W_2 \phi_{it} + \varepsilon_{it}$, i refers to spatial units, t refers to a given period, β is a vector of fixed unknown parameters, μ_i refers to individual effects of spatial units, W_1 and W_2 are the spatial weights matrix, ε_{it} are i.i.d error terms for all i and t with $E(\varepsilon_{it}) = 0$ and $E(\varepsilon_{it}\varepsilon'_{it}) = \sigma^2 I_{NT}$.

This model differs from traditional panel data model by two possible situations. In the first, it was added to error term a spatial term with a coefficient λ usually called the spatial autocorrelation coefficient and the error structure has been changed. If ρ=0, this model is called a spatial error model. This could be, for example, a spatial association of some independent variable which was omitted from the model. In the second, was added a new explanatory variable with a coefficient ρ usually called the spatial lag coefficient, so the number of explanatory variables has increased by one. If λ=0, this model is called a spatial lag model. It means that neighbor's values affect the explained variable.

The presence of spatial effects makes the OLS estimation method inappropriate. The spatial error model is a special case of a regression with a non-spherical error term, in which the off-diagonal elements of the covariance matrix express the structure of spatial dependence. So, in this case, OLS estimator is unbiased, but is no longer efficient since classical estimators for standard errors will be biased. The spatial lag model includes a spatial lag term which should be treated as endogenous variable, since all neighbors' explanatory variables and errors terms appear in the right side of the equation. In this case, OLS will be biased and inconsistent due to the simultaneity bias. To avoid these problems, the literature suggested alternative estimation methods like instrumental variables, generalized methods of moments and, most commonly, maximum likelihood derivation (see Anselin, 1988; Anselin and Hudak, 1992).

Elhorst (2003) presented an estimation procedure to spatial panels using maximum likelihood derivation. However, like traditional panel data models, one of three possible assumptions about the parameter vector μ_i has to be chosen. If μ_i is the same for all spatial units, so the traditional spatial regression procedure is appropriate. If μ_i is assumed to be fixed to each spatial unit, so the fixed effects estimation procedure is more appropriate. If μ_i is assumed to be a random variable with $E(\mu_i \mu_j) = \sigma_\mu^2$ if $i=j$ and zero otherwise, so the random effects estimation procedure is more adequate. In this paper, the chosen spatial units are very heterogeneous and the data represents all population, so the fixed effects method looks like to be more appropriate. Henceforward, this estimation procedure is presented.

The traditional estimation method for the fixed effects model is to eliminate the intercepts β_I and μ_i from the regression equation by demeaning the Y and X variables, then estimate the resulting demeaned equation by OLS and subsequently recover the intercepts β_I and μ_i (Baltagi, 2001). It should be noted that only $(\beta_1 + \mu_i)$ are estimable and not β_1 and μ_i separately, unless a restriction such as $\sum_i \mu_i = 0$ is imposed. However, maximum likelihood procedure differs from OLS procedure, because it does not make corrections for degrees of freedom. Under the assumption of normality, the general log-likelihood function of the spatial model is:

$$-\frac{NT}{2}\ln\left(2\pi\sigma^2\right)+T\sum_{i=1}^{N}\ln\left(1-\lambda\omega_i\right)-\frac{1}{2\sigma^2}\sum_{t=1}^{T}\varepsilon_t\varepsilon'_t \qquad (2)$$

where $\overline{Y}=\left(\overline{Y}_1,...,\overline{Y}_N\right)'$, $\overline{X}=\left(\overline{X}_1,...,\overline{X}_N\right)'$ and ω_i are the characteristics roots of the spatial weights matrix . The difference in log-likelihood function to spatial models is that in the spatial error model, the disturbance term is $\varepsilon_t=(I-\lambda W)\left[\left(Y_t-\overline{Y}\right)-\left(X_t-\overline{X}\right)\beta\right]$ and in the spatial lag model it is $\varepsilon_t=(I-\lambda W)\left(Y_t-\overline{Y}\right)-\left(X_t-\overline{X}\right)\beta$.

The estimation procedure follows Anselin (1988) steps[2]. Both model types are clearly a nonlinear optimization problem and some optimization routine is necessary. The spatial lag model is simpler and a two-stage procedure is enough to parameters estimation. In contrast, the spatial error model is more complex and needs an iterative two-stage procedure, since the derivation of the log-likelihood function with respect to λ is not enough to obtain the parameters. Indeed, a numerically complex simultaneous approach is necessary. In both cases, the log-likelihood function optimization requires that *W* is a matrix of known constants, that all diagonal elements of the weights matrix are zero, and that the characteristic roots of *W*, denoted ω, are known. The first assumption excludes the possibility that the spatial weight matrix is parametric. The second assumption implies that no spatial unit can be viewed as its own neighbor, and the third assumption presupposes that the characteristic roots of *W* can be computed accurately using the computing technology typically available to empirical researchers. The latter is also needed to ensure that the log-likelihood function of the models we distinguish can be computed. Fortunately, these assumptions are satisfied either to spatial contiguity matrix or to inverse distance matrix (Lee, 2001).

The procedures with panel data is almost the same as the cross-sectional procedures, however the computation is harder to implement and high computer capacity is necessary, especially the spatial error model. Another difference is that the fixed effects model could have the incidental parameter problem, once that parameters to estimate grows with sample size. In this case, only the slope coefficients can be estimated consistently, in the case of short panels, where *T* is

[2] See Anselin (1988), p. 181-182 to a complete description of these steps.

fixed and $N \to \infty$. The coefficients of the spatial fixed effects cannot be estimated consistently because the number of observations available for the estimation of μ_i is limited to T observations (Anselin, 2001). However, the slope coefficients in the demeaned equation is not a function of the estimated μ_i, so they can be consistently estimated since the large sample properties of the fixed effects model when $N \to \infty$ do apply for the demeaned equation (Lee, 2001). Elhorst (2003) argues that the incidental parameters problem is independent of the extension to spatial error autocorrelation or to the inclusion of a spatially lagged dependent variable since it also occurs without these two extensions. In this paper, the slope coefficients are the main interest, so this problem will not affect the results interpretations. Clearly, this problem disappears in panels where N is fixed and $T \to \infty$.

3.2. Exploratory analysis

The first step to estimate any spatial model is to verify the existence of some spatial relationship among variables. Following Anselin and Bera (1998), spatial dependence or autocorrelation is the seemly values coincidence in seemly locations. Figure 1 shows the spatial distribution of Rio Grande do Sul per capita GDP growth in the 1970-2000 period. It is possible to identify similar values in near locations.

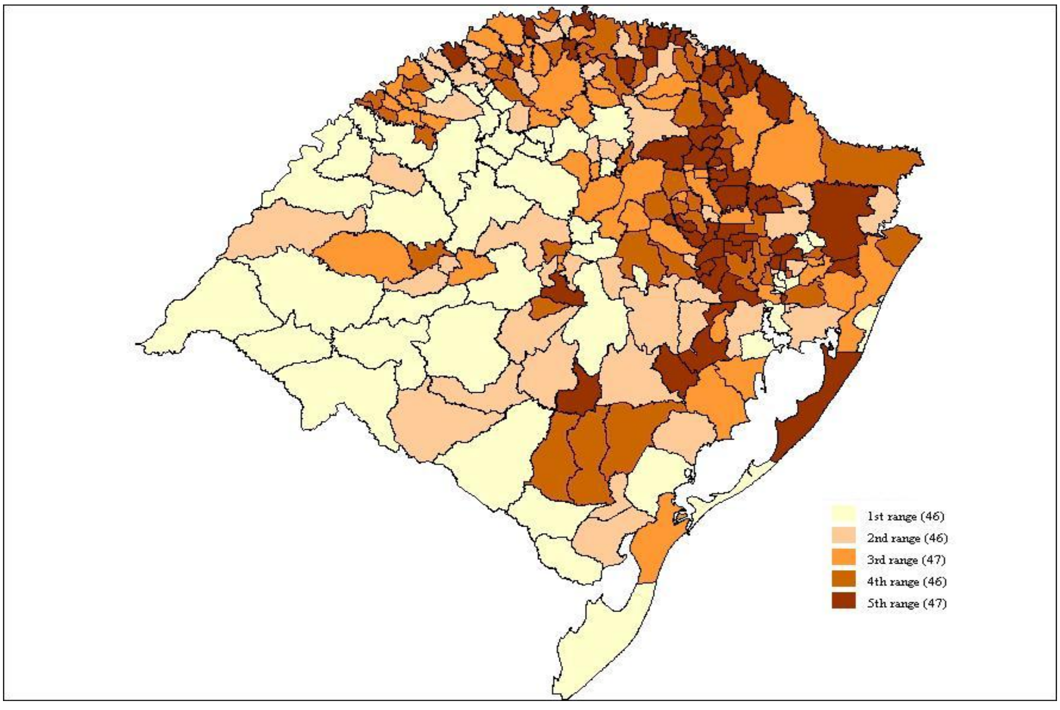

Figure 1 – Quantile map of per capita GDP growth of Rio Grande do Sul in 1970-2000 period.

The high values are concentrated at the State's North. Low values could be seen in the northwest and in the south. In the south they are more disperse because cities are more disperse too. Although figure 1 observation allows identifying some similar values, in fact, the correct form to identify spatial dependence is using statistical tests. The most common test is the Moran's I test. The test is given by:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} n_{ij} x_i x_j}{\sum_{i=1}^{n} x_i^2} \qquad (3)$$

where n represents the number of spatial units, n_{ij} represents the spatial weight matrix elements and x_i e x_j are the demeaned variable values. The main problem that arises with this test is that the results are very influenced by the chosen weight matrix. What matrix should be chosen? The choice always should be theorical. In this paper, is used a squared inverse arc distance weight matrix, because the intention is to use a matrix similar the traditional gravitational model of transport costs and to decrease the far neighbors weight. The matrix elements are defined according the following criteria:

$$\begin{cases} n_{ij} = 0 \ if \ i = j \\ n_{ij} = \dfrac{1}{d_{ij}^2} \ if \ d_{ij} \leq d^* \\ n_{ij} = 0 \ if \ d_{ij} > d^* \end{cases} \qquad (4)$$

where n_{ij} represents a spatial weight matrix element and d_{ij} is the arc distance between two spatial units (centroids). This matrix is standardized, so its line sum is always will be one if:

$$n^*_{ij} = \frac{n_{ij}}{\sum_j n_{ij}} \qquad (5)$$

where n^*_{ij} is an element of the standardized weight matrix. This matrix is symmetric and their main diagonal has elements equal to zero. The d* chosen also could be arbitrary. To avoid this problem was chosen the matrix with Moran's I statistics more significant to economic growth in the studied period as suggested by Abreu et al. (2005). The most significant was the weight matrix with d*=110 km. Moran's I statistics permits to divide spatial relationship in four quadrants[3]. Anselin (1995) suggested the use of Local Indicators of Spatial Association (LISA) to identify and explore spatial dependence when it is not very known. A way to do that, is to plot Moran's I quadrants in the State's map to better visualization. The LISA cluster maps of selected variables are in figure 2.

Figure 2 shows all significant values of Moran's I statistic colored. By on side, the figure also shows that high-high association in the State's northeast grew, by other side, the figure shows that low-low association spread up over the South region and in the most cities in the northwest. The low-low association in the South and high-high association in economic growth in the North is an indication that Rio Grande do Sul has at least two spatial regimes, one at South and one at North, since the figure 2 presented some evidence of variance instability. This recognized problem may cause many problems in tests interpretation and in regression results analysis, so a proper way to deal with this heterogeneity is necessary. One traditional way to deal with is to estimate two separated models in contrast to a one model only. Besides solve heterogeneity problems, this proceeding helps to identify different effects of independent variables on dependent variables of these regions.

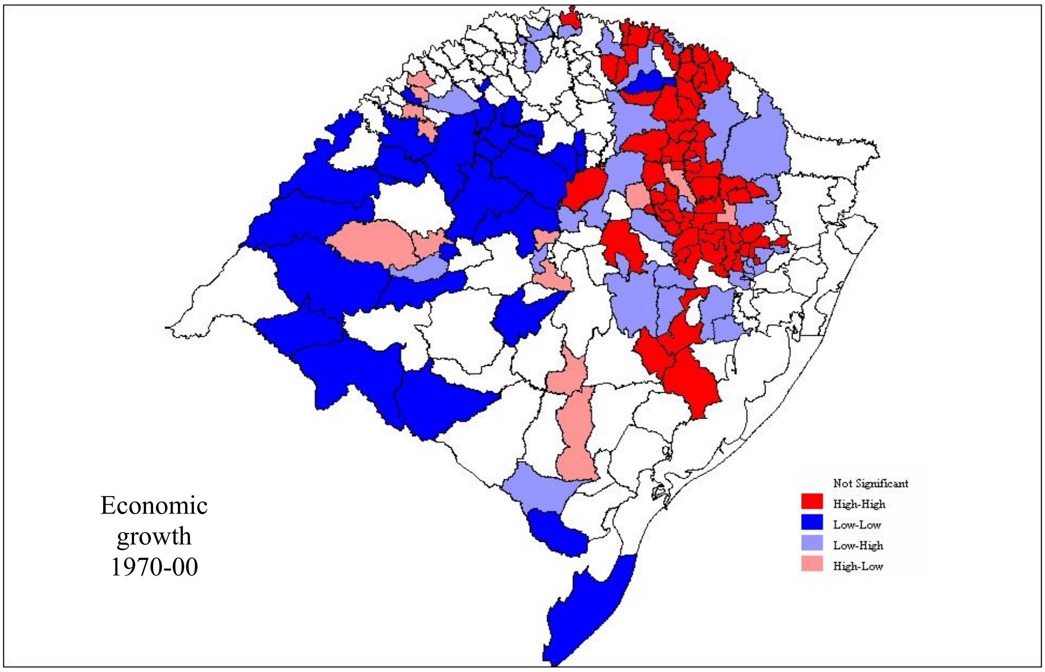

Figure 2 – LISA cluster map for Rio Grande do Sul cities.

Once spatial association is identified the second step is to estimate the econometric model considering it. The next subsection presents the obtained results using a spatial econometric procedure for panel data.

[3] The Moran's I tests of State's GDP in all periods and for economic growth in all period is presented in figure A.1 in the appendix.

3.3. Results

The chosen explanatory variables are showed in table 1. The data has two sources. The per capita GDP and manufacture share are from the Fundação de Economia e Estatística (FEE) and average schooling years and urbanization share of population are from Instituto Brasileiro de Geografia e Estatística (IBGE). Spatial units (cities) were homogenized to their 1970 organization. This means that the actual 496 cities were reduced to the 232 cities that exist in 1970, where the new cities are incorporated to their original city following the methodology proposed by FEE-UNISC (2007).

Table 1 – Explanatory variables

Theoretical variable	**Proxi variable**
Knowledge spillovers	Average years of schooling
Localization economies	Manufacture share
Urbanization economies	Urbanized share of population

The last subsection identified some evidence of spatial heterogeneity. Le Gallo and Dall'erba (2003) argued that spatial heterogeneity can be linked to the concept of convergence clubs. However, they are hard to select without any bias, the authors suggest that they can be detected using exploratory spatial data analysis which relies on geographic criteria. So, this paper uses the obtained Moran's I statistics observed in the LISA cluster map of the last subsection to identify the heterogeneity. The results suggest that the traditional political division of the State is a good start point since it is possible to observe seemly values in neighbor cities in the North and in the South of the State. Following this, the State's cities are divided in two regions, North and South. The geographical division is showed in figure 3. The North region contains 180 cities and South region contains 52 cities. As commented in the introduction, the North region concentrates the most part of economic activities and of population. So, besides the basic model with all State's cities other two econometric models are estimated.

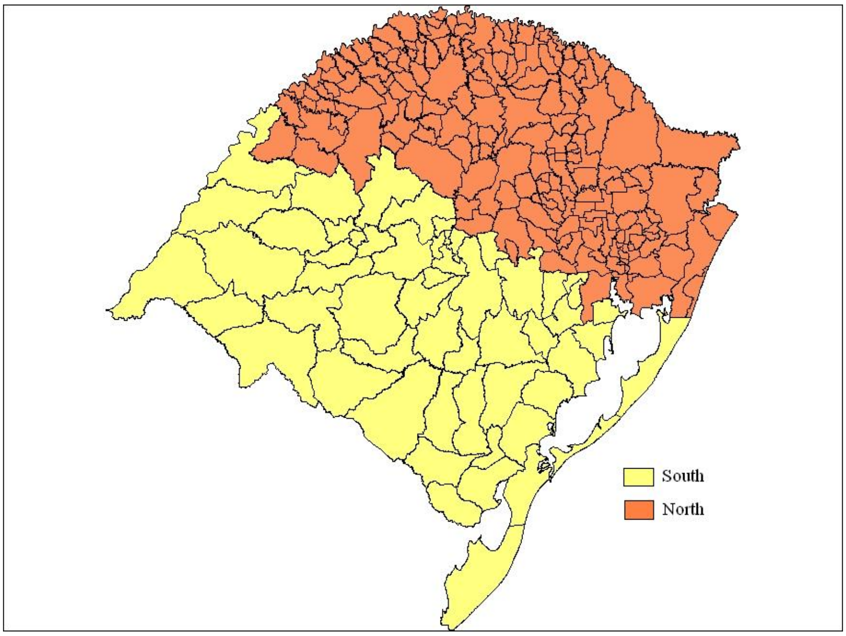

Figure 3 – State's North-South geographical division

As showed in the last section, the spatial association in the econometric model can be of two forms: spatial lag model or spatial error model. For each one of three models both spatial association forms are estimated by maximum likelihood estimation. This implies that six regressions are estimated. They are showed in table 2 below. The Shapiro-Francia test for residuals normality indicates that residuals normality can not be rejected at 1% significance level. It validates the maximum likelihood estimation procedure and the Likelihood Ratio (LR) and the Lagrange Multiplier (LM) tests[4]. The spatial model choice is based on the LR test, when it's not enough to determine which model should be chosen the criteria is the greatest log-likelihood value.

Following this criterion, table 2 shows that the spatial lag is more appropriate when all State's cities are considered. The LR test rejects the hypothesis that there aren't spatial effects in Rio Grande do Sul cities over the period of both types since the values 46.76 and 40.16 are far from the qui-square distribution with one degree of freedom that is 6.63. It means that there is an improvement in likelihood that should be considered. The spatial lag shows the greater likelihood and LM test for spatial dependence in the residuals rejects the alternative hypothesis of $\lambda \neq 0$.

The main conclusion of these tests is that there are spatial externalities which helps to explain the growth of Rio Grande do Sul cities and it can not be ignored. The results shows the evidence of knowledge spillovers and urbanization economies, but no localization economies when all States cities are considered. It should be emphasized that the evidence of neighbor's effects (spatial dependence) of both types has important theoretical implications. This means that

[4] The spatial models be nested with the fixed effects model is another condition for LR test, but this condition is clearly satisfied since the spatial models only adds a spatial structure to the basic model.

externalities are not bounded in a city. The cities proximity allows, for example, people to transit in many cities. It is very common people live in one city and work in another one. This not only creates a market in the origin city but also allows the ideas to flow (trough face-to-face contacts) among different cities.

Table 2 – Spatial panel data results

	Dependent variable: GDP growth		
Independent Variables	**(1) Fixed Effects**	**(2) Spatial Lag**	**(3) Spatial Error**
GDP_{t-1}	-0.9847	-0.8789	-0.9432
	(-24.88)	(-22.282)	(-26.355)
Schooling	0.0637	0.0522	0.0423
	(7.58)	(6.887)	(4.923)
Manufacture share	0.1259	0.0890*	0.1271
	(1.98)	(1.747)	(2.415)
Urbanization share	0.0423*	0.1394	0.1230
	(0.75)	(2.446)	(2.103)
ρ		0.1929	
		(4.706)	
λ			0.3109
			(4.697)
Log-likelihood	725.66	749.04	745.74
LR (($\chi^2(1)$))	-	46.76	40.16
LM error	-	1.862 (0,1719)	-
Adjusted R^2	0.6723	0.7459	0.7455
Shapiro-Francia**	0.665 (0.2531)	-0.187 (0.5742)	0.366 (0.3571)

Notes: t-statistics in parenthesis. * Not significant at 5% level. **Z calculated.

Table 3 shows the results for the state division. It shows that the spatial error model is appropriate to South's cities and that the spatial lag model is appropriate to North's cities. The model choice means that neighborhood affects the two regions in different way. The neighbor effects in the North region are in all estimated parameters, since they are spatial multipliers, which imply that it includes neighbor spillover effects. In the South, the neighbor effect is in the error, which means that it affects the economic growth of these cities trough a not included variable. This could be, for example, a negative externality (region geography or clime) or the transport costs to main markets (these cities are far from the State's capital).

Table 3 – Spatial panel data results by regions

Independent Variables	(4) Fixed Effects	(5) Spatial Lag	(6) Spatial Error	(7) Fixed Effects	(8) Spatial Lag	(9) Spatial Error
	Dependent variable: GDP growth					
GDP_{t-1}	-1.0607	-0.9170	-1.0331	-1.0015	-0.9181	-0.9725
	(-15.64)	(-12.511)	(-15.937)	(-21.54)	(-20.401)	(-24.056)
Schooling	-0.0058*	-0.0041*	-0.0146*	0.0762	0.0713	0.0677
	(-0.35)	(-0.321)	(-1.086)	(6.690)	(7.844)	(6.876)
Manufacture share	0.0267*	0.0377*	0.0966*	0.1275	0.1178	0.1377
	(0.27)	(0.502)	(1.369)	(1.650)	(1.915)	(2.152)
Urbanization share	(0.4829)	0.4689	0.3125	0.0565*	0.0732*	0.0647*
	(2.91)	(3.734)	(3.087)	(0.710)	(1.154)	(0.989)
ρ		0.2119			0.1460	
		(2.837)			(3.216)	
λ			0.5709			0.1809
			(7.319)			(2.306)
Nobs	156	156	156	540	540	540
Log-likelihood	212.29	220.55	228.69	547.11	556.99	551.76
LR (($\chi^2(1)$))	-	16.52	32.80	-	19.76	9.30
LM error	-	-	-	-	0.7960 (0.3722)	-
Adjusted R^2	0.4328	0.7582	0.7994	0.3094	0.7310	0.7262
Shapiro-Francia**	0.238	-0.257	1.178	-0.262	0.025	-0.305
	(0.4057)	(0.6015)	(0.1193)	(0.6034)	(0.4898)	(0.6199)

Notes: t-statistics in parenthesis. * Not significant at 5% level. **Z calculated.

The estimated model included the lagged per capita GDP. This allows inferring about convergence existence and about speed of that in the studied period. The results show that South's cities convergence rate is around 3.54% per year while it is 3.46% in North cities. Even tough these results can not be compared. In the North region the coefficient is a spatial multiplier while in the South the neighbor effects are in the error term. The convergence result is not surprising because there are controls for externalities effects, so the results are in fact a conditional convergence speed. Conditional convergence is found in many works which used small spatial units of the same country as cities, since factors mobility can help a lot this convergence process. The proximity of spatial units allow workers move to other cities where there are jobs opportunities with a low migration cost and allow capitals to flow with a good level of information about the markets.

The results show an evidence of localization economies in the North cities, but no evidence for the South cities. The North region concentrates the most part of the State's industry production, the industry is diversified and includes steel, automobiles, chemical, food, furniture, clothes, shoes, among other industries. Unfortunately the estimated parameter does not capture this diversity effects. In this paper, localization economies include both inter-firms economies and inter-sectors economies. It differs from precedent works in two ways: In first place, they analyses localization economies separately and just consider economies from industries from the same sector and, in second place, they don't consider the neighbor effect. It implies that they only consider the possibility of localization economies exist inside the cities and, for consequence, no neighbor cities effects are considered.

Considering inter-industrial sector economies, Henderson (1988) and Ciccone and Hall (1995) found evidence of these localization economies for United States, such as Henderson (1988) for Brazil, Henderson and Kuncoro (1996) for Indonesia and Henderson et al. (2001) for Korea. Glaeser et al. (1995) using aggregate manufacture data found no evidence. The authors argued that United States industrial cities didn't growth due to crowd out effects from old capitals (land occupation, for example) and because these old capitals represent sunk investments. Very probably, the crowd out effect could not be seen in Rio Grande do Sul yet. Many State's industries are expanding their production capacity in the same location where they are installed. In this case, internal and external scale effects are bigger than an eventual congestion effect. However, the South region industrial cities show a decline as described by Glaeser et al. (1995). This region didn't attract new industry sectors and there was a decline in the existing ones due the absence of localization economies, for instance.

The results don't show evidence for urbanization economies in the North region, but show an evidence for South cities where the coefficient is significant. The interpretation of this result is that North region has experimented negative externalities effects from high urban agglomeration. Henderson (1999b) affirms that an excessive concentration of people and activities takes to a lack of efficiency due to negative externalities like congestion, pollution and crime, so, following the author, there will be an optimal urbanization level. Perhaps many North cities, especially in the metropolitan area, are in the declining part of the curve. This is not the case of South cities where many cities decrease their population. The higher growth in urban areas may signify a change in the economic profile. The industry decadence let at least two options to people, which can migrate or looks for an alternative activity. In this case, the service sector is a good alternative, however service sector make goods that can't be transported, so they are necessarily produced near to consumer, this means, generally, in urban areas.

The results show an evidence of knowledge spillovers in North cities, but not in the South cities. The interpretation of these results is that people learn from one another, so they will learn more when the people around them have more human capital. Another interpretation of these results is that high human capital level cities produce more ideas and innovations and that these innovations produce economic growth. This process becomes very attractive to firms which will choose these high human capital cities to locate. It is an important agglomerative force. Besides that high human capital cities also attract high technologies firms, since they need high skills and specialized workers. These firms are more dynamics and impulse city economic growth. Cities with low human capital cannot go along with technological improvement process and have low economic growth. It should be emphasized that the obtained results also consider not only city human capital, but also neighbor human capital. So, there are knowledge spillovers among neighbor cities. A firm can choose to locate at one city, but it will use labor force from many neighbor cities. This creates knowledge links among people from many cities, so all cities are benefited by knowledge spillovers and have higher economic growth. The evidence of this process in the North and the lack of evidence in the South may be a good explanation of regions inequalities in the economic growth, since many authors believe that is the “engine” of economic growth.

4. Conclusions

The present paper studied the role of externalities in the economic growth of Rio Grande do Sul cities. It was presented a spatial panel data model that allows considering neighbor effects and that help to solve some problems that appear in many cross-section studies. The paper also differs from preview works in growth of cities because it uses GDP data and not employment data. Another difference is the externalities classification. Localization economies were divided in inter-firms and inter-sectors economies and separated from urbanization economies which refer to people agglomeration phenomena and the possibly spillover effects generated by that. This classification was tested and the findings show that the North, the richest part of the state, experimented knowledge and localization economies. However, the South, the poorest part of the State, didn’t experiment these types of positive externalities, which helps to explain its low economic growth in the period. The region only presented an evidence of urbanization spillovers, however they act only inside the cities and did not presented a neighbor effects. Since the appropriate model for the region is a spatial error, this means that spillovers effects occur in some variable which was not included in the model.

The spatial econometrics tools helped to identify some spillover effects. If externalities are so difficulty to see, at least today, is possible to identify spatial dependence among spatial units like cities. It helps to understand the agglomeration process in some regions in detriment of others. It’s clear that some external effects are important in this process. External effects are a big challenge in economics not only to empirical works, but also to formal theorical models. Even tough none deny their existence, they are clearly invisible.

The results helped to identify some causes of State's regional inequality based on the existent literature. However, there is not too much to say about policy suggestions. The absence of positive spillover effects in South looks like the traditional core-periphery model and it is difficulty to suggest any kind of policy to revert that process. Since agglomerative forces are very strong as showed in the exploratory analysis and in the estimated model. The education investment is the most common policy suggestion, however in factors mobility context, it is not guaranteed that migration will not happen. Recently, the region is receiving investments in papers and navy industry which can maybe help the region development and create some kind of agglomeration economies and attract some new economic activities, like furniture industries, for instance.

Finally, despite this paper is only a start point using this new data basis, the spatial analysis gave some indication of the necessity of future research about a better region division. It should be done using robust methods to test which is the better representation of the State regional inequality. It will allow understanding better not only how the externalities act but also how it affects the economic development of Rio Grande do Sul cities.

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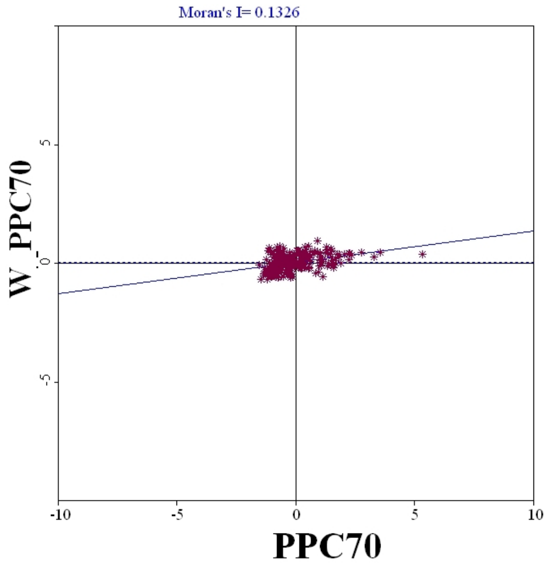
6. Appendix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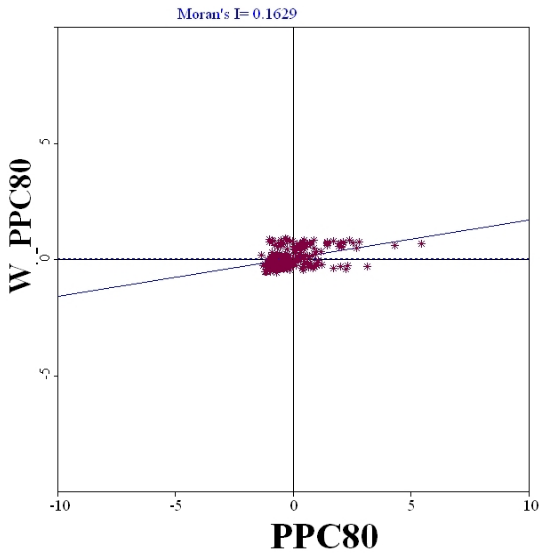
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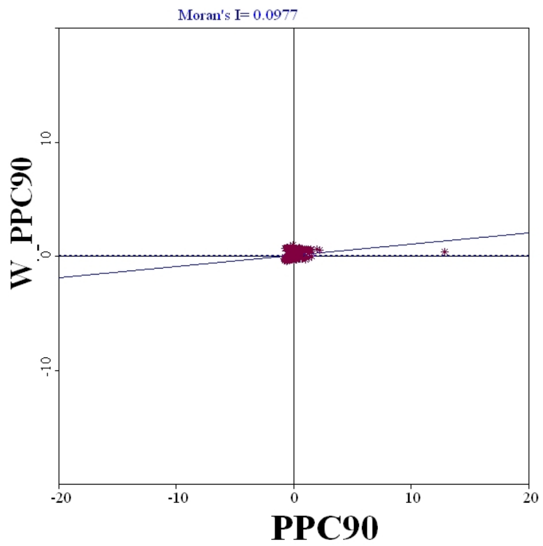
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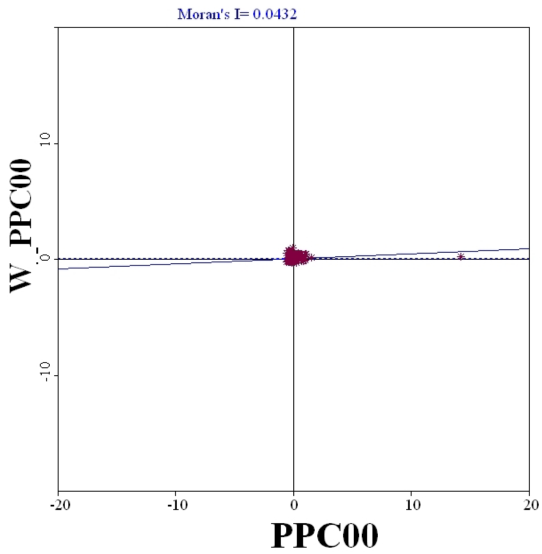
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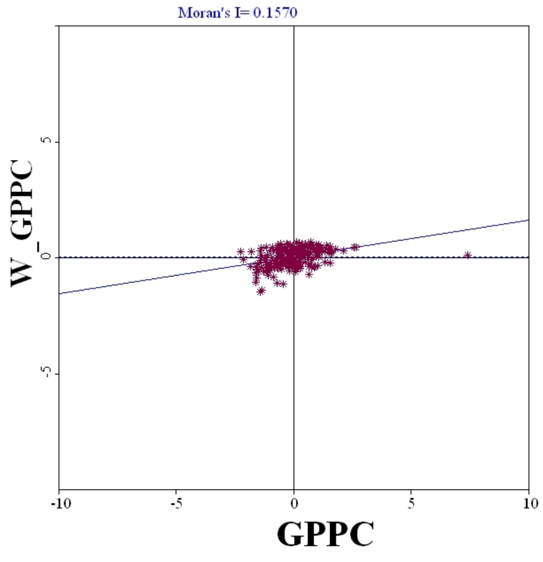
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Figure A.1 – Moran scatter plot of Rio Grande do Sul cities GDP and cities economic growth.

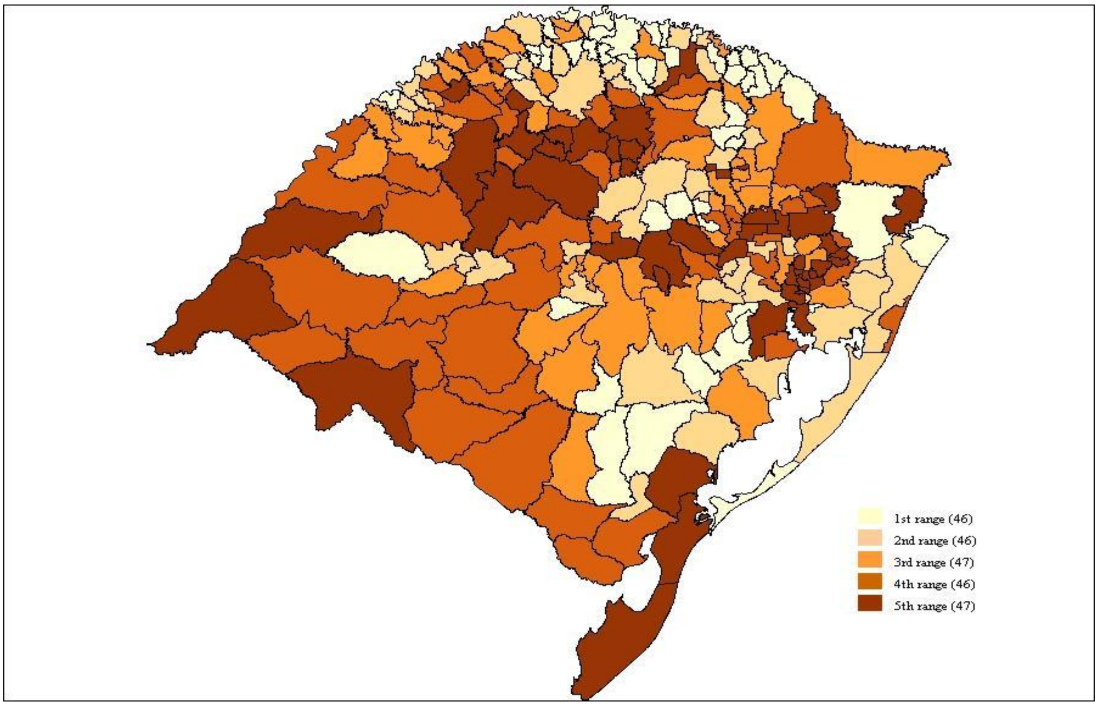

Figure A.2. – Quantile map of GDP per capita of Rio Grande do Sul in 1970.

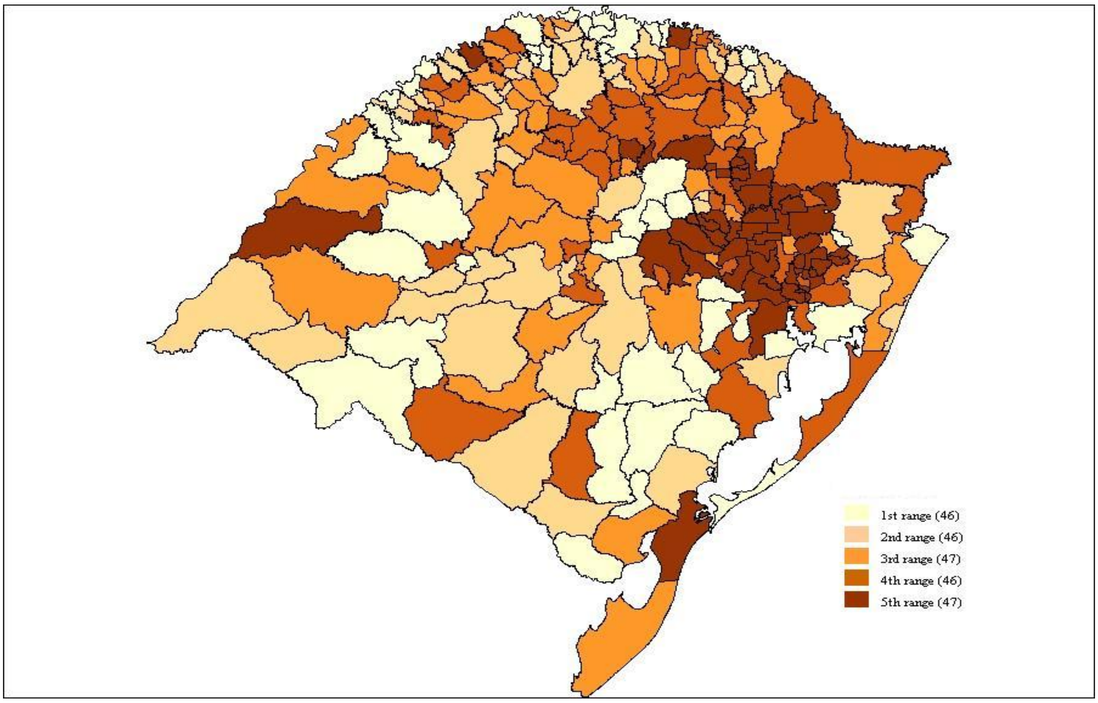

Figure A.3. – Quantile map of GDP per capita of Rio Grande do Sul in 2000.

Table A.1. – Variables descriptive statistics.

Variable (year)	Obs.	Mean	Std. Dev.	Min.	Max.
Per capita GDP 70	232	2709.62	1289.51	728.38	9617.33
80	232	5188.04	2522.39	1819.12	18929.56
90	232	5869.56	5196.56	1698.90	72771.01
00	232	7776.31	9324.53	2612.09	140218.80
School years 70	232	2.56	0.6159	1.1	5.2
80	232	3.46	0.6653	1.9	6.7
90	232	4.56	0.7462	2.8	8.1
Urbanization share 70	232	0.3184	0.2399	0.03	0.98
80	232	0.4349	0.2475	0.06	1.00
90	232	0.5169	0.2533	0.11	1.00
Manufacture share 70	232	0.1809	0.1799	0.01	0.82
80	232	0.2303	0.2091	0.01	0.80
90	232	0.2156	0.2277	0	0.87

Table.A.2. – Spatial weight matrix descriptive statistics.

Region	Order	Mean	Median	d* (Km)	Cut-Off
State	232 x 232	146.42	140.07	110	65.85
South	52 x 52	136.97	129.11	90	65.85
North	180 x 180	119.48	111.38	90	32.07