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ORGANIZATION AND DISTRIBUTION OF ECONOMIC ACTIVITY ACROSS BRAZILIAN REGIONS AND THEIR IMPACT ON REGIONAL ECONOMIC INDICATORS

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Tese de doutorado, apresentado como requisito para obtenção do grau de Doutor em Economia pelo Programa de Pós-Graduação em Economia da faculdade de Administração, Contabilidade e Economia, da Pontifícia Universidade Católica do Rio Grande do Sul.

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DEDICATÓRIA

Dedico esta tese à minha mãe, Rose,
e a minha noiva, Milene.

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RESUMO

Esta tese de doutorado compreende três ensaios que abordam questões pouco exploradas pela literatura de economia regional no Brasil. No primeiro artigo é analisada a importância do tamanho das empresas para o crescimento econômico das 558 micro-regiões brasileiras de 1999 a 2009. Estimações de dados em painel com efeitos fixos (FE) e uma análise econométrica espacial considerando dependência espacial e heterogeneidade espacial foram usadas. As estimativas para o Brasil como um todo mostram que a presença de grandes empresas no setor industrial contribuiu positivamente para o crescimento econômico das microrregiões, enquanto que as pequenas empresas apresentaram uma relação negativa com o crescimento econômico. A presença de heterogeneidade espacial na amostra é caracterizada por dois clusters espaciais diferentes com relação à renda per capita. A análise de cada cluster espacial mostra que a relação entre tamanho da empresa e crescimento econômico nas regiões mais ricas permanece a mesma, enquanto nas regiões de menor PIB per capita, o tamanho das empresas não influencia o crescimento econômico. O segundo artigo utiliza análise econométrica espacial para investigar qual a relação entre o tamanho das empresas e os indicadores de desenvolvimento econômico dos municípios brasileiros de 2000 a 2010. A investigação é motivada pela quantidade de recursos e esforços que os governos dedicam a políticas que atraem grandes empresas e apoiam pequenas empresas locais. Os modelos estimados apresentam diferentes resultados entre setores e indicadores de desenvolvimento. O sinal encontrado para a relação entre o crescimento do emprego e o tamanho da empresa depende dos setores considerados. Assim, os resultados recomendam uma atenção especial por parte dos formuladores de políticas públicas na elaboração das suas estratégias de desenvolvimento local. No terceiro artigo é analisado o padrão de localização do emprego ocupacional no Brasil em 2010, bem como é testada a hipótese de especialização funcional em função do tamanho dos municípios do Brasil e se esta varia de acordo com setor industrial analisado. Os resultados encontrados mostram que existe significativa heterogeneidade espacial na distribuição das ocupações dentro do setor industrial nos municípios brasileiros. Também se confirma a hipótese de especialização funcional em função do tamanho das cidades e a importância de se analisar cada setor separadamente, pois nem todos os setores apresentaram o mesmo padrão de especialização funcional. Esses resultados

fornecem informações que auxiliam na compreensão da estrutura setorial e ocupacional das economias regionais, fatores estes que influenciam diretamente o crescimento e desenvolvimento regional.

ABSTRACT

This dissertation comprises three essays aimed at addressing issues little explored by regional economics literature in Brazil. In the first paper, there is an analysis of the importance of the size of companies for the economic growth of the 558 Brazilian micro-regions from 1999 to 2009. Panel data estimations with fixed effects (FE) and a spatial econometric analysis considering spatial dependence and spatial heterogeneity were used. Estimates show that the presence of large companies in the industrial sector has contributed positively to the economic growth of micro-regions, whereas small businesses presented a negative relation to economic growth. The presence of spatial heterogeneity in the sample is characterized by two different spatial clusters regarding per capita income. The analysis of each spatial cluster separately points out that the relation between company size and economic growth in the richest regions remains the same, while in the regions of lower GDP per capita, the size of companies does not influence economic growth. The second paper uses spatial econometric analysis to investigate the relation between size of companies and economic development indicators of Brazilian municipalities from 2000 to 2010. The investigation is motivated by the amount of resources and effort that governments dedicate to policies attracting and supporting local business. The estimated models present dissimilar findings across sectors and development indicators. For instance, the sign of the relationship between employment growth and company size depends on the sectors considered. Thus, the results recommend special attention on the part of policy makers in formulating their local development strategies. In the third paper there is an analysis of the location pattern of occupational employment in Brazil in 2010, as well as a test of the hypothesis of functional specialization according to the size of Brazilian municipalities and if this specialization changes according to the industrial sector. The results show that there is significant spatial heterogeneity in the distribution of occupations in the industrial sector in Brazilian municipalities. In addition, the hypothesis of functional specialization in function of the size of the cities and the importance to analyze each sector separately was confirmed. As not all sectors present the same pattern of functional specialization, especially for occupations related to management and R&D activities. These results provide additional information to understand sectoral and occupational structure of

regional economies, factors that have a direct influence in the regional growth and development.

Sumário

1. Introduction

A subject often discussed both in planning sessions of regional development and in academic literature is related to which firm size should receive more attention from policy makers.

The role of small business in economic development has been a topic of intense debate since the work of Birch (1979). Some theories in favor of small firms claim that they are more efficient, innovative, and thus, lead to higher levels of economic growth. On the other hand, the endogenous growth theory, especially, advocates that economies of scale and scope exhibited by large firms allow higher levels of research and development and, consequently, the introduction of innovation generates economic growth (Deller, 2010).

The firm-size debate in the literature is also related to which has created more jobs, small or large businesses. According to Greenstone et al. (2010), for many decades, the traditional approach of public policies focused on regional employment growth with the purpose of attracting large companies as a means to improve employment. This strategy has led regional governments to a fiscal war – they dispute new plants by offering land, public investment, and fiscal benefits. However, recent research has shown small companies as the greatest contributors to employment growth (Komarek and Loveridge, 2015; Neumark, 2011; Shaffer, 2006).

According to the World Bank (2014), small and medium enterprises (SME) make special contributions to income growth, employment and poverty reduction in developing economies. Therefore, they deserve special support, although the literature does not provide conclusive evidence of a bigger contribution of SMEs compared to large enterprises to growth and employment in developing country contexts. These inconclusive results can be related to the interaction of size with country conditions, more specifically, level of local development, income, institutional problems and financial constraints.

As noted in the academic literature, firm size is a relevant issue and can be considered one of the relevant factors for the growth and development of a region. However, this view, reflected in a regional economic analysis, sustains that companies/industries are drivers of economic growth. This idea can be extended with an analysis that takes into account the supply (input) of industrial production, more precisely the role of human capital and special mixes of occupations to strengthen the productivity and profitability of companies (Wan et. al. 2012).

Currid and Stolarick (2010) advocate that occupations and companies are both important. Analyzing them simultaneously will lead to a better understanding of regional competitiveness and possibilities for development policies.

Therefore, it is noted in the literature the increase of studies arguing that regional and urban planning should be taken into account not only in sectoral, but also in occupational issues (Varas and Ubeda, 2010). The importance of occupational analysis refers to endogenous factors of the region, such as local human resources, education and skills. These factors directly influence regional development.

According to what was presented so far, this dissertation has the objective of answering three questions: (i) Which is the relation between the size of industrial companies and economic growth? (ii) Does the size of companies impact regional economic development indicators? and (iii) What is pattern of location of occupational employment in Brazilian municipalities? In addition to this introduction, the dissertation is divided in three chapters.

The first chapter analyzes the importance of the size of industrial companies for the economic growth of the 558 Brazilian micro-regions from 1999 to 2009. Panel data estimations with fixed effects (FE) and a spatial econometric analysis considering spatial dependence and spatial heterogeneity were used. This paper is a first effort in the sense of verifying if there is difference in the effect of large or small companies in economic growth.

The second chapter studies the relation between company size and income, employment and poverty growth in different sectors of the 5507 Brazilian municipalities from 2000 to 2010. The relation between firm size and economic growth is analyzed, considering the presence of geographic spillovers, as failing to consider aspects such as spatial dependency may cause econometric problems as omitted variable bias and endogeneity (Badinger et. al., 2004; Ertur and Koch, 2007; Mohl and Hagen, 2010).

The second paper expands the debate on company size and differs from the first for 3 reasons. First, it the expands analysis beyond economic growth, as it analyzes the relationship between company size and factors related to economic development (per capita income, employment, and poverty). Second, it uses all company sizes, not just large and small. Finally, the analysis is done for two different sectors of the economy, services and industrial sector.

The third chapter examines the pattern of location of occupational employment in Brazilian municipalities in the year of 2010. In addition, it checks whether there is functional specialization according to the size of Brazilian municipalities. And more, if these patterns of functional specialization differ across industries.

For this purpose, the locational quotient (QL) will be used for each occupational group within the industrial sector as a whole and each city size group. Finally, an exercise similar to the previous one shall be done, but the analysis will be carried out for each industrial sector.

2. The importance of firm size for the economic growth of Brazilian micro-regions

2.1 Introduction

Recognition of the economic importance of micro and small business, especially for employment generation, makes Brazilian and international institutions - such as the Brazilian Support Service for Micro and Small Business (SEBRAE) and the World Bank[1] - support the activities of smaller local business. On the opposite side, Brazil has witnessed, in the past decades, a fiscal war between States and Municipalities, where the purpose of all parties involved is attracting large business to their region, through subsidies and grants[2].

Therefore, there are public efforts and resources directed to both attracting large business and creating and strengthening micro and small business. However, there is little debate in Brazil regarding the connection between the size of the business and regional economic growth. In this case, the absence of discussion based on data collected with methodological rigor does not seem to be caused by failure of politicians and public officials, but by the lack of academic works on the issue, as it will be seen below.

[1] On projects of the World Bank to support micro and small business, see Beck *et. al*.(2005).

[2] The fiscal war, which has started in the 90s, is still subject of intense debate in the National Congress. See, for example, http://www1.folha.uol.com.br/mercado/2015/04/1613568-senado-aprova-validacao-de-incentivos-fiscais-de-estados.shtml

In international academic literature, this discussion, although there is no consensus, brings outcomes and conclusions that may guide - up to a certain point - public policy makers that aim at boosting local economy, through the support to productive activities in the region (Loveridge and Nizalov, 2007).

Literature highlights some factors in favor of large business. Greater capacity to innovate and fully explore breakthrough innovations is presented as key features of large business (Lee et. al., 2012; Pagano and Schivardi, 2003).

Greater productivity by this company is associated to innovation. According to Idson and Oi (1999), the organization of large companies enables the allocation of more productive individuals, as they have more advanced technologies, equipment and work organization.

Exporting potential is another feature associated to large firms. Empirical analysis indicate that exporting potential[3] is positively related to the size of the business (Esteve-Perez et. al., 2005; Araujo and Hiratuka, 2006).

De Negri (2006) also shows that the likelihood of a firm becoming an exporter increases as its production scale is expanded. Finally, according to Gomes and Ellery (2007), Brazilian exporters are approximately 6 times larger than non-exporting firms, which is a result similar to the United States, where exporters are, in average, 5.6 times larger than a non-exporting firm.

Such relation can be derived from both the economies of scale found in large companies (Liu and Shu, 2003) and greater access to credit by these companies (Ling-Yee and Ogunmokum, 2001). For Biesebroeck (2005), greater credit availability for large companies is also strongly correlated with productivity, therefore generating more economic growth.

On the other hand, micro and small business also have particular characteristics that are important to have greater economic efficiency. Smaller establishments are generally associated to larger rates of employment growth (Neumark et. al., 201; Shaffer, 2006). In addition, small companies are mostly intensive in working, thus they are able to be important agents of generation of new jobs and, as a consequence, reducing unemployment (Komarek e Loveridge, 2014).

Some authors highlight that innovative capacity and productivity gains can be characteristic of small business as well. Greater competition and incentive to

[3] For a review on the relation between the size of the firm and the exporting potential, also see Silva (2012).

entrepreneurship, which are typical of markets fragmented in small companies, may introduce new products and/or new production processes, which contributes to accelerate the pace of economic growth (Acs and Audretsch, 2003; Beck et. al., 2005; Wong et. al. 2006).

Although small firms present characteristics that might increase economic efficiency, the empirical findings of the relation between economic growth and the presence of small firms are ambiguous, depending mostly on the level of development of the country or region.

In a context of developed regions, literature shows that the impact of entrepreneurship, deriving from the exploitation of business opportunities, on the economic growth is positive (Mueller, 2007; Van Stel et. al., 2005). However, entrepreneurship tends to play a different role, depending on the stage of economic development of the country. Thus, the relation between the level of entrepreneurship and economic growth would be negative for developing countries and positive for developed countries (Acs et. al., 2008; Van Stel et. al., 2005).

Considering the limited studies on the subject regarding Brazilian economy, Cravo (2010) and Cravo et. al. (2012) investigate exclusively the relation between small and medium size business and economic growth. The authors have found evidence suggesting a negative relation between the size of the small and medium size business segment and growth in Brazilian regions. However, by including the human capital variable in the small and medium size business variable, the relation becomes positive. This finding suggests that firms with an elevated level of human capital are capable of generating economic growth.

The empirical analysis presented in this article is aimed at collaborating with a discussion that is not only little explored in academic literature in Brazil, but is also key to guide public policies on regional development. Certainly, empirical findings on the relation between the size of firms and economic growth may bring light to the decision of stimulating micro and small business and/or employ efforts to attract and keep large business in the local economy.

Therefore, this work proposes different models that, together, look for solidity and consistency in its findings. The proposed models enable - in contrast with other articles on the subject for Brazilian economy - estimating and comparing impact deriving from the concentration of micro and small business, as well as the participation of large business in the local economy.

Initially, panel data estimations are used, applying fixed effect methodology. These estimations were prepared using variables normally used to model growth[4], such as population, education, income, in addition to the variable that indicates the size of firms. Subsequently, the relation between the size of firms and economic growth is analyzed, considering the presence of geographic spillovers, as failing to consider aspects such as spatial dependency and heterogeneity may cause econometric problems as omitted variable bias and endogeneity (Badinger et. al., 2004; Ertur and Koch, 2007; Mohl and Hagen, 2010).

In addition to this introduction, the article is divided into three more sections. In section 2, the methodologies and data used in this study are described. Section 3 presents an exploratory analysis of data and presents the main findings of the work. Next, final comments close the article.

2.2 Methodological aspects

2.2.1 Specification of models

The empirical strategy of analyzing the importance of the size of firms for the economic growth of micro-regions is set by using economic growth equations, according to the proposal of Mankiw et. al. (1992), Barro (1991) and Lee *et. al.* (2012).

Therefore, the hypothesis to be tested may be described through the following equation:

$$y_{it} = \alpha + \beta Z_{it-1} + VP_{it}\gamma + \delta FS_{it} + \rho_{it} \quad (1)$$

where y_{it} is the growth rate of GDP per capita, Z_{it1} is the natural logarithm of GDP per capita, VP_{it} is a standard variable vector used in economic growth equations, in this case referring to the population growth rate and to the average study years, FS is the variable that indicates the size of the firm and ρ_{it} is an error term.

The methodology initially used was panel data with fixed effects (FE). Using fixed effects enables to mitigate the omitted variable bias, possibly present in the

[4] See, for example, Mankiw et. al. (1992) and Barro (1991).

economic growth equation[5]. However, this methodology does not consider the effects of the presence of geographic spillovers in the economic growth of regions, therefore econometric problems may occur (Badinger *et. al*., 2004; Ertur and Koch, 2007; Mohl and Hagen, 2010).

According to Dall'erba and LeGallo (2008) there are three reasons to incorporate spatial effects in growth models. First, from an econometric standpoint, one of the hypothesis of OLS estimations is based on the independence of error terms and violation of this assumption leads to unreliable estimates and inferences. Second, it enables to capture effects of geographic overflows between regions. Third, spatial discrepancies on the dependent variable can act as outdated dependent variables to explain omitted variables.

In order to control the effects of spatial dependence, LeSage and Pace (2009) approached three models as the most frequently used: SEM (spatial error model), SAR (spatial autoregressive) and SDM (spatial durbin model).

SEM (spatial error model) models spatial dependence by the error term, and it can be described by the following equation:

$$y_{it} = \alpha + \beta Z_{it-1} + \gamma VP_{it} + \delta FS + \delta_{it} \qquad (2)$$

$$\delta_{it} = \theta \sum_{j=1}^{N} w_{ij}\delta_{jt} + \varepsilon_{it}$$

where variables are the same used in equation 1, except for the error term δ_{it}, which, through the w_{ij} term contains information regarding spatial structure and connectivity between regions i e j, θ is the spatial error coefficient and $\varepsilon \sim N(0, \sigma^2, I_n)$. This specification indicates that a random shock introduced in a region affects all regions through the spatial structure.

In the SAR (spatial autoregressive) model, spatial dependence is included in the model through the values spatially lagged from the dependent variable, as described in equation 3.

[5] The equation was also estimated through GMM system (Blundell and Bond, 1998 and Arellano Bover, 1995), with the purpose of minimizing the endogeneity problem possibly present in economic growth equations. However, trial findings indicate that endogeneity remains. The findings of such estimations can be found in the Appendix A (Table 1.A) of this article.

$$y_{it} = \vartheta \sum_{j=1}^{N} w_{ij} y_{jt} + \beta Z_{it-1} + VP_{it}\gamma + \delta FS + \rho_{it} \quad (3)$$

where ϑ represents the autoregressive spatial parameter and the other variables are the same used in equation 4.

According to LeSage and Pace (2009), the spatial lag used in the SAR model can be used in order to generate an extension of the model known as SDM (spatial durbin model). This model includes spatial discrepancies of the dependent variable and independent variables, which enables to obtain externalities and spillovers deriving from different sources. SDM is estimated from the following equation:

$$y_{it} = \vartheta \sum_{j=1}^{N} w_{ij} y_{jt} - \beta_1 Z_{it-1} + \beta_2 \sum_{j=1}^{N} w_{ij} Z_{jt-1} + \gamma_1 VP_{it} + \gamma_2 \sum_{j=1}^{N} w_{ij} VP_{jt} + \delta_1 FS_{it} + \delta_2 \sum_{j=1}^{N} w_{ij} FS_{jt} + \rho_{it} \quad (4)$$

where $w_{ij}Z_{jt-1}$, $w_{ij}VP_{jt}$ and $w_{ij}FS_{jt}$ are the variables spatially lagged from the natural logarithm of lagged GDP per capita, of the vector of variables used in economic growth equations and of the variable that indicates firm size, respectively. The remaining variables were already described in equation 5.

Estimations of these models through OLS are inappropriate, as in the SEM model the parameters will be inefficient due to the non-orthogonal structure of the error term, while in the SAR model the estimations via OLS generate biased and inconsistent findings due to simultaneity in the nature of the spatial autocorrelation caused by the introduction of spatial lag. Therefore, the most appropriate estimation for these models is that based on maximum likelihood or instrumental variables (Anselin, 1988).

More recently, Elhortst (2010) proposed that the estimation of these models through panel data is preferable to cross-sections, as panel data usually contain more information, greater variation and less collinearity between the variables, in addition to generating more efficient estimations. Given these advantages, a spatial panel with control for time fixed effects will be used to estimate the three models previously described.

2.2.2 Exploratory spatial data analysis

The presence of spatial heterogeneity will be tested through exploratory spatial data analysis (ESDA), showing if the parameters used in the analysis are constant or not in space.

Ertur et. al. (2006) show that the presence of spatial heterogeneity and the resulting identification of spatial regimes can be achieved with exploratory spatial data analysis (ESDA). Therefore, the natural logarithm of the per capita income is used in the starting period to verify the existence of different spatial regimes.

The Moran Scatterplot and local Moran's I enable to identify different patterns of spatial distribution. The Moran scatterplot can be understood as a regression coefficient deriving from the global Moran's I, that provides a manner to visualize the linear association between an observation and its spatial lag (Anselin, 1996).

According to Anselin (1995), the local indicators of spatial association (LISA) are calculated as follows:

$$I_l = \frac{y_j \sum_{j=1}^{n} w_{ij} y_i}{\sum_{i=1}^{n} y_i^2} \tag{5}$$

where *n* indicates the number of regions, w_{ij} are the elements of the spatial weights matrix, y_i and y_j are the values of the used variable, while *i* and *j* refer to the different regions.

The findings deriving from the application of this indicator show two possible types of clusters or outliers, thus indicating that the regions may present two distinct or similar patterns, according to the variable used.

2.2.3 Spatial weights matrices and data

The object of the analysis of this study is comprised of the 558 micro-regions in Brazil. These regions refer to groups of municipalities with similar characteristics, both economic and geographic. According to Cravo (2010), micro-regions enable a large number of observations and reduce distortions observed at municipal level.

In order to achieve the goals initially proposed, we used information deriving from different statistical basis regarding the period from 1999 to 2009, subdividing them in five subperiods 1999-2001, 2001-2003, 2003-2005, 2005-2007 and 2007-2009[6].

Through data provided by RAIS (Annual Social Information Report), it is possible to calculate the variables that indicate firm size and education.

The size firm variable is gathered by calculating the ratio between the quantity of employees in large (small) manufacturing plants and the quantity of employees in the total industrial employment. Then, the firm size variable is measured by the share of the employment in large (small) firms in the total formal labor force in manufacturing sector, as in Beck et. al. (2005) and Komarek and Loveridge (2015).

The definitions of size are based in Brazilian institutions (IBGE and SEBRAE) in which the size of establishments are defined as the number of employees, and this definition is used by these institutions for policies in credit, technologies and export. According to these institutions, large manufacturing firms are those that have more than 500 employees[7], while small firms have up to 99 employees.

The variable indicating education is calculated by the average study years of all individuals participating in the formal sector. The use of such proxy is due to the fact that there is no data regarding average study years for the entire population at a micro-region level for the years analyzed in this study.

For the other variables analyzed, we used the database of IPEADATA (Institute of Applied Economic Research) and IBGE (Brazilian Institute of Geography and Statistics), thus gathering information regarding the GDP and the population of each micro-region, respectively, to obtain the following variables: GDP per capita growth rate, natural logarithm of GDP per capita in the first year of the analyzed period and population growth rate.

In order to model spatial interactions, it is necessary to specify how the regions comprising the sample are connected, and the tool used to represent this connectivity is the spatial weights matrix (Ertur and Koch, 2007).

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[6] The division in five subperiods is due to the fact that in order to make economic growth estimations through panel data, it is necessary to divide the analysis period in subperiods between 3 to 5 years, so that the effects of the business cycle do not compromise the findings (Lee et. al., 2012).

[7] Based on the work of Beck et. al. 2003, an alternative measure of large firm (> 250 employees) was also used.

In this study, the spatial weights matrix is prepared based on the neighboring relations between the regions inserted in the sample. Therefore, at first the queen contiguity matrix, in which neighbor regions are those that share a common physical border, is used. In addition, the spatial weights matrices of the nearest k-neighbors will be used, as in Ertur and Koch (2007) and Mohl and Hagen (2010), which consist in measuring the neighborhood effect from the distance of the region centroid. In these matrices, all micro-regions have the same number of neighbors.

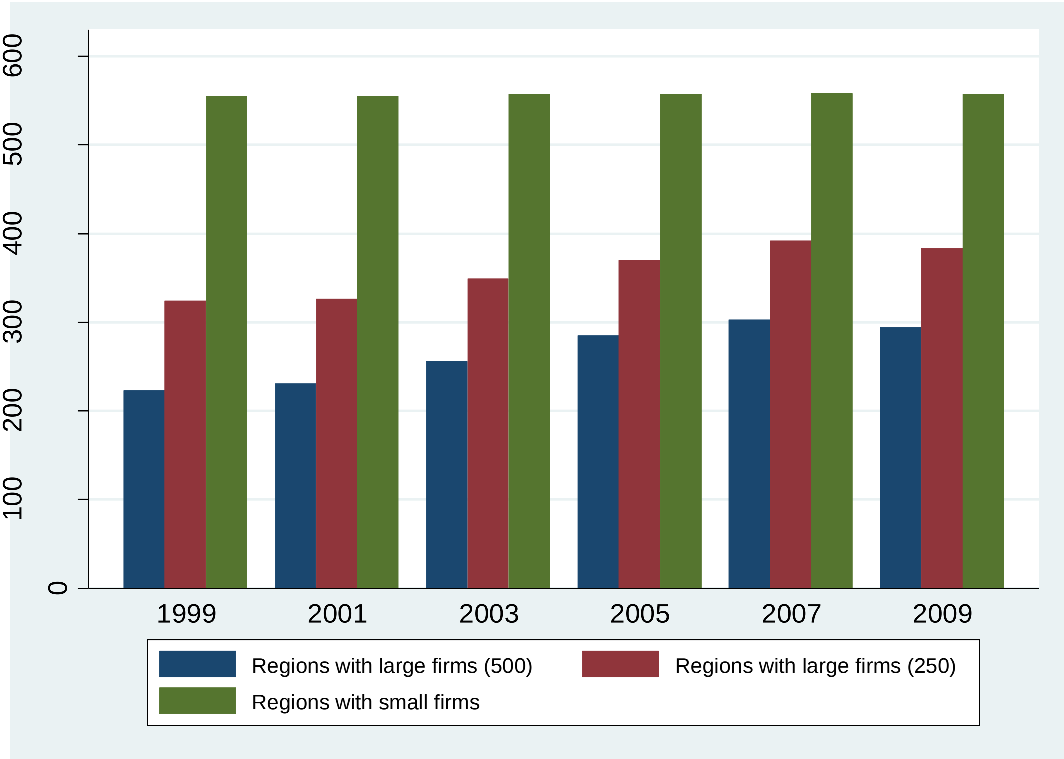
The matrix choice is according to the literature, and the use of different matrices is intended to mitigate matrix choice arbitrariness, so that the findings are not influenced by the choice of a certain neighborhood matrix.

2.3 Findings

2.3.1 Exploratory data analysis

The political-administrative division of Brazil into micro-regions subdivides the country into 558 geographic units. According to data from RAIS (Chart 1), only 223 micro-regions, from that total, have firms in the industrial sector with more than 500 employees in the year 1999. In 2009 this number increased to 295 micro-regions with presence of large firms. This represents an increase of about 32% in the number of micro-regions with the presence of large firms.

Chart 1 – Micro-regions by industrial firms



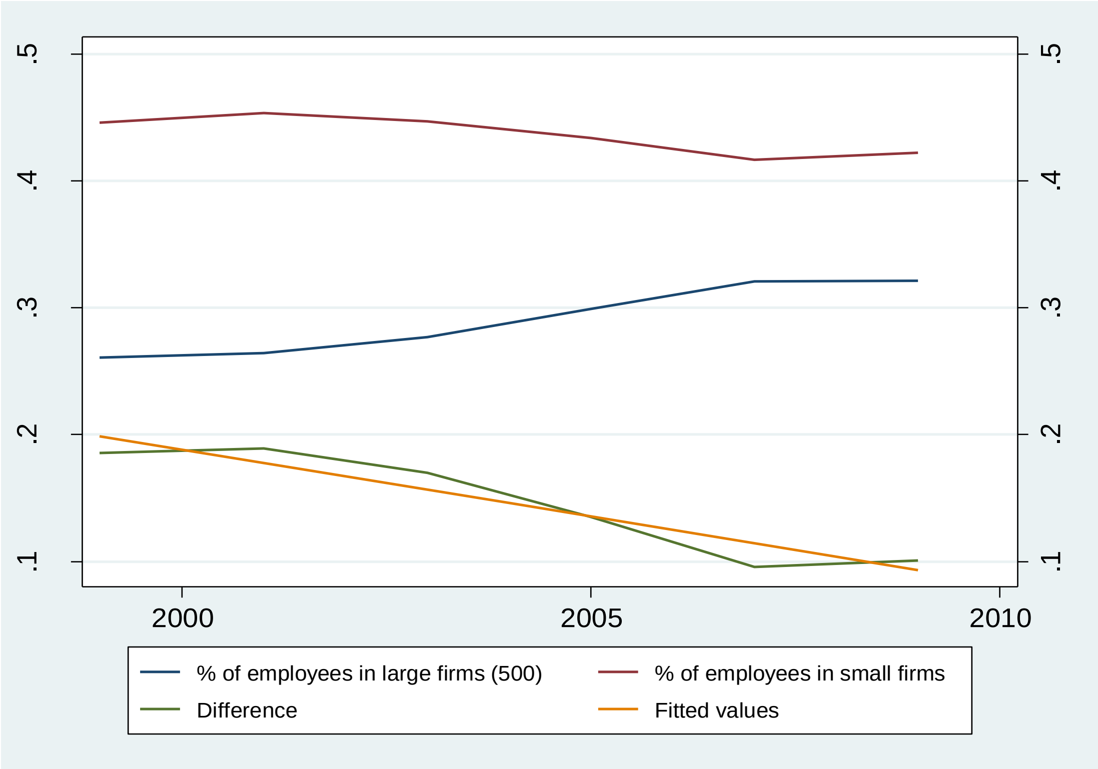
Source: RAIS. Prepared by the author.

By considering as large firms those with more than 250 employees, it is also possible to see an increase in the presence of these firms in the micro-regions of the country, from 324 to 383, an increase of around 18%. Micro and small business in the industrial sector are present in most micro-regions, as it can be seen in the chart above.

The analysis of employment by firm size (Chart 2) shows a falling trend in employment in small firms in the industrial sector, as their participation in total industrial employment decreased from 44.61% in 1999 to 42.22% in the last period reviewed. Meanwhile, in large companies - with more than 500 employees - employment percentage increased during the period under study, from 26% in 1999 to a little more than 32% in 2009.

Chart 2 shows a line indicating the difference between employment percentage in small business and employment percentage in large business, and this difference presents a falling trend throughout period reviewed. The difference, that was of approximately 20 percentage points in the beginning of the period, decreased to approximately 10 percentage points.

Chart 2 – Employment percentage in large (500) and small business



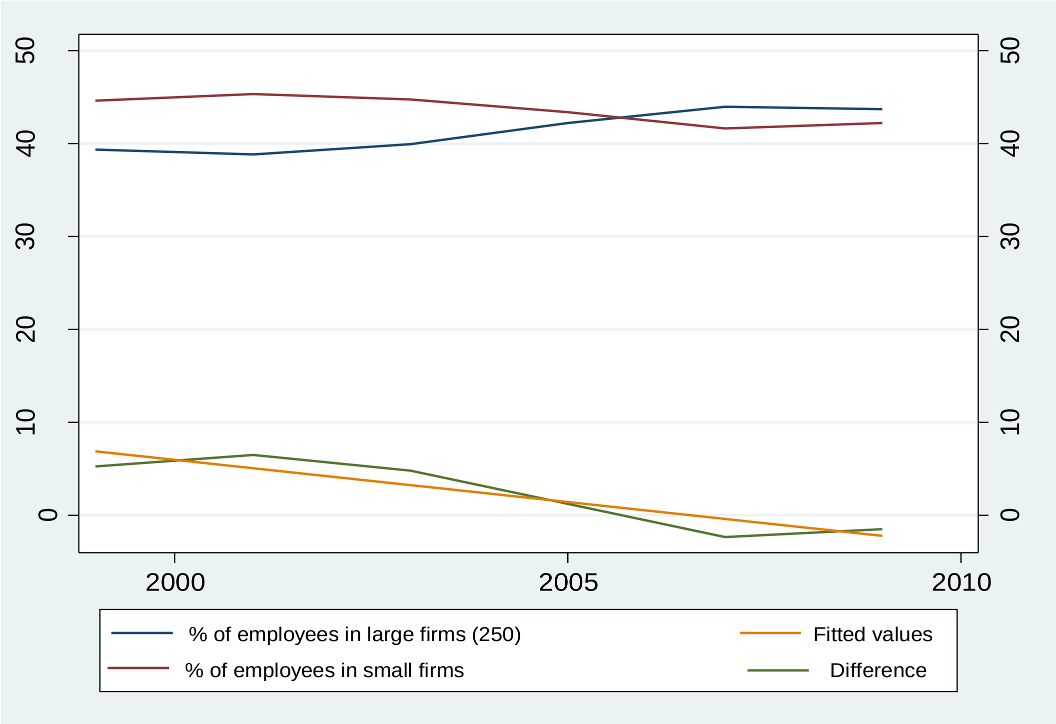
Source: RAIS. Prepared by the author.

By considering as large companies those with more than 250 employees, it is also possible to see an increasing trend in employment in these companies. However, it is noteworthy that in the last years of the analysis most of industrial employment is concentrated in large companies, and not in small business (Chart 3). In the year 2009, approximately 43% of total industrial employment is in large companies, while small business hold 42% of employment.

The line representing the difference in employment percentage between small and large business presents, at first, positive values for this difference, but in the last periods it presents negative values, as in these periods most jobs are concentrated in large business, and not in small ones.

In general, the findings show industrial employment growth in large business, with both definitions of large business, and a decrease in the participation of small business in the total of industrial employment. Despite the clear importance of large companies in Brazil, there is little study regarding their impact in economic growth, especially at regional level.

Chart 3 – Employment percentage in large (250) and small business



Source: RAIS. Prepared by the author.

Therefore, the next sections are aimed at filling in this blank in literature and presenting empirical findings that demonstrate what is the existing relation between firm size and economic growth at regional level.

2.3.2 Findings from estimations via fixed effects

The findings obtained from panel data estimations with fixed effects (Table 1) are subdivided into three models. Model 1 indicates the impact of the presence of large companies in economic growth of micro-regions, using as large company variable those with more than 500 active links. In model 2, companies with more than 250 employees are considered large companies. Model 3 shows the relation between small companies and economic growth of micro-regions.

In models 1 and 2, findings indicate a positive and statistically significant sign for the large company variable, and the large companies with more than 250 employees presented an explanation coefficient with greater magnitude Thus, it can be inferred that the presence of large companies of the industrial sector contributes positively for the growth of GDP per capita of micro-regions. Such findings are in accordance with the facts observed by Lee *et. al*. (2012), where the presence of large firms fosters growth of GDP per capita of the countries analyzed.

Table 1 – Findings of estimations with fixed effects for all Micro-regions

Micro-regions	Fixed effects		
Estimation	Model 1	Model 2	Model 3
Lag LN GDP per *capita*	-0.616 (-32.73)***	-0.617 (-32.84)***	-0.619 (-32.90)***
Education level	0.059 (17.61)***	0.058 (17.33)***	0.058 (17.27)***
Population growth rate	-0.5276 (-9.63)***	-0.5324 (-9.73)***	-0.53 (-9.69)***
Large firm (500)	0.069 (3.14)***		
Large firm (250)		0.076 (3.81)***	
Small firm			-0.081 (-4.16)***
Observations	2784	2784	2784
Number of micro-regions	558	558	558

Note: Numbers between brackets are t statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA and RAIS. Prepared by the author.

The remaining explanatory variables from both models also presented statistical significance and signs consistent with economic theory. The population growth rate and the lag variable of the natural logarithm of GDP per capita presented negative signs, while the sign found for education was positive.

The negative sign of the lag variable of the natural logarithm of GDP per capita, is in accordance with neoclassical growth models. Such finding indicates a convergence process, in which regions with lower levels of initial per capita income tend to grow more rapidly than those where this level of initial income is higher.

The theoretical basis also supports the negative sign of population growth rate, as according to Mankiw *et. al*. (1992), the highest population growth rates are associated to locations with lower per capita income growth rates. Therefore, a high population growth rate impacts negatively the growth of GDP per capita.

The positive sign of the variable associated with human capital indicates that the higher the education level of the population, the higher the economic growth of the region where this population is inserted tends to be.

The findings from the third model show a negative and significant effect of small industrial firms in growth, thus suggesting that these companies do not contribute to speed up the economic growth of micro-regions. The negative relation between small business and economic growth found in this study is in agreement with the findings obtained by Cravo *et al* (2010) and Cravo (2010).

2.3.3 Spatial analysis

2.3.3.1 Spatial dependence

We report in this section the findings obtained from the spatial panel estimations with fixed effects, using a[8] first order matrix Queen (Table 2). The findings were similar in all three estimated models and with the different spatial weights matrices used, only changing the magnitude of the coefficients, but with the same relations between the independent variables and the dependent variable.

The estimation through SDM model presents findings that are interpreted differently from the two also estimated models SEM and SAR. This happens because the coefficients of the independent variables represent the direct effect on the dependent variable, while the coefficients of spatially lagged independent variables capture the spatial effects of these variables on the dependent variable.

The spatial parameters λ and ρ, which demonstrate the spatial dependence of the dependent variable, presented positive and significant values in all estimations.. This indicates that the spatial structure influences the path of the growth rate of GDP per capita and that neglecting spatial dependence may generate omitted variable bias and lead to inconsistent estimators.

The findings obtained from the SDM estimation show that per capita income is negatively related to growth, indicating an income convergence process. The spatial lag of this variable presented significant and positive coefficient, thus showing that regions

[8] There were also findings obtained using the nearest k-neighbors spatial weights matrix (k=5), and those can be found in Appendix B (Table 2.B) of this article.

with high GDP per capita impact positively the economic growth of the neighboring region.

Table 2 – Results of spatial panel models

Micro-regions Estimation	SEM			SAR			SDM		
Lag LN GDP per *capita*	-0.67 (-38.81)***	-0.67 (-38.9)***	-0.67 (-38.88)***	-0.64 (-37.94)***	-0.64 (-38.04)***	-0.65 (-38.07)***	-0.66 (-38.37)***	-0.66 (-38.45)***	-0.67 (-38.53)***
Education level	-0.01 (-1.28)	-0.01 (-1.26)	-0.01 (-1.4)	0.00 (-0.73)	0.00 (-0.72)	0.00 (-0.87)	-0.01 (-1.26)	-0.01 (-1.25)	-0.01 (-1.35)
Population growth rate	-0.43 (-9.18)***	-0.43 (-9.22)**)	-0.44 (-9.23)***	-0.42 (-8.91)***	-0.42 (-8.96)***	-0.42 (-9.00)***	-0.43 (-9.12)***	-0.43 (-9.16)***	-0.44 (-9.25)***
Large firm (500)	0.02 -1.10			0.02 (-1.22)			0.02 (-1.12)		
Large firm (250)		0.04 (2.29)**			0.04 (2.48)**			0.04 (2.32)**	
Small firm			-0.03 (-2.17)**			-0.04 (-2.82)***			-0.04 (-2.56)**
W*Lag LN GDP per capita							0.1642 (4.74)***	0.1630 (4.69)***	0.1491 (4.26)***
W*Education level							0.02 (2.32)**	0.02 (2.3)**	0.02 (2.34)**
W*Population growth rate							0.21 (2.25)**	0.21 (2.22)**	0.20 (2.13)**
W*Large firm (500)							0.01 (-0.18)		
W*Large firm (250)								0.01 (-0.2)	
W*Small firm									-0.07 (-2.21)**
λ	0.32446 (13.67)***	0.32422 (13.65)***	0.32210 (13.52)***						
ρ				0.24729 (12.01)***	0.24639 (11.96)***	0.24731 (12)***	0.31499 (13.19)***	0.31445 (13.15)***	0.30765 (12.8)***
Observations	2790	2790	2790	2790	2790	2790	2790	2790	2790.00
Log-likelihood (LIK)	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221

Note: Numbers between brackets are t statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA and RAIS. Prepared by the authors.

The coefficient of the variable of population growth rate was negative and significant, which indicates that a high population growth rate impacts negatively the growth of GDP per capita. The spatial lag of population growth rate, on the other hand, presented a positive and significant coefficient, thus suggesting that the growth rate of

GDP per capita within a micro-region is positively influenced by population growth of its neighbors.

The variable associated to human capital presented negative sign and statistic significance only when the k-neighbors (k=5) spatial weights matrix was used. However, this spatially lagged variable presented positive and significant coefficient, thus indicating that the higher education levels of neighboring regions are beneficial to the economic growth of the micro-region.

For the variables associated to large firms, the findings show a positive sign for both definitions of large firms, and statistically significant only for that which the definition is more than 250 employees. Therefore, it may be inferred that the presence of large companies of the industrial sector interferes positively in the growth rate of GDP per capita of the micro-regions.

The findings related to spatial lag of variables of large firms also presented positive sign, however, they did not present statistical significance. Therefore, it is not possible to infer the impact of the presence of large firms of neighboring regions in the economic growth rate.

By inserting the variable referring to small business, the findings show a negative and significant effect of small industrial establishments in the growth of GDP per capita. Such finding indicates that in the regions where the presence of small establishments of the industrial sector is higher, the growth rate of GDP per capita is lower. The findings of this spatially lagged variable show negative sign and statistical significance, which suggest a negative relation between small business in neighboring regions and growth rate of GDP per capita.

The estimations using the SEM and SAR models presented findings that are similar to those previously described. These two models show that, by controlling spatial dependence both by the error term and by spatially lagged values of the dependent variable, the relation found between large business and economic growth remains positive. On the other hand, the relation between small business and economic growth was negative.

The use of these spatial dependence models provide supporting and more robustness to the findings obtained from fixed effect estimations and GMM. Therefore confirming that during the period analyzed, large industrial firms were more important for the growth of GDP per capita of Brazilian micro-regions than small firms.

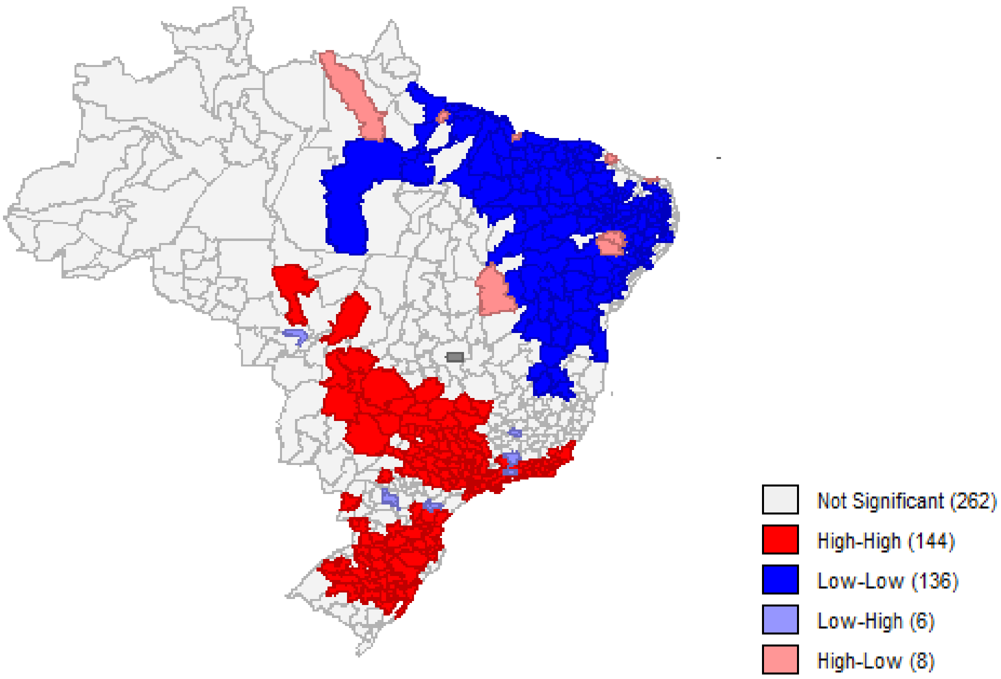
2.3.3.2 Spatial heterogeneity

Literature indicates that there are different productive and economic dynamics between the Brazilian micro-regions, associated to distinct levels of development as well, thus forming different spatial regimes (Cravo *et al*., 2014; Laurini *et al*., 2005; Silveira-Neto and Azzoni, 2006).

The findings of local Moran's I and of Moran Scatterplot are in agreement with the literature and suggest two different spatial regimes regarding per capita income (Figure 1 and Figure 2)[9], one of higher per capita income, comprising the South, Southeast and Central-West regions, and other of lower per capita income, related to the North and Northeast regions of Brazil.

Finding the existence of two different spatial regimes in Brazil suggests that the relation between firm size and economic growth must be analyzed separately in each regime, so that the relation between explained variable and explanatory variables may be changed according to the spatial regime.

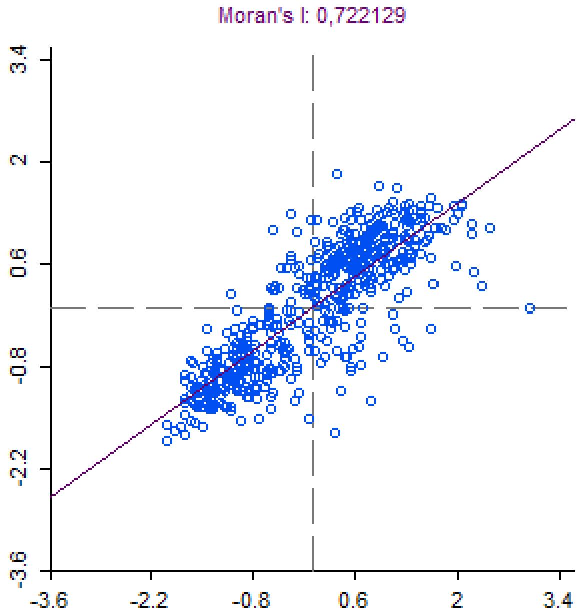
Figure 1 – local Moran's I (LISA) of the natural logarithm of GDP per capita in the starting year



Source: IBGE and IPEADATA. Prepared by the authors.

[9] The contiguity relation used in the analysis of local *I de Moran* local was the first order Queen spatial weights matrix. Other matrices were also used, and their findings are in the Appendix C of this article.

Figure 2 – Moran Scatterplot of the natural logarithm of GDP per capita in the starting year



Source: IBGE and IPEADATA. Prepared by the authors.

Therefore, the initial sample is divided in two, one comprising South, Southeast and Central-West regions, with 306 micro-regions, and other comprising the North and Northeast regions of Brazil, with 252 micro-regions. And the three models are estimated again, with the different spatial weights matrices.

The findings reported in this section refer to the first order Queen matrix. The findings obtained with the k-neighbor matrix (k=5) can be found in the Appendix D of this study.

Table 3 presents findings related to the regions with lower per capita income, located in the North and Northeast of Brazil. In these regions, the findings do not show significant values for coefficients referring to different firm sizes. Therefore, it is not possible to make inferences regarding the relation between firm size and economic growth in the North and Northeast micro-regions of the country.

In the remaining variables, findings are not much different from what was found for Brazil as a whole. It is noteworthy, however, the coefficient of the variable associated to human capital. The magnitude of the coefficients increased, regarding Brazil as a whole, as well as their statistical significance. Thus, they show a negative relation between the levels of human capital and the growth rate of GDP per capita.

Table 3 - Results of spatial panel models for the North and Northeast regions

Micro-regions Estimation	SEM			SAR			SDM		
Lag LN GDP per *capita*	-0.6410 (-24.97)***	-0.6418 (-25.02)***	-0.6423 (-24.98)***	-0.6256 (-24.44)***	-0.6264 (-24.48)***	-0.6275 (-24.45)***	-0.6459 (-25.07)***	-0.6460 (-25.11)***	-0.6477 (-25.04)***
Education level	-0.0218 (-3.6)***	-0.0211 (-3.51)***	-0.0218 (-3.63)***	-0.0225 (-3.72)***	-0.0219 (-3.63)***	-0.0226 (-3.76)***	-0.0204 (-3.38)***	-0.0201 (-3.35)***	-0.0205 (-3.41)***
Population growth rate	-0.4213 (-7.01)***	-0.4220 (-7.03)***	-0.4228 (-7.03)***	-0.3877 (-6.47)***	-0.3883 (-6.48)***	-0.3900 (-6.5)***	-0.4358 (-7.23)***	-0.4357 (-7.24)***	-0.4377 (-7.26)***
Large firm (500)	-0.0004 (-0.01)			0.0009 (0.04)			0.0008 (0.03)		
Large firm (250)		0.0330 (1.57)			0.0306 (1.42)			0.0282 (1.33)	
Small firm			-0.0139 (-0.76)			-0.0173 (-0.93)			-0.0134 (-0.73)
W*Lag LN GDP per capita							0.1566 (2.91)***	0.1598 (2.97)***	0.1529 (2.82)***
W*Education level							-0.0046 (-0.36)	-0.0074 (-0.59)	-0.0051 (-0.41)
W*Population growth rate							0.3341 (2.77)***	0.3414 (2.83)***	0.3307 (2.74)***
W*Large firm (500)							0.0106 (0.21)		
W*Large firm (250)								-0.0562 (-1.34)	
W*Small firm									-0.0122 (-0.32)
λ	0.2313 (6.22)***	0.2335 (6.28)***	0.2309 (6.2)***						
ρ				0.1448 (4.47)***	0.1457 (4.5)***	0.1451 (4.49)***	0.2230 (6.02)***	0.2258 (6.11)***	0.2221 (5.99)***
Observations	1260	1260	1260	1260	1260	1260	1260	1260	1260
Log-likelihood (LIK)	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221

Note: Numbers between brackets are t statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA and RAIS. Prepared by the authors.

Findings related to South, Southeast and Central-West regions can be found in Table 4. For these regions, some findings differ not only from the previous analysis, but also from Brazil as a whole.

First, in these regions, firm size has a statistically significant relation with the growth rate of GDP per capita. According to the findings, the large firms in the industrial sector contribute positively for the growth of GDP per capita of the micro-regions. Small business, on their turn, presented a negative and significant relation with the explained variable.

Table 4 - Results of spatial panel models for the South, Southeast and Central-West regions

Micro-regions Estimation	SEM			SAR			SDM		
Lag LN GDP per *capita*	-0.7033 (-30.05)***	-0.7028 (-29.97)***	-0.7076 -30.1900	-0.6767 (-29.79)***	-0.6768 (-29.74)***	-0.6828 (-30.02)***	-0.6983 (-29.66)***	-0.6968 (-29.56)***	-0.7013 (-29.84)***
Education level	0.0330 (2.91)***	0.0316 (2.8)***	0.0321 (2.85)***	0.0394 (3.56)***	0.0380 (3.45)***	0.0388 (3.54)***	0.0330 (2.93)***	0.0313 (2.79)***	0.0328 (2.94)***
Population growth rate	-0.4189 (-5.49)***	-0.4249 (-5.56)***	-0.4232 (-5.55)***	-0.4816 (-6.35)***	-0.4862 (-6.4)***	-0.4816 (-6.36)***	-0.4480 (-5.88)***	-0.4565 (-5.99)***	-0.4543 (-5.99)***
Large firm (500)	0.0534 (1.98)**			0.0557 (2.09)**			0.0583 (2.17)**		
Large firm (250)		0.0408 (1.5)			0.0487 (1.8)*			0.0456 (1.69)*	
Small firm			-0.0875 (-3.04)***			-0.1043 (-3.62)***			-0.0988 (-3.45)***
W*Lag LN GDP per capita							0.1039 (2.17)**	0.0956 (2)**	0.0694 (1.43)
W*Education level							0.0451 (2.11)**	0.0455 (2.14)**	0.0517 (2.43)**
W*Population growth rate							-0.2885 (-1.89)*	-0.2900 (-1.9)*	-0.2556 (-1.69)*
W*Large firm (500)							-0.0010 (-0.02)		
W*Large firm (250)								0.0572 (1.01)	
W*Small firm									-0.1429 (-2.41)**
λ	0.3257 (9.95)***	0.3234 (9.86)***	0.3173 (9.59)***						
ρ				0.2760 (10.19)***	0.2749 (10.14)***	0.2718 (10.03)***	0.3046 (9.26)***	0.3015 (9.15)***	0.2875 (8.63)***
Observations	1530	1530	1530	1530	1530	1530	1530	1530	1530
Log-likelihood (LIK)	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994

Note: Numbers between brackets are t statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA and RAIS. Prepared by the authors.

Regarding the variable associated to human capital, the coefficients presented positive and significant signs, showing that the levels of human capital in these regions contribute for a higher growth rate of GDP per capita. This finding differs both from what was found for the entire country and from findings related to the North and Northeast regions. The remaining findings are similar to those obtained in previous estimations.

2.4 Final comments

The purpose of this work is to analyze in a empirical manner the relation between firm size and economic growth of Brazilian micro-regions during the period from 1999 to 2009. The empirical strategy used consists in preparing a data panel for estimation through fixed effects, as well as performing analysis that control the effects of spatial dependence and spatial heterogeneity.

The findings from both estimations – fixed effects and spatial dependence – indicate that the presence of large firms is positively related to the growth rate of GDP per capita. The opposite happens regarding small firms.

The spatial econometrics models also enable to infer that the presence of small establishments in the neighboring regions had a negative relation with economic growth rate. Regarding the influence of large establishments in neighboring regions, there were no significant findings.

Considering the spatial heterogeneity observed in the sample, the effects of spatial dependence in the relation between firm size and economic growth are estimated separately for each regime. The findings from these analyses were different from those deriving from the analysis related to Brazil as a whole.

In the micro-regions of the North and Northeast of Brazil, firm size does not seem to influence economic growth rate, as the findings did not present statistical significance. In the South and Southeast regions, the relation found is similar to Brazil as a whole, with large firms contributing for a higher growth rate of GDP per capita, while small companies presented a negative relation with economic growth.

The findings related to the importance of human capital to economic growth are also different among both spatial regimes. In the regions with higher per capita income, the variable that indicates education presented a positive relation with economic growth, while in regions with lower per capita income it was found a negative sign in the variable related to education.

In general, the findings obtained in this work show that large firms tend to contribute more for regional economic growth than small firms. Considering the literature on the subject, it is possible to credit these findings to specific characteristics of large establishments, such as greater international integration, greater productivity, greater access to credit and greater innovation capacity. Finally, following the same line of reasoning, the distinct findings from both Brazilian regions suggest that the characteristics mentioned above are better explored in locations with higher levels of development.

The negative relation between small business and economic growth can be associated to the quality of institutions and levels of human capital, which do not provide a proper environment to expand productive entrepreneurship (Dias and McDermott, 2006), and cause entrepreneurship to happen more due to the need to undertake than due to the generation of business opportunities.

3. Firm size and economic development: Evidence for the Brazilian Municipalities

3.1 Introduction

Firm size has been object of intense investigation in economic literature. Normally the focus of this research object is the contrast between large business – the major players in the market – and a great number of small enterprises, that are individually vulnerable and sometimes dependents of public support, but collectively endowed with vast political capital (Moscarini and Postel-Vinay, 2012). However, empirical evidence is rather mixed about whether small and large firms differ in the aggregate, in terms of their impact on overall economic growth (Bruce et. al. 2009).

According to Shaffer (2006) if the firm size is important, there could be some characteristics associated to the large firms that might stimulate growth, and perhaps other factors related to the small firms that can act in favor of growth. A better understanding about these possibilities can stimulate the growth and development of a region or county.

Part of the debate in the literature is related to which created more jobs, the small business or the large ones. In favor of small firms, some research has shown the small firms as the greatest contributors to the employment growth (Komarek and Loveridge, 2015; Neumark, 2011; Shaffer, 2006).

Deller and McConnon Jr (2009), in their analysis for the U.S. states, suggest that the relation between employment growth and microenterprises change according to the sector. A higher share of microenterprises in the producing sector is associated with higher levels of employment growth. In the service sector, these enterprises have a positive relationship with the growth of employment.

In contrast to the works presented above, Bruce et. al. (2009) and Ayyagari et. al. (2014) found a positive relation between large firms and employment growth. Indicating that faster employment growth is found in places with more large-firm activity.

The debate is also addressed in the relation between per capita income and firm size, more specifically an important trend in economic development policy-making is the promotion of small firms to enhance local economic growth.

However, as in the firm size-employment relation, with the results found in the literature is not possible asserting precisely which size firms are more significant contributors to the per capita income growth, depending mostly on the level of local development. Deller (2010) points out that in developing regions where institutions are not well established, the role of small business is unclear. Thus, in developing countries the relation between small firms and income growth may be negative (Acs *et. al.*, 2008; Deller, 2010; Van Stel *et. al.*, 2005).

In a context of developed economies, the findings indicate that smaller firms are associated with faster growth of income (Deller and McConnon, 2009; Shaffer, 2002; Shaffer, 2006b). Komarek and Loveridge (2015), in turn, show that the most important for the regional income growth are the medium sized firms.

Firm size distribution can also be important to reduce poverty. Even though this concept is not well addressed in the literature there are some studies analyzing three factors associated to firm size and poverty reduction: these factors are, small and medium enterprise sectors (SME), entrepreneurship and self-employment.

As noticed by Deller and McConnon Jr (2009) most of the staff employed in small businesses is derived from secondary labor markets (e.g. lower education levels, women, minorities, immigrants, etc. Thereby the promotion of small business may represent a poverty mitigation strategy (Deller and McConnon Jr, 2009).

The importance of small enterprises for the poverty reduction is also defended by Gebremarian et. al. (2004). According to the authors, by creating jobs and promoting economic growth, small businesses play a critical role in poverty alleviation. They also play an important role in community development by enticing private investment back into undeveloped areas and spreading the benefits of economic growth to people and places too often left behind.

Another significant way to alleviate poverty is related to entrepreneurship. However, there are a reduced number of researches focusing in the relation between entrepreneurship and poverty, specially in developing countries. Amorós and Cristi (2010) found results indicating that entrepreneurship activities have a positive effect in reducing poverty.

In developing countries, the entrepreneurs are self-employed or have only a reduced number of employees (Banerjee and Duflo, 2007). Then, as well as entrepreneurship and SME, the self-employment could be a way to reduce poverty. Rupasingha and Goetz (2013) analyzed the relation between poverty and self-employment, providing empirical evidence of the support of self-employment as a way to reduce the countrywide poverty.

As can be noted in the international academic literature, the firms size is a relevant issue and can be considered one of the relevant factors for the growth and development of a region. However, this issue is still little discussed in Brazil. In this sense Cravo et. al. (2012) and Cravo et. al. (2015) investigate exclusively the relation between small and medium-sized enterprises (SME) and economic growth in Brazilian micro regions. The authors have found evidence suggesting a negative relation between SMEs and growth. However, when included the human capital variable in the small and medium size business variable, the relation becomes positive.

Before the analysis so far, this work aims in addition to filling a gap in Brazilian academic literature, to analyze more thoroughly the relationship between size of business and economic development. Therefore, the proposed models enable – in contrast with other articles on the subject for Brazilian economy – to estimate the relation between the firm size and income, employment and poverty growth in different sectors of the 5507 Brazilian municipalities from 2000 to 2010.

The relation between the size firms and economic growth is analyzed, considering the presence of geographic spillovers, as failing to consider aspects such as spatial dependency may cause econometric problems as omitted variable bias and endogeneity (Badinger et. al., 2004; Ertur and Koch, 2007; Mohl and Hagen, 2010).

In addition to this introduction, the article is divided into three more sections. In section 2, the methodologies and data used in this study are described. Section 3 presents an exploratory analysis of data and presents the main findings of the work. Next, final comments close the article.

3.2 Methodological aspects

3.2.1 Specification of models

The empirical strategy of analyzing the relation between establishment size and economic growth of municipalities is set by using economic growth equations, according to the proposal of Beck et. al. (2005), Bruce et. al. (2007) and Shaffer (2002; 2006).

Therefore, the hypothesis to be tested may be described through the following equation:

$$Growth_i = \alpha + \beta FirmSize_i + \delta\ ConditionalSet_i + \rho_i \quad (1)$$

where $Growth_i$ is the growth rate of per capita income, employment or poverty, $\beta FirmSize_i$ refers to different size of enterprises, $ConditionalSet_i$ is a standard variable vector used in economic growth equations, in this case referring to the log of income or employment in the initial year, human capital, physical capital, population density and population in the initial year, ρ_i is an error term.

The presence of geographic spillovers in the economic growth of regions is considered, therefore econometric problems may occur (Badinger *et. al.*, 2004; Ertur and Koch, 2007; Mohl and Hagen, 2010). According to Dall'erba and LeGallo (2008) there are three reasons to incorporate spatial effects in growth models. First, from an econometric standpoint, one of the hypothesis of OLS estimations is based on the independence of error terms, and any violation of this assumption leads to unreliable estimates and inferences. Second, it enables to capture effects of geographic overflows between regions. Third, spatial discrepancies on the dependent variable can act as outdated dependent variables to explain omitted variables.

The Lagrangian Multiplier tests (Anselin et. al., 1996) were used to choose between spatial models. The results indicated that in order to control the effects of spatial dependence, the most appropriate for income and employment models are the spatial error model (SEM). Nevertheless, for poverty model, the test indicates the spatial autoregressive model (SAR).

The SEM (spatial error model) models spatial dependence by the error term, and it can be described by the following equation:

$$Growth_i = \alpha + \beta FirmSize_i + \delta\ ConditionalSet_i + \delta_i \quad (2)$$

$$\delta_i = \theta \sum_{j=1}^{N} w_{ij}\delta_j + \varepsilon_i$$

where variables are the same used in equation 1, except for the error term δ_i, which, through the w_{ij} term contains information regarding spatial structure and connectivity between regions i e j, θ is the spatial error coefficient and $\varepsilon \sim N(0, \sigma^2, I_n)$. This specification indicates that a random shock introduced in a region affects all regions through the spatial structure.

In the SAR (spatial autoregressive model), the spatial dependence is included in the model through the spatially lagged values of the dependent variable, as described in equation 3.

$$Growth_i = \rho \sum_{j=1}^{N} w_{ij} yGrowth_j + \beta ZFirmSize_i + ConditionalSet_i + \rho_{it} \quad (3)$$

where ρ is the spatial autoregressive parameter and the other variables are the same used in the equation 1.

We use four different measures for establishment size, then the equation (2) is estimated using a single measure of establishment for each sector and each dependent variable, resulting in twelve separates sets of estimates for each dependent variables.

3.2.2 Exploratory spatial data analysis

The presence of spatial dependence will be tested through exploratory spatial data analysis (ESDA), showing if the parameters used in the analysis are constant or not in space.

The Moran's I test measures the level of global spatial autocorrelation, and is written in the following form:

$$I_t = \left(\frac{n}{S_0}\right)\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i-\bar{y})(y_j-\bar{y})}{\sum_{i=1}^{n}\ (y_i-\bar{y})^2} \tag{4}$$

where w_{ij} is a binary element of spatial weight matrix W which assumes value equal to 1 if the regions i e j are spatially connected, otherwise the value of the w_{ij} is zero; y_i denotes the analyzed variable in region i, $\bar{y}$ is the average value of the variable; n is the number of regions; e S_0 is the sum of all elements of W.

Values of I_t higher (smaller) than the expected value $E\,(I) = -\frac{1}{n-1}$ indicates positive (negative) spatial autocorrelation.

The findings of Moran’s I for all variables used in the regressions with different weights matrices can be found in the Appendix E of this study.

3.2.3 Data specification

The object of the analysis of this study is comprised of the 5507 municipalities in Brazil. In order to achieve the goals initially proposed, we used information deriving from different statistical basis regarding the period from 2000 to 2010 (Table 1).

The dependent variables are the growth rates of per capita income, employment and poverty between the years 2000 and 2010. All explanatory variables are related to the first year of the analysis. This procedure aims to mitigate the endogeneity problem from the reverse causality (Bruce et al, 2009; Deller, 2010; Komarek and Loveridge, 2015; Shaffer, 2006).

The variables related to human capital were divided into educational capital - percentage of individuals aged 25 years or older that completed high school - and health capital - infant mortality. It was decided to divide the human capital in educational capital and health capital, as in McDonald and Roberts (2002), because, according to the authors, not only the educational capital is positively related to economic growth, but also a healthier population tends to be more productive and hence generate more growth, moreover its omission can generate a bias in the model.

The stock of residential capital was defined as a proxy for physical capital. This variable, is a component of overall physical capital stock (Chen et.al. 2011) and is used for analysis of smaller geographical units in Brazil (Barros et. al., 2013; Lima e Silveira-Neto, 2015; Nakabashi, et. al., 2013).

Table 1 – Variables and sources

	Year	Source
Dependent variables		
Per capita GDP growth	2000-2010	IPEADATA/IBGE
Employment growth	2000-2010	RAIS
Poverty growth	2000-2010	Atlas do Desenvolvimento Humano
Independent variables		
ln per capita income	2000	IPEADATA/IBGE
ln employment	2000	Atlas do Desenvolvimento Humano
ln poverty	2000	Atlas do Desenvolvimento Humano
ln population	2000	IPEADATA/IBGE
Education	2000	Atlas do Desenvolvimento Humano
Child mortality	2000	Atlas do Desenvolvimento Humano
Physical capital	2000	IPEADATA/IBGE
Population density	2000	IPEADATA/IBGE
Microenterprise	2000	RAIS
Small enterprise	2000	RAIS
Medium enterprise	2000	RAIS
Large enterprise	2000	RAIS

Prepared by the authors.

The variable population density refers amount of individuals per square kilometer. It was inserted in the equation as a proxy for the agglomeration effects.

The firm size variable is gathered by calculating the ratio between the quantity of manufacturing (service) employees in each size and the quantity of employees in the total industrial (service) employment. Then, the firm size variable is measured by the share of the employment in four different categories of firm size in the total formal labor force in manufacturing and service sector, as in Beck et. al. (2005) and Komarek and Loveridge (2015).

Table 2 shows the result of calculating the firm size variable to a random municipality.

Table 2 – Example

SECTOR \ SIZE	Microfirms	Small firms	Medium firms	Large firms
Manufacturing	19.71%	28.19%	7.68%	44.42%
Service	18.05%	20.82%	9.31%	51.82%

Source: IBGE and SEBRAE. Prepared by the author.

The definitions of size are based in Brazilian institutions (IBGE and SEBRAE) in which the size of establishments are defined as the number of employees (Table 3), and this definition is used by these institutions for policies in credit, technologies and export.

Table 3 – Definition of firm size

SECTOR / SIZE	Microenterprise	Small enterprise	Medium enterprise	Large enterprise
Manufacturing	< 19 employees	Between 20 and 99	Between 100 and 499	> 500 employees
Service	< 9 employees	Between 10 and 49	Between 50 and 99	> 100 employees

Source: IBGE and SEBRAE. Prepared by the author.

3.2.4 Weight matrix

In order to express spatial interactions between municipalities, it is necessary to specify how these areas comprising the sample are connected, and the tool used to represent this connectivity is the spatial weights matrix.

In a spatial weight matrix the neighbor structure is defined by a *n* x *n* positive matrix (W) in which each element w_{ij} of the W matrix indicates how the localization *i* and localization *j* are spatially connected. The spatial weights w_{ij} are nonzero if the localization *i* and *j* are physically adjacent, and zero otherwise.

The matrix choice is according the structure of the sample. Since the size of the municipalities is not homogeneous, the use of a weight matrix based on distance or contiguity is likely to lead to a very unbalanced connectedness structure. A common solution to this problem consists of considering nearest neighbors weight matrices, forcing each unit to have the same number of neighbors (Anselin, 2002; De Dominicis et. al. 2013).

The concept of the *k* nearest neighbors is calculated from the distance between the centroids of the regions and the form of this matrix is the following:

$$W = \begin{cases} w_{ij}^{*}(k) = 0 \text{ if } i = j \\ w_{ij}^{*}(k) = 1 \text{ if } d_{ij} \le d_i(k) \\ w_{ij}^{*}(k) = 0 \text{ if } d_{ij} > d_i(k) \end{cases}$$

where $d_i(k)$ is the critical cut-off distance for each region i, d_{ij} is the great circle distance between centroids of region i and j. This spatial structure means that each region has exactly k neighbors.

In this study, the spatial weights matrices of the nearest k-neighbors (k=5) will be used.

3.3 Findings

In this section the findings obtained from the estimations of the employment, income and poverty growth models are reported. The models were estimated by spatial error model (SEM) – for income and employment – and by spatial autoregressive model (SAR) for poverty. The k-nearest matrix (k=5) was used for estimate all models.

The spatial parameters λ – spatial parameter for the spatially lagged error term – and ρ - spatial autoregressive parameter for the spatially lagged dependent variable – presented positive and significant values in all estimations. This indicates that the spatial structure influences the path of the growth rate and that neglecting spatial dependence may generate omitted variable bias and lead to inconsistent estimators.

In income model (Table 4), all the explanatory variables from income model presented statistical significance, indicating several consistent determinants of income growth. The negative sign of the natural logarithm of income in the initial year, is in accordance with neoclassical growth models. Such finding indicates a convergence process, in which regions with lower levels of initial per capita income tend to grow more rapidly than those where this level of initial income is higher.

Same inverse relation was found to the variables health and population density, indicating that unhealthier population and agglomeration can lead to a lower income growth rate. The positive sign of the variables associated with human capital, physical capital also indicates the importance of these variables to the income growth of the municipalities.

In the main variables under investigation, firm size, findings indicate a positive and statistically significant sign for the small manufacturing variable. Therefore, it can be inferred that in municipalities where the percentage of employees in small firms of the industrial sector was higher, the growth of per capita income was faster. This result is consistent with the results obtained by Shaffer (2002) in an analysis for US counties.

Table 4 – Results of spatial error model (SEM) – income growth

Variables	Income growth							
	Manufacturing				Service			
Ln income	-0.5709***	-0.5738***	-0.5701***	-0.5703***	-0.5701***	-0.5702***	-0.5701***	-0.5702***
	(-57.24)	(-57.37)	(-57.25)	(-57.22)	(-57.28)	(-57.24)	(-57.28)	(-57.25)
Ln employment								
Ln population	-0.0012	-0.0025	-0.0019	-0.0014	-0.0013	-0.0017	-0.0005	-0.0016
	(-0.51)	(-0.9983)	(-0.75)	(-0.56)	(-0.54)	(-0.69)	(-0.21)	(-0.63)
Education	0.0065***	0.0067***	0.0066***	0.0066***	0.0066***	0.0065***	0.0065***	0.0065***
	(9.73)	(9.97)	(9.79)	(9.79)	(9.79)	(9.78)	(9.78)	(9.79)
Health	-0.0071***	-0.0070***	-0.0069***	-0.0071***	-0.0071***	-0.0071***	-0.0071***	-0.0071***
	(-22.03)	(-21.98)	(-22.07)	(-22.08)	(-22.05)	(-22.09)	(-22.08)	(-22.08)
Population density	-0.000008*	-0.000007	-0.000008	-0.000008*	-0.000008*	-0.00008	-0.000009*	-0.00008
	(-1.68)	(-1.54)	(-1.60)	(-1.65)	(-1.69)	(-1.62)	(-1.75)	(-1.64)
Physical capital	0.0373***	0.0370***	0.0367***	0.0369***	0.0370***	0.0368***	0.0370***	0.0369***
	(14.29)	(14.25)	(14.11)	(14.17)	(14.26)	(14.19)	(14.26)	(14.20)
Microenterprises	0.0076				-0.0236***			
	(1.63)				(-2.66)			
Small enterprises		0.0231***				0.0082		
		(3.34)				(0.79)		
Medium enterprises			0.0070				0.0165**	
			(0.78)				(2.34)	
Large enterprises				-0.0036				0.0012
				(-0.27)				(0.21)
λ	0.5909***	0.5916***	0.5902***	0.5909***	0.5911***	0.5901***	0.5886***	0.5909***
	(41.31)	(41.40)	(41.22)	(41.31)	(41.34)	(41.20)	(41.01)	(41.31)
Observations	5507	5507	5507	5507	5507	5507	5507	5507
Log-likelihood (LIK)	2825.97	2830.23	2824.94	2824.67	2828.18	2824.94	2827.36	2824.65

Note: Numbers between brackets are z statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA, Atlas do Desenvolvimento Humano and RAIS. Prepared by the author.

For the other size of firms in manufacturing sector, the findings show not significant effect in income growth.

In the service sector, the relation between size firm and income growth is different. The medium firms have a positive relation with the income growth, while the micro ones have a negative relation with the growth of per capita income. The results are not significant for small and large enterprises in the service sector.

The different results related to micro and small firms in service and manufacturing sector are in consonance with Rajan and Zingales (2001), whose claim is that different mechanism and characteristics work in different sectors. This fact tends to possibly generate impact on the income that vary according to the sector analyzed.

In both service and manufacturing sector, the large business did not show statistical significance in relation the income growth.

The findings related to employment model (Table 5) presented negative sign to the microenterprises. Therefore, it is not possible to infer the impact of the presence of small firms in the employment growth rate. This results are in opposition to the view that smaller firms are generally associated to larger rates of employment growth, probably due to the fact that in developing countries the role of micro and small enterprises is not clear due to not well established institutions (Deller and McConnon, 2009).

Table 5 – Results of spatial error model (SEM) – employment growth

	Employment growth							
Variables	Manufacturing				Service			
Ln employment	-0.5529***	-0.5544***	-0.5567***	-0.5577***	-0.4256***	-0.5471***	-0.5534***	-0.4802***
	(-62.85)	(-62.46)	(-62.58)	(-62.97)	(-46.51)	(-57.24)	(-62.87)	(-49.27)
Ln population	0.5553***	0.5565***	0.5551***	0.5538***	0.4255***	0.5453***	0.5622***	0.5048***
	(43.36)	(43.49)	(43.39)	(43.30)	(33.87)	(42.63)	(43.31)	(39.03)
Education	0.0078***	0.0077***	0.0078***	0.0074***	0.0034	0.0070***	0.0076***	0.0053**
	(3.27)	(3.26)	(3.30)	(3.13)	(1.58)	(2.96)	(3.22)	(2.30)
Health	-0.0058***	-0.0055***	-0.0056***	-0.0058***	-0.0029***	-0.0053***	-0.0055***	-0.0035***
	(-5.83)	(-5.54)	(-5.68)	(-5.90)	(-3.19)	(-5.37)	(-5.56)	(-3.62)
Population density	-0.00003*	-0.00003*	-0.00003*	-0.00003*	-0.0000008	-0.00003	-0.00003**	-0.00003*
	(-1.84)	(-1.79)	(-1.73)	(-1.83)	(-0.04)	(-1.56)	(-2.01)	(-1.69)
Physical capital	0.0556***	0.0571***	0.0554***	0.0554***	0.0270***	0.0546***	0.0578***	0.0411***
	(6.90)	(7.11)	(6.89)	(6.91)	(3.69)	(6.85)	(7.19)	(5.20)
Microenterprises	-0.0377**				1.1063***			
	(-1.97)				(29.30)			
Small enterprises		0.0426				0.3485***		
		(1.50)				(8.22)		
Medium enterprises			0.1123***				0.0731**	
			(3.04)				(2.53)	
Large enterprises				0.2471***				-0.3904***
				(4.48)				(-15.76)
λ	0.2958***	0.2974***	0.2951***	0.2964***	0.2452***	0.2952***	0.3001***	0.2936***
	(15.29)	(15.39)	(15.25)	(15.33)	(12.27)	(15.25)	(15.56)	(15.15)
Observations	5507	5507	5507	5507	5507	5507	5507	5507
Log-likelihood (LIK)	-4700.21	-4701.03	-4697.54	-4692.11	-4307.05	-4668.51	-4698.95	-4580.62

Note: Numbers between brackets are z statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA, Atlas do Desenvolvimento Humano and RAIS. Prepared by the author.

The positive sign to medium and large firms in the manufacturing sector indicates that in municipalities where the presence of medium and large enterprises of the industrial sector was higher, the growth of employment was faster.

The relation between firm size and employment growth is also different when is analyzed the service sector. The findings show a positive and significant sign to the variables micro, small and medium enterprises. By inserting the variable referring to large firms, the findings show a negative and significant sign for the large ones in the service sector. Such finding indicates that in the regions where the presence of large firms of the service sector is higher, the growth rate of employment is lower.

This difference between services and manufacturing, with opposite trends between sectors, it is even clearer than the difference found in the income model. In this model, the smaller the firm size in the service sector, higher employment growth. While in manufacturing larger firms are positively correlated with employment growth.

The negative sign of the natural logarithm of employment in the first year indicates a convergence process, as in income model. The variables related to population, education and physical capital presented a positive sign. This demonstrated the importance of such variables in order to explain the growth of employment. The variables related to health and agglomeration effects presented negative and significant sign.

In both models, income e employment, the spatial parameter for the spatially lagged error term (λ) presented positive and significant values. It means that a random shock introduced in a specific municipality will impact, besides the income and employment rates of the same municipality, it will impact also the income and employment rates of others municipalities.

The findings on firm size and poverty growth (Table 6) indicate statistic significance only for firms in the manufacturing sector. The results show that different size of firm differ in terms of their impact on poverty growth.

Micro firms in the manufacturing sector have a positive and statistically significant relation with growth in poverty. Then it can be said that faster poverty growth is found in municipalities with more micro firm activity. On the other hand, municipalities with more small, medium and large firms in the manufacturing sector are related with lower poverty growth, specially the medium and large ones that presented higher coefficient associated to poverty growth.

These results are in part according to the literature (Deller and McConnon Jr, 2009; Gebremarian et. al., 2004) that defends the importance of small and medium enterprises (SME) for poverty reduction. However also brings results regarding the importance of large firms for the poverty alleviation. The negative relation between poverty growth and large firms can be explained by the more permanent and effective jobs associated to large firms (Shaffer, 2006).

As in income and employment models, the the natural logarithm of poverty in the first year presented a negative sign, indicating a convergence process. The education and physical capital also presented negative sign. The variables related to health, agglomeration and population show positive and significant sign.

The positive and significant value of the spatial parameter ρ indicates that municipalities whose neighbors have high growth of poverty tend to have higher poverty growth as well.

Table 6 – Results of spatial autoregressive model (SAR) – poverty growth

	Poverty growth							
Variables	Manufacturing				Service			
Ln poverty	-0.1310*** (-9.23)	-0.1310*** (-9.25)	-0.1347*** (-9.48)	-0.1295*** (-9.16)	-0.1275*** (-8.99)	-0.1301*** (-9.17)	-0.1281*** (-9.05)	-0.1265*** (-8.89)
Ln population	0.0520*** (10.44)	0.0538*** (10.75)	0.0556*** (10.97)	0.0533*** (10.57)	0.0507*** (10.24)	0.0515*** (10.37)	0.0518*** (10.24)	0.0516*** (10.36)
Education	-0.0028** (-2.47)	-0.0028** (-2.49)	-0.0028** (-2.45)	-0.0026** (-2.31)	-0.0027** (-2.41)	-0.0027** (-2.36)	-0.0027** (-2.38)	-0.0027** (-2.38)
Health	0.006*** (11.57)	0.0057*** (11.10)	0.0059*** (11.50)	0.006*** (11.54)	0.0059*** (11.45)	0.0059*** (11.43)	0.0059*** (11.46)	0.0059*** (11.46)
Population density	0.00003*** (3.93)	0.00003*** (3.70)	0.00003*** (3.77)	0.00003*** (3.90)	0.00003*** (3.96)	0.00003*** (3.89)	0.00003*** (3.84)	0.00003*** (3.88)
Physical capital	-0.0584*** (-11.86)	-0.0586*** (-11.92)	-0.0581*** (-11.81)	-0.0582*** (-11.80)	-0.0585*** (-11.87)	-0.059*** (-11.98)	-0.0586*** (-11.89)	-0.0583*** (-11.80)
Microfirms	0.0193* (1.84)				0.0183 (0.93)			
Small firms		-0.0572*** (-3.70)				-0.0325 (-1.40)		
Medium firms			-0.0835*** (-4.16)				0.0135 (0.85)	
Large firms				-0.0703** (-2.34)				-0.0143 (-1.21)
ρ	0.583*** (42.78)	0.580*** (42.51)	0.5814*** (42.64)	0.5819*** (42.66)	0.5819*** (42.66)	0.5824*** (42.72)	0.5822*** (42.71)	0.5817*** (42.63)
Observations	5507	5507	5507	5507	5507	5507	5507	5507
Log-likelihood (LIK)	-1564.32	-1559.17	-1557.35	-1563.26	-1565.58	-1565.04	-1565.66	-1565.29

Note: Numbers between brackets are z statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels.
Source: IBGE, IPEADATA, Atlas do Desenvolvimento Humano and RAIS. Prepared by the author.

3.4 Discussion and conclusion

The purpose of this work is to analyze in an empirical manner the relation between firm size and economic development of Brazilian municipalities during the period from 2000 to 2010. More specifically, we used spatial econometrics to analyze the relation between size of manufacturing/service firms and the growth rate of income, employment and poverty.

The use of the municipalities-level data, the different economic development metrics and the sector-specific data used here are more disaggregated than in most prior studies. It allows us to better understanding the issue.

The findings indicate that firm size plays an important role on economic development. Nonetheless the results change according to the metric of measure and the type of sector. This dissimilarity can be associated to different mechanisms and characteristics that are related to different sectors.

The estimated models allow us to obtain some important results. Considering manufacturing sectors, employment growth is significantly and positively related to the size of the firm, whereas the same relation is statistically significant and negative for service sectors. Consistently with this, when poverty growth becomes the exogenous variable, the size of manufacturing firms has the opposite sign: small, medium, and large ones present significant and negative effect on poverty growth. Finally and quite unexpectedly, microenterprises of service sectors have negative effect on income growth, contrasting to their positive effect on employment.

Overall, the results have some implications to policy makers. The main one point is regarding the dissimilarity findings across sectors and development indicators. This fact recommends special attention on the part of policy makers in formulating their local development strategies. Thus, one should take into account specific regional needs to establish appropriated environment and policies.

4. Occupational employment pattern and functional specialization in the Brazilian cities

4.1Introduction

Production agglomeration is one of the most remarkable characteristics of the geography of economic activities and is probably the most direct evidence of the general need of the companies for benefiting from the presence of externalities (Lafourcade and Mion, 2007).

Modern agglomeration theories have started with Marshall's externalities. According to Marshall (1920), external economies are the main sources of industrial agglomeration. Therefore, companies group in a certain location, as they obtain increasing scale returns deriving from factors such as knowledge spillovers, the possibility of specializing in the supply of goods and services and the existence of a contingent of specialized workers (pooling).

In this regard, the location decision of industrial companies may be influenced by various factors, such as transportation costs, scale economies and technology spillovers (Fujita and Thisse, 2002; Krugman, 1991; Venables, 1996). The interaction of these factors create new forces favorable to agglomeration and may explain the distribution of economic activity in space.

However, these traditional approaches focused on the industrial structure of the regions, leaving an open gap, as they have not put much attention to the supply side of industrial production, especially the role of occupations or skills as an increasing source of productivity and profitability of companies (Wan et. al., 2013).

Barbour and Markusen (2007) add that if occupational compositions of the sectors can vary substantially between regions, assumptions based only on sector analysis could result in poorly targeted workforce and economic development programs. With empirical data, Currid and Stolarick (2010) show that “evaluating occupations and industries simultaneously can lead to a better understanding of a policy approach towards regional competitiveness and possibilities for growth”. Thus, the analysis of a regional economy should be prepared to consider the occupational employment in addition to industry.

In this context, there are some prepositions that point out the importance of analyzing the occupational/functional structure of a regional economy. First, analysis of the occupational structure has gained importance because they can provide, through channels such as local human resources, skills, education, important insights for regional development (Koo, 2005).

Second, in recent years there has been increased mobility of companies and productive fragmentation across geographic areas (Fochezatto, 2016). The fragmentation process consists of a change in the organization of companies generated from the separation of management and production functions in the companies (Duranton and Puga, 2005).

According to Scott (2009) the growing fragmentation of companies can be explained by the reduction in transportation and cost factors that have enabled companies located in large urban concentrations to fragment certain functions, which were previously vertically integrated. Silva and Hewings (2010), in turn, show that even though external factors to the company are important to explain industrial fragmentation, factors related to the internal organization of the company should be considered, more specifically communication costs and managerial structure.

The factors affecting fragmentation of companies eventually change the occupational composition of cities as well. Causing management and R&D functions to concentrate in larger cities, while functions related to production tend to locate in small cities (Bade et. al. 2004; Duranton and Puga, 2005).

Empirical evidence confirms this location pattern, that is called functional specialization, suggesting that the occupational activities related to high-level of cognitive work tend to be concentrated in large cities, whereas the capital-intensive work tends to be concentrated in small cities (Elvery, 2010; Scott, 2008).

Brunelle (2013) adds that since sectoral specialization is still about to be an important attribute of local economic development, regions are increasingly differentiating by specialization in activities and tasks performed within a given industry. Thus, from the point of view of regional development, it is not enough to attract a particular sector of activity, it is also necessary to analyze the profile of occupations that will happen in the region (Fochezatto, 2016).

However, there are some occupations whose the distribution between the cities differs more significantly according to the sector. Elvery (2010) suggest that information on how occupational mixes vary across city size in different industrial sectors may shed light on whether such differences are concentrated in certain sectors of the economy. Thus showing that functional specialization may be different, not only according to city size, but also according to the industrial sector.

According to what was presented so far, the present analysis has three purposes. The first is to identify spatial location patterns of occupations in Brazilian municipalities in 2010. The second is to verify whether there is functional specialization according to the size of Brazilian municipalities. And more, if these patterns of functional specialization differ across industries, justifying both occupational analysis as sectorial.

Initially, the local Moran’s I (LISA) is used to analyze the spatial location patterns of occupations. Subsequently, to test the other two hypotheses, the Locational Quotient (LQ) shall be used.

In order to verify whether there is difference in the occupational structure according to the size of the city, an urban hierarchy-based typology shall be used. This typology, considering the size of population, reflects the fact that economic activities at the top of urban hierarchy differ substantially from those at the bottom of urban hierarchy. Sectoral differences will be obtained by analyzing the industrial sector as a whole and then each of 12 industrial sectors separately.

The analysis carried out herein is relevant due to three reasons. First, the importance of function analysis by city size is directly related to local development, as the occupations (functions) that comprise a city are associated to labor skills and to the capability of companies, and those may be features that generate economic prosperity for the cities (Markusen and Venables, 2013).

Second, the expanded analysis for each industrial sector enables to gather information on the differences between industries, regarding technical and organizational restraints of spatial fragmentation of functions (Bade et. al. 2015). Last of all, the present paper fills a gap in the national literature by providing functional employment mapping, at a disaggregated regional level, using a combined approach of industry and occupation.

The remainder of the paper is organized as follows. The second section details the methodology and the database used in the paper. The third section presents the findings and the fourth section concludes the paper.

4.2 Methodology

4.2.1 Data sources

For this analysis, the database containing 5564 Brazilian municipalities, 12 manufacturing sectors and 22 occupational sub groups (Table 2). We use information deriving from RAIS (Annual Social Information Report), IPEADATA (Institute of Applied Economic Research) and IBGE (Brazilian Institute of Geography and Statistics). All data used are from 2010.

Through data provided by RAIS, it is possible to obtain the variables related to occupational and sectoral employment. The database of IPEADATA and IBGE was used, thus gathering information regarding the total population of each municipality.

Regarding the occupation of individuals, those were classified according to the main Sub-Groups of the Brazilian Classification of Occupations (CBO) 2002. CBO 2002 is composed as follows: ten great groups, 48 main sub-groups, 192 sub-groups, 607 base groups and 2511 occupations, such structure implies a competence level for each group.

Table 2 – Sectoral and occupational information

Manufacturing sub-sectors	IBGE code	Occupational groups: White collars	CBO code	Blue collars	CBO code
Non-metalic mineral production	2	Heads of companies and the organisations	12	Workers from metals and composites transformation	72
Metallurgy industry	3	Executives and managers of service companies	13	Workers from manufacture and installation of electrical and electronics	73
Mechanical industry	4	Managers	14	Assemblers of precision and music instruments	74
Eletrical equipments and communication	5	Researchers and multiscientific professionals	20	Jewellers, glassmakers and ceramic workers	75
Transport materials industry	6	Mathematics, physics and engineering professionals	21	Workers from textile and clothes industry	76
Wood and wood products industry	7	Health, biological and related professionals	22	Workers from wood and wood products industry	77
Paper, publishing and printing	8	Legal sciences professionals	24	Transversal functions orkers	78
				Craft workers	79
Rubber, smoke and leather	9			Workers from continuous processes industry	81
Chemical industry	10			Workers from steel plants and building materials	82
Textile and clothes industry	11			Workers from manufacture of pulp and paper	83
Footwear industry	12			Workers from manufacture of food, beverage and smoke	84
Food and beverage	13			Production, processing and distribution operators	86
				Workers repair and mechanical maintenance services	91
				Maintenance supervisors	95
				Other workers from conservation, maintenance and repair	99

Prepared by the authors.

The occupational sub-groups used in the sample are divided in white-collar and blue-collar occupation (Table 2), such division is in conformity with Duranton and Puga (2005) and Bade et. al. (2015). Both occupation groups, white-collar and blue-collar, correspond to approximately 66% of the total industrial employment. The remaining occupations are basically related to technical level occupations, they were excluded from the sample for not being part of the scope of the work.

4.2.2 Local Moran's I (LISA)

The identification of spatial location patterns of occupations will be done through local Moran's I (LISA). This methodology provides a means to view and to identify different patterns of spatial distribution of occupations between and across sectors.

According to Anselin (1995), the local indicators of spatial association (LISA) are calculated as follows:

$$I_l = \frac{y_j \sum_{j=1}^{n} w_{ij} y_i}{\sum_{i=1}^{n} y_i^2} \qquad (2)$$

where *n* indicates the number of municipalities, w_{ij} are the elements of the spatial weight matrix, y_i and y_j are the values of the used variable (occupational LQ), while *i* and *j* refer to the different municipalities.

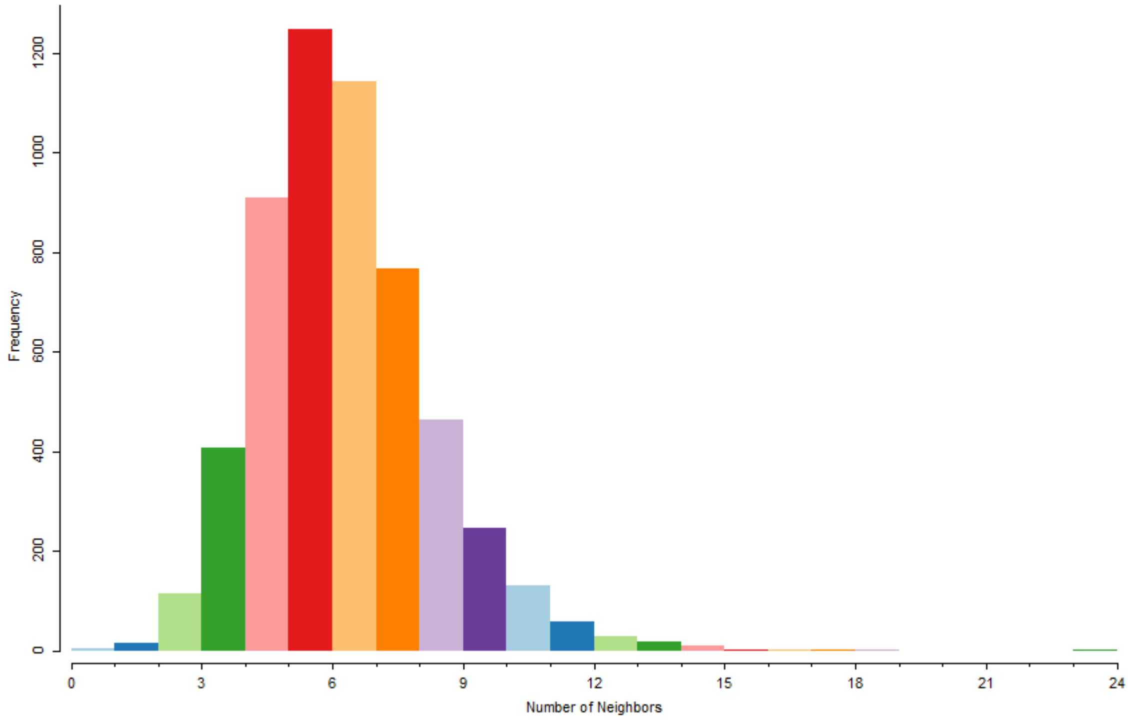
The findings deriving from the application of this indicator show two possible types of clusters or outliers, thus indicating that the regions may present two distinct or similar patterns, according to the variable used.

In order to model spatial interactions between municipalities, it is necessary to specify a structure that defines neighbors, and the tool used to represent this connectivity is the spatial weight matrix.

The matrix choice is according to the structure of the sample. This neighborhood structure, obtained with a first order Queen contiguity matrix, may be viewed through the connectivity histogram (Figure 1). This Figure describes the distribution of locations by number of neighbors.

Figure 1 indicates a very unbalanced connectedness structure of neighbors. A common solution to this problem consists of considering nearest neighbors weight matrices, forcing each unit to have the same number of neighbors (Anselin, 2002; De Dominicis et. al. 2013). In this paper, the spatial weights matrices of the nearest k-neighbors (k=5) shall be used.

Figure 1- Connectivity histogram (Q1)



Prepared by the authors.

4.2.3 Location Quotient (LQ)

In order to check whether there is functional specialization in municipalities in Brazil, and whether such localization pattern changes according to the size of the municipality, the Location Quotient (LQ) was used. The location quotient (LQ) is commonly used to identify territorial specialization because they show the spatial agglomeration regardless of the size of the place, and it has some good characteristics, such as simplicity, transparency and data requirements (Lazzeretti et. al. 2008).

LQ compares the relative specialization of a region in an occupation regarding the national average and is defined as:

$$LQ_{ij} = \frac{e_{ij}/e_j}{E_i/E} \quad (1)$$

where *i* is each group of occupation and *j* stands for each municipality *j* (*j* = 1, . . ., 5564*)*, e_{ij} is the municipality employment at each occupational group, e_j is the total municipality employment, E_i is national employment by occupational group and E is the national employment.

A value above one indicates an employment share in an occupation *i* in a municipality *j* larger than the national average. An LQ below 1 indicates that this share is below the national average.

Calculation of LQ was made at occupational, sectoral and municipal levels. More specifically, the occupational group indexes (white and blue) were calculated within the entire industry and for each municipality. It was also calculated for each occupational group, within each of the 12 industrial sectors and for each municipality.

As an additional control of correction of potential irregularities in the data in small municipalities, a minimum cut-off of 50 employees in the municipality was used. Such procedure is according to international literature (Bertacchini and Borrione, 2013; Henderson and Ono, 2008; Lazzeretti et. al., 2008).

In order to find answers regarding functional specialization according to the size of the municipality, the municipalities were divided in five classes of size according to the population[10] (Table 1). Then the average was calculated for each population group.

Table 1- Municipality size class.

City Size	Municipalities	% municipalities
<5000	1301	23,38%
Between 5000 and 19999	2612	46,94%
Between 20000 and 99999	1368	24,59%
Between 100000 and 500000	245	4,40%
>500000	38	0,68%

Source: IPEADATA and IBGE. Prepared by the author.

4.3 Results

4.3.1 Exploratory data analysis

The database contains 5564 Brazilian municipalities, from this total, approximately 83% of the municipalities have personnel employed in the industrial sector (Table 3). Observing the occupations in the industrial sector, blue-collar occupations are present in 96% of these municipalities, while white-collar occupations

[10] Such division follows the provisions of IBGE. www.ibge.gov.br

appear in approximately 73% of the municipalities with presence of the industrial sector.

Table 3 – Municipality information

	Municipalities with manufacturing employment	%	Municipalities with white collar occupations	%	Municipalities with blue collar occupations	%
All Manufacturing sub-sectors	4642	83,43%	3424	73,76%	4459	96,06%
Non-metalic mineral production	2859	51,38%	1410	49,32%	2581	90,28%
Metallurgy industry	2452	44,07%	1093	44,58%	2352	95,92%
Mechanical industry	1498	26,92%	776	51,80%	1400	93,46%
Eletrical equipments and communication	787	14,14%	416	52,86%	672	85,39%
Transport materials industry	997	17,92%	487	48,85%	913	91,57%
Wood and wood products industry	2852	51,26%	1390	48,74%	2703	94,78%
Paper, publishing and printing	1916	34,44%	881	45,98%	1697	88,57%
Rubber, smoke and leather	1510	27,14%	790	52,32%	1258	83,31%
Chemical industry	1863	33,48%	1195	64,14%	1621	87,01%
Textile and clothes industry	2602	46,76%	1364	52,42%	2442	93,85%
Footwear industry	739	13,28%	329	44,52%	686	92,83%
Food and beverage	3926	70,56%	2474	63,02%	3603	91,77%

Source: RAIS. Prepared by the authors.

Distribution of occupations among municipalities is more distinct when industrial sub-sectors are analyzed (Table 3). The sector that is present in most municipalities is food and beverage, comprising 3926 (70.56%) Brazilian municipalities. The distribution of white and blue collar occupations in the food and beverage sector in these municipalities is similar to what is found for the industrial sector as a whole.

The footwear industry is the one which is located in a lower number of municipalities amongst the thirteen sub-sectors, being located in only 739 (13.28%)

municipalities. This sector also has a major difference regarding distribution of occupations, as blue-collar occupations are present in almost the total of these municipalities (92.83%), while white-collar are in less than half of the locations with footwear industry (44.52%)

The sector with the greatest difference in the distribution of occupations between municipalities is the metallurgy industry. Blue-collar occupations are in 95.92% of the municipalities with the presence of this sector, while white-collar occupations are in only 44.58% of the municipalities.

The findings presented in Table 3 indicate the existence of industrial fragmentation by functions in Brazilian municipalities, as in all of the sectors reviewed there is a difference between the number of municipalities with blue and white collar occupations. It is also noteworthy that there are differences between industrial sectors regarding the presence of industrial employment in municipalities as well as the occupational distribution in the cities, and such facts show the importance of both sectoral and occupational analysis.

Employment distribution is also distinct when industrial sectors and occupations in these sectors are analyzed. Despite the importance of the industrial sector for economic dynamics, employment in this sector represents 17.89% of total formal employment (Table 4). Blue-collar occupation represents approximately 62% of all industrial employment, which is almost two-thirds of the total of industrial employment in Brazil, while white-collar is almost 4%.

However, when the sectors are reviewed separately, the percentage of blue and white collar occupation has greater variation. Again, the footwear industry stands out, due to three reasons. First, for being the sector with the lower contingent of employed personnel amongst all sectors, representing only 0.79% of all industrial employment. Second, for being the sector with the largest percentage of white and blue collar, as almost 90% of sectoral employment is comprised of these occupations. Last of all, the footwear industry has the lowest percentage of white-collar occupation (1.13%) and the highest percentage of blue-collar occupation (88.74%).

The chemical industry, despite being one of those with the highest percentage of industrial employment, is the one with the smallest contingent employed in the occupations reviewed, with 58.8% of the personnel employed in white and blue collar occupations. However, the chemical industry, among all sectors, has the highest percentage of white-collar occupations (6.60%).

It is worth mentioning that the food and beverage sector is the largest industrial sub-sector, in terms of employment, representing almost 4% of industrial employment. It is also the sector with the lowest percentage of blue-collar occupations (48.62%).

Table 4 – Sectoral and occupational employment

	Employment	Share of total employment	Employment at white collar (WC) occupations	Employment at blue collar (BC) occupations	Share of WC over manufacturing	Share of BC over manufacturing
All Manufacturing sub-sectors	7885638	17,89%	314302	4896927	3,99%	62,10%
Non-metalic mineral production	410671	0,93%	12298	233457	2,99%	56,85%
Metallurgy industry	796617	1,81%	29030	543447	3,64%	68,22%
Mechanical industry	566490	1,29%	29684	344993	5,24%	60,90%
Eletrical equipments and communication	281779	0,64%	17627	175156	6,26%	62,16%
Transport materials industry	583777	1,32%	31353	412266	5,37%	70,62%
Wood and wood products industry	468743	1,06%	12929	345535	2,76%	73,72%
Paper, publishing and printing	406074	0,92%	19455	221171	4,79%	54,47%
Rubber, smoke and leather	327271	0,74%	14975	199141	4,58%	60,85%
Chemical industry	902703	2,05%	59570	471238	6,60%	52,20%
Textile and clothes industry	1036949	2,35%	23746	787467	2,29%	75,94%
Footwear industry	348691	0,79%	3956	309425	1,13%	88,74%
Food and beverage	1755873	3,98%	59679	853631	3,40%	48,62%

Source: RAIS. Prepared by the authors.

The data addressed so far indicate that there are differences in the occupational composition in the sectors. However, they do not make it possible to reach conclusions on the location of occupations in Brazil. In this regard, the next section brings information on the pattern of spatial location of the occupations in Brazilian municipalities.

4.3.2 Results from local Moran's I (LISA)

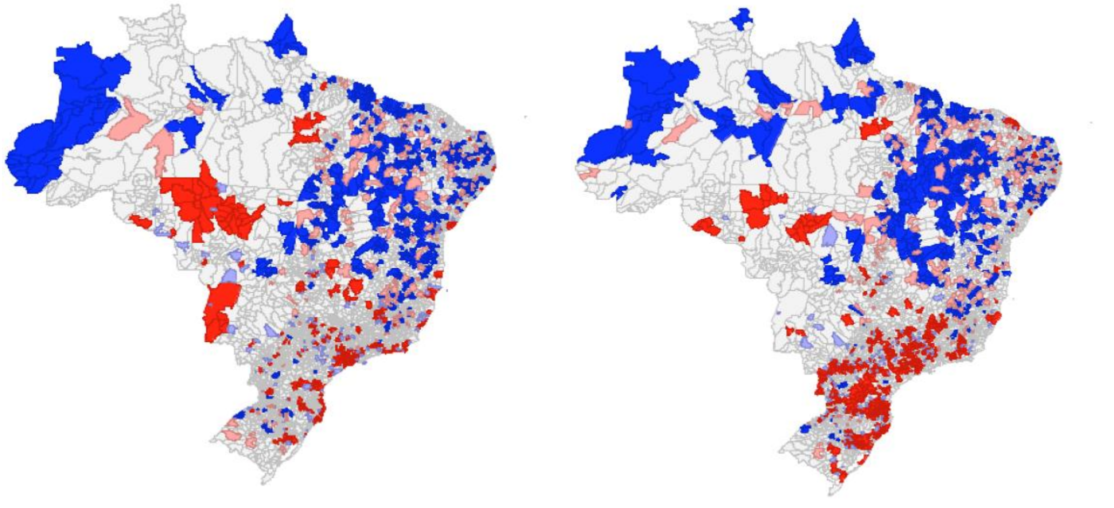
The findings obtained with the application of LISA enable the identification of four patterns of spatial location. More specifically, for this article, significant high-high values mean municipalities with high LQ surrounded by municipalities with high LQ, as low-low mean municipalities with low LQ surrounded by municipalities with low LQ. High-low values indicate municipalities with high values of LQ surrounded by locations with low LQ values, and low-high means that municipalities with low values of LQ surrounded by locations with high LQ values.

Figure 2 presents the results of the LISA applied for both occupational groups (white and blue) in the manufacturing sector. It is clear at first the difference between the Center-South and North-Northeast regions, with significant differences regarding the composition of clusters. Municipalities located in the Center-South regions appear with dominance of high-high cluster for both occupational groups, while municipalities belonging to the North-Northeast regions have a dominance of low-low type clusters.

Such pattern of spatial location of occupations reflects the heterogeneity of the composition of the Brazilian industrial sector. In the North and Northeast, not only the participation in the industrial sector is low, but also the productive base has low spatial integration, while the Center-South, especially the State of São Paulo, hold great part of the industrial sector in Brazil, and the industrial productive base presents strong chaining (Arruda & Ferreira, 2014; Arruda et. al. 2016; Perobelli et. al 2010).

Figure 2 allows to see that there are differences between the location of both occupational groups. Blue-collar occupations appear with more high-high type clusters than white-collar occupations. Based on such configuration, it is possible to infer that there is a production fragmentation in Brazilian municipalities, as the occupational group related to production activities is more distributed in municipalities in Brazil than the occupational group related to management and research and development activities.

Figure 2 – LISA map for white and blue collar occupations.



White-collar occupations *Blue-collar occupations*

Subtitle:		Not significant High-High Low-Low Low-High High-Low

Prepared by the authors.

When the sub-sectors are analyzed separately, the regional inequalities in occupational distribution are even more remarkable (Figures A.1 and A.2). The predominant location tendency in the Center-South is visible for both occupational groups in virtually all sectors. Exception for wood and wood products industry, which high-high clusters are more strongly located in municipalities of the South and North regions.

The sectors with greater occupational distribution among Brazilian municipalities are non-metalic mineral production and food and beverage sectors. Although these sectors are more distributed, the location pattern differs between regions, with high-high clusters located predominantly in municipalities of the Center-South region, while the high-low pattern is in the North-Northeast regions.

What may be perceived by comparing the differences between white-collar and blue-collar occupations among sectors is that the latter occupational group has a larger number of significant values for the four location patterns than the first group. This result indicates a fragmentation of industrial activity in Brazil, since the activities related to management and research and development are located in less municipalities than the activities related to production.

However, it is worth mentioning that in this pattern, production activities seem to be located in municipalities near to white-collar occupations. It is possible to conclude, then, that despite the existence of productive fragmentation, it does not reduce regional inequalities of occupational distribution.

The analysis of occupational location pattern focuses on the different occupational compositions in the sectors. It indicates, initially, that stimulus policies and attraction of certain sectors should be prepared taking into consideration the occupational composition of sectors. In this regard, the next section brings findings that help deepening the understanding about sectoral and occupational dynamics of Brazilian municipalities according to population size.

4.3.2 Results from locational quotient (LQ)

Before presenting and discussing the findings with the application of the locational quotient (LQ), it is worth showing the initial findings on the distribution of industrial employment and occupational distribution by municipality size (Table 5). The data obtained indicate that over half of the industrial employment and half of the population of Brazil is concentrated in cities with more than one hundred thousand inhabitants. While cities with less than 20 thousand inhabitants, notwithstanding being 70% of the total, have little more than 10% of industrial employment and approximately 17% of the population.

Table 5 – Industrial and occupational employment by city size

City Size	Municipalities	% municipalities	% population	% manufacturing	% white collar	% blue collar
<5000	1301	23,38%	2,29%	1,29%	0,68%	1,49%
Between 5000 and 19999	2612	46,94%	14,82%	9,78%	5,50%	10,71%
Between 20000 and 99999	1368	24,59%	28,13%	26,77%	18,37%	28,02%
Between 100000 and 500000	245	4,40%	25,46%	33,21%	31,91%	34,59%
>500000	38	0,68%	29,29%	28,96%	43,53%	25,19%

Source: RAIS. Prepared by the authors.

Distribution of occupational employment by city size shows a higher concentration of white-collar occupations in large cities, with little more than 43% of these occupational group located in cities with more than 500 thousand inhabitants.

Blue-collar occupations are more present in smaller cities, compared to white-collar, with approximately 40% of the blue-collar located in cities with no more than one hundred thousand inhabitants.

The data presented in Table 5 help introducing the issue of occupational dynamics in Brazilian municipalities, indicating, at first, an occupational concentration in favor of large cities. Secondly, it shows the existence of fragmentation of industrial activities and a possible functional specialization in Brazilian municipalities.

Table 6 shows findings of locational quotient (LQ) for white and blue collar occupations in the industry as a whole, separating the cities by groups of population size. With these data, the issue of functional specialization according to city size may be more deeply addressed and analyzed.

Table 6 – Locational Quotient (LQ) by city size

Sectors	City Size	White collar LQ	Blue collar LQ
All manufacturing	<5000	0.65	1.24
	Between 5000 and 19999	0.69	1.12
	Between 20000 and 99999	0.73	1.01
	Between 100000 and 500000	0.92	0.98
sectors	>500000	1.22	0.89

Source: RAIS and IBGE. Prepared by the authors.

The findings show that there is functional specialization in Brazilian cities, but it differs according to city size. It happens because there is functional specialization of small cities in blue-collar occupations, given that in groups of municipalities with no more than 20 thousand inhabitants, the LQ found was higher than 1. Large cities, in turn, seem to be specialized in white-collar occupations, as they bear LQ higher than 1 only in this occupational group.

These results are consistent with the literature on economic specialization of cities (Bade et. al. 2004; Brunelle, 2013; Duranton and Puga, 2005). Indicating that there is a pattern where large cities concentrate functions of management, research and development of companies, while small cities concentrate the production functions of companies.

This functional specialization pattern can be explained by the wage premium literature that shows that the relative wages of workers assigned to functions with higher levels of skill are, in the average, higher in larger cities (Elvery et. al. 2010). Then, knowledge-intensive functions like management and research and development (R&D) tend to be located preferably in large cities.

Now, the question of whether differences of functional specialization among city sizes also vary between manufacturing sectors. Table 7 shows the results from Locational Quotient (LQ) for white and blue collar occupations inside each industrial sector and city size group.

The LQ findings for blue-collar occupations remain indicating a functional specialization pattern for small cities in the majority of the sectors reviewed. Except for the materials transportation industry, where the LQ value is higher than 1 in small and medium cities.

White-collar occupations, on the other hand, do not follow the functional specialization pattern in 4 of the 12 sectors. In the materials transportation industry and the mechanical industry this occupational group did not present LQ higher than 1 in none of the groups of cities. In the non-metallic mineral production sector and wood and wood products industry, although the highest LQ is in large cities, small cities also have value higher than one.

The findings for the footwear industry are worth mentioning for two reasons. First, in this sector the LQ was higher than one for all groups of city size. And, second, it was the sector with the highest value of locational quotient in large cities, with value higher than 3 in cities with more than 500 thousand inhabitants.

In the remaining sectors, the pattern found was the same of the industry as a whole, with specialization of white-collar occupations only in large cities.

The analysis of each sector separately confirms one of the initial hypothesis, that the functional specialization pattern according to city size differs between the sectors, therefore justifying the application of such analysis. It shall be added that analysis addressing the occupational mix within the specific manufacturing industries enable a better understanding of the economic composition of a region (Currid and Stolarick, 2010).

Table 7 – Locational Quotient (LQ) by sector and city size

Sectors	City Size	White collar LQ	Blue collar LQ
Non-metalic mineral production	<5000	0.69	1.34
	Between 5000 and 19999	1.11	1.14
	Between 20000 and 99999	0.92	1.00
	Between 100000 and 500000	1.07	0.84
	>500000	1.11	0.73
Metallurgy industry	<5000	0.80	1.02
	Between 5000 and 19999	0.86	1.08
	Between 20000 and 99999	0.83	1.02
	Between 100000 and 500000	0.94	0.97
	>500000	1.00	0.96
Mechanical industry	<5000	0.67	1.22
	Between 5000 and 19999	0.74	1.12
	Between 20000 and 99999	0.69	1.05
	Between 100000 and 500000	0.84	1.00
	>500000	0.96	0.95
Eletrical equipments and communication	<5000	0.38	1.37
	Between 5000 and 19999	0.52	1.14
	Between 20000 and 99999	0.79	1.05
	Between 100000 and 500000	0.78	0.99
	>500000	1.25	0.82
Transport materials industry	<5000	0.93	0.95
	Between 5000 and 19999	0.50	1.09
	Between 20000 and 99999	0.57	1.04
	Between 100000 and 500000	0.70	0.97
	>500000	0.86	0.90
Wood and wood products industry	<5000	1.09	1.09
	Between 5000 and 19999	0.96	1.05
	Between 20000 and 99999	1.02	0.98
	Between 100000 and 500000	1.11	0.92
	>500000	1.14	0.90
Paper, publishing and printing	<5000	0.43	1.38
	Between 5000 and 19999	0.62	1.30
	Between 20000 and 99999	0.90	1.10
	Between 100000 and 500000	0.91	1.00
	>500000	1.00	0.92
Rubber, smoke and leather	<5000	0.50	1.38
	Between 5000 and 19999	0.47	1.22
	Between 20000 and 99999	0.72	1.05
	Between 100000 and 500000	0.98	0.94
	>500000	1.11	0.82
Chemical industry	<5000	0.59	1.18
	Between 5000 and 19999	0.55	1.11
	Between 20000 and 99999	0.67	1.13
	Between 100000 and 500000	0.80	1.08
	>500000	1.18	0.95
Textile and clothes industry	<5000	0.71	1.20
	Between 5000 and 19999	0.84	1.15
	Between 20000 and 99999	0.98	1.04
	Between 100000 and 500000	1.20	0.97
	>500000	1.25	0.94
Footwear industry	<5000	1.07	1.05
	Between 5000 and 19999	1.01	1.06
	Between 20000 and 99999	1.39	1.00
	Between 100000 and 500000	1.72	0.94
	>500000	3.10	0.81
Food and beverage	<5000	1.08	1.34
	Between 5000 and 19999	0.96	1.25
	Between 20000 and 99999	1.03	1.09
	Between 100000 and 500000	1.14	0.99
	>500000	1.34	0.83

Source: RAIS and IBGE. Prepared by the authors.

4.4 Final comments

The present study was aimed at analyzing the location pattern of occupational employment in Brazilian municipalities in the year of 2010. Verifying whether there is functional specialization according to city size, and also whether this specialization remains when the industrial sectors are analyzed separately.

In order to reach such objectives, at first the occupations were separated in two groups, white-collar occupations and blue-collar occupations, according to Duranton and Puga (2005) and Bade et. al. (2004, 2015). Later, the locational quotient (LQ) was calculated for each occupational group in the industrial sector as a whole and each city size group. An exercise similar to the previous one was carried out, however, the analysis was made for each industrial sub-sector. The results arising from the LQ enabled the application of local Moran's I for the analysis of the spatial location pattern of the occupations.

The findings show that there is significant spatial heterogeneity in the distribution of occupations inside the industrial sector in Brazilian municipalities. The greatest occupational concentrations are located in the Center-South of Brazil, a fact that was verified both for white-collar and blue-collar occupations. The analysis of each sector separately also indicates an even larger difference.

The application of LQ by groups of city size indicates a functional specialization of large cities in white-collar occupations. It indicates that in these cities there is greater presence of knowledge-intensive functions, such as those related to management and research and development, than the average of Brazilian cities.

In small cities, on the other hand, the findings indicate that there greater presence of employment related to production functions. It is possible, then, to state that these cities are specialized in blue-collar occupations. This functional specialization pattern, where large cities have higher proportion of white-collar occupations and small cities have higher proportion of blue-collar occupations, is according to international literature (Bade et. al. 2004; Brunelle, 2013; Duranton and Puga, 2005).

The exercise done for the occupational composition of each industrial sub-sector confirmed the importance of analyzing each sector separately. This is because not all sectors have the same functional specialization pattern, especially for white-collar occupations.

In general, the contribution of the analysis presented herein is towards providing information that may help to understand the structure of regional economies and its consequential development. As the occupational analysis refers to endogenous factors of the region, such as local human resources, education and skills. These factors directly influence regional growth and development.

5. Conclusions

The purpose of the dissertation is bringing up the debate on topics not widely approached in Brazilian economic literature, but which are dealt with in international literature as key factors for local and national development. Therefore, providing relevant information for public policy makers and for future academic studies of the issues addressed herein.

On one hand, the matter of attraction and location of firms by size is object of study and debate, both in academic and governmental environments. A question is whether it is better to stimulate local small firms, creating employment and income, or to attract a large firm aiming at boosting the local economy. However, the answer requires more empirical analysis that provide robust findings and expand the debate.

On the other hand, the issue of firms as drivers of growth and development may be expanded by also reviewing the occupational structure of the region. As beyond the firm’s issue, it is important to understand the constitution of the local workforce, so that the qualification of workers tend to be related to productivity gains and competitiveness.

In this regard, the thesis is comprised of three independent essays aiming at answering the questions addressed above. In the first article, there was an effort to determine the impact of large and small firms on the economic growth of Brazilian micro-regions during the period from 1999 to 2009. The empirical strategy used consisted in analyzing the issue through data panels with fixed and spatial effects and in a way to controlling the effects of spatial dependence and spatial heterogeneity.

The main findings of the first article were (1) that the presence of large firms in the industrial sector is positively related to the economic growth of micro-regions, whereas small businesses presented a negative relation to economic growth. (2) The presence of spatial heterogeneity in the sample suggests that the relation between firm size and economic growth varies according to the level of development of the region, as in wealthier regions the relation remains the same of Brazil as a whole, whereas in regions with lower GDP per capita the size of firms has no influence on the economic growth.

The issue of firm size is expanded in the second paper. Spatial econometrics cross-section estimates were used to review the relation between the different sizes of firms and municipal regional development indicators in the year of 2010. Therefore, the second paper expanded the debate, as it had used all sizes of firms, different sectors and three regional development indicators (income, employment and poverty).

The findings of the second article indicate that firm size is an important factor in regional development, although they require special attention from public policy makers in the preparation of local development strategies, as the estimated models show that the findings differ between sectors and development indicators.

Regarding the third essay, the topic is more significantly different from the other two, as the analysis is focused on the supply (input) of industrial production, more specifically in the structure of occupational employment in Brazil. Thus, the article has three purposes: (1) analyzing the occupational employment location pattern in Brazil in 2010, (2) testing the hypothesis of functional expertise due to the size of the cities and (3) whether this expertise varies according to the industrial sector reviewed.

The findings indicate that occupations have specific location patterns and they vary according to the sector and the region reviewed. Therefore, a better understanding of the topic aids in the preparation of policies aiming at increasing the efficiency and productivity of regions, as the occupational constitution of a city is directly related to local human resources, skills, education.

Bibliography

ACS, Z.; DESAI, S.; HESSELS, J. Entrepreneurship, economic development and institutions. **Small Business Economics**, 2008. n. 31, p. 219–234.

ANSELIN, L. **Spatial econometrics: Methods and models**. Kluwer, Dordrecht, 1988.

ANSELIN, L. Local indicators of spatial association - LISA. **Geographical Analysis**, 1995. v. 27, n. 2, p. 93-115.

ANSELIN, L. The moran scatterplot as an ESDA tool to assess local instability in spatial association. In: FISCHER, M.; SCHOLTEN, H.; UNWIN, D. (orgs) **Spatial Analytical Perspectives on GIS**. London: Taylor and Francis, 1996, p. 111-125.

ANSELIN, L. (2002), Under the hood: Issues in the specification and interpretation of spatial regression models. **Agricultural Economics**, v. 27, p. 247-267.

ARAÚJO, G, D.; HIRATUKA, C. Exportações das firmas domésticas e influências das firmas transnacionais. In: DE NEGRI, J, A.; ARAÚJO, B, C. (orgs) **As empresas brasileiras e o comércio internacional**. Brasília: IPEA, 2006, p. 317-339.

ARBIA, G.; LE GALLO, J.; PIRAS, G. Does evidence on regional convergence depend on the estimation strategy?, Outcomes from analysis of a set of NUTS2 EU regions. **Spatial Economic Analysis**, 2008. n. 3, p. 209-224.

ARELLANO, M.; BOVER, O. Another look at the instrumental-variable estimation of error-component models. **Journal of Econometrics**, 1991. n. 68, p. 29-51.

ARRUDA, E. F.; FERREIRA, R. T. Dinâmica intraregional do brasil: quem dirige o crescimento industrial das regiões brasileiras? **Economia aplicada**, 2014. v. 18, n. 2, p. 243–270.

ARRUDA, E. F.; FERREIRA, R. T; CASTELAR, P. U. De C. Um modelo dinâmico para a atividade industrial e suas repercussões inter/intraregionais e internacionais. **Revista brasileira de estudos regionais e urbanos (RBERU)**, 2016. v. 10, n. 1, p. 99–126.

BADE, F.-J.; BODE, E.; CUTRINI, E. Spatial fragmentation of industries by functions. **Annals of regional science**, 2015. v. 54, p. 215–250.

BADE, F.-J.; LAASER, C.-F.; SOLTWEDEL, R. Urban specialization in the internet age – empirical findings for Germany. **Kiel working paper**, ago. 2004. n. 1215.

BADINGER, H.; MÜLLER, W.; TONDL, G. Regional convergence in the European Union 1985-1999: A spatial dynamic panel analysis, **Regional Studies**, 2004. v. 38, n. 3, p. 241-253.

BARBOU, E.; MARKUSEN, A. Regional occupational and industrial structure: Does one imply the other? **International Regional Science Review**, 2007. v. 30, n. 1, p. 72-90.

BARRO, J, B. Economic growth in a cross section of countries, **The Quarterly Journal of Economics**, 1991. v.106, n. 2, p. 407-443.

BARROS, G., NAKABASHI L.; SAMPAIO A. Determinantes do capital físico: o papel do capital humano e da qualidade institucional. Paper presented at the 41st Encontro Nacional de Economia (ANPEC), 2013, Foz do Iguaçu, Paraná.

BECK, T.; DEMIRGUC-KUNT, A.; LEVINE, R. SMEs, growth, and poverty: Cross-country evidence. **Journal of Economic Growth**, 2005. n. 10, p. 199–229.

BERTACCHINI, E. E.; BORRIONE, P. The geography of the Italian creative economy: the special role of the design and craft-based industries. **Regional studies**, 2013. v. 47, n. 2, p. 135–147.

BIESEBROECK, J, V. Firm size matters: growth and productivity growth in African manufacturing. **Economic Development and Cultural Change**, 2005. v. 53, n. 3, p. 545-583.

BIRCH, D, L. The Job Generation Process: Final Report to Economic Development Administration. MIT Program on Neighborhood and Regional Change: Cambridge, MA, 1979.

BLUNDELL, R; BOND, S. Initial conditions and moment restrictions in dynamic panel data models. **Journal of Econometrics**, 1998. n. 87, p. 115-143.

BOND, S.; HOEFFLER, A.; TEMPLE, J. GMM estimation of empirical growth models, Centre for Economic Policy Research, **Discussion Paper**, 2001. n. 3048, p. 1-33.

BRUCE, D.; DESKINS, J. A.; HILL, B. C.; RORK, J. C. (Small) business activity and state economic growth: does size matter? **Regional Studies**, 2009. v. 43, n. 2, p. 229-245.

BRUNELLE, C. The growing economic specialization of cities: disentangling industrial and functional dimensions in the Canadian urban system, 1971–2006. **Growth and change**, 2013. v. 44, n. 3, p. 443–473.

CHEN J.; GUO F.; ZHU A. The housing-led growth hypothesis revisited: evidence from Chinese provincial panel data, **Urban Studies**, 2011. v. 48, p. 2049–2067.

CRAVO, T, A.; BECKER, B.; GOURLAY, A. Regional growth and SMEs in Brazil: A spatial panel approach, **Regional Studies**, 2014. V. 49, n. 12, p. 1-22.

CRAVO, T, A.; GOURLAY, A.; BECKER, B. SMEs and regional economic growth in Brazil. **Small Business Economics**, 2012. n. 14, p. 1–14.

CRAVO, T, A. SMEs and economic growth in the Brazilian micro-regions. **Papers in Regional Science**, 2010. v. 89, n. 4, p. 711-735.

CURRID, E.; STOLARICK, K. The occupation–industry mismatch: new trajectories for regional cluster analysis and economic development. **Urban studies**, Fev. 2010. v. 2, n. 47, p. 337–362.

DALL'ERBA, S.; LE GALLO, J. Regional convergence and the impact of European structural funds over 1985-1999: A spatial econometric analysis. **Papers in Regional Science**, 2008. v. 87, n. 219-245.

DE DOMINICIS, L; ARBIA, G; De GROOT, H, L, F. Concentration of manufacturing and service sector in Italy: accounting for spatial dependence and firm size distribution. **Regional Studies**, 2013. v. 47, n.3, p. 405-418.

DELLER, S. C. Spatial variations in the role of microenterprises in economic growth. **The Review of Regional Studies**, 2010. v. 40, n.1, p. 71-97.

DELLER, S. C.; McCONNON Jr, J. C. Microenterprises and Economic Growth: A Panel Study of the US States 1977 to 1997, **Applied Economic Letters**, 2009. v. 16, p. 1307–1312.

DE NEGRI, J.A. Rendimentos Crescentes de Escala e o Desempenho Exportador das Firmas no Brasil. In: DE NEGRI, J. A.; ARAÚJO, B. C. O. (org). **As Empresas brasileiras e o comércio internacional**. Brasília: IPEA, 2006, p.189-214.

DIAS, J.; MCDERMOTT, J. Institutions, education, and development: The role of entrepreneurs**. Journal of Development Economics**, 2006. n. 80, p. 299–328.

DURLAUF, S, N.; JOHNSON, P, A.; TEMPLE, J, R, W. Growth Econometrics. In: AGHION, P.; DURLAUF, S. (Eds). **Handbook of Economic Growth**, Elsevier, 2005, p. 555-677.

DURANTON, G.; PUGA, D. From sectoral to functional urban specialization. **Journal of urban economics**, 2005. p. 343–370.

ELHORST, J, P. Spatial panel data models. In: FISCHER, M.; GETIS, A. (Eds). **Handbook of Applied Spatial Analysis**, Springer, 2010, p. 377-407.

ELVERY, J. A. City size and skill intensity. **Regional science and urban economics**, 2010. v. 40, p. 367–379.

ERTUR, C.; KOCH, W. Growth, technological interdependence and spatial externalities: Theory and evidence. **Journal of Applied Econometrics**, 2007. v. 22, p. 1033-1062.

ERTUR, C.; LE GALLO, J.; BAUMONT, C. The European regional convergence process, 1980-1995: Do spatial regimes and spatial dependence matters?. **International Regional Science Review**, 2006. v. 29, n.1, p. 3-34.

ESTEVE-PEREZ, S. *et. al*. A survival analysis of manufacturing firms in export markets. In: ARAUZO-CAROD, J. M.; MANJON-ANTOLIN, M. C. **Entrepreneurship, Industrial Location, and Economic Growth**. Edward Elgar Publishing Limited, 2007.

FOCHEZATTO, A. Estrutura setorial e distribuição de ocupações nas regiões brasileiras, 2006-2011. **Eure**, 2016. v. 42, n. 126, p. 237–262.

FUJITA, M.; THISSE, J. Industrial agglomeration under Marshallian externalities. In Economics of agglomeration: **Cities, industrial location, and regional growth**. Cambridge: Cambridge University Press, 2002.

GEBREMARIAM, G.; GEBREMEDHIM, T.; JACKSON, R. (2004), The role of small business in economic growth and poverty alleviation in West Virginia: an empirical analysis. Selected paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Denver, Colorado, August 1-4, 2004.

GOMES, V.; ELLERY Jr., R. Perfil das exportações, produtividade e tamanho das firmas no Brasil. **Revista Brasileira de Economia**, 2007. v. 61, n.1, p. 33-48.

GREENSTONE, M.; HORNBECK, R.; MORETTI, E. Identifying Agglomeration Spillovers: Evidence from Winners and Losers of Large Plant Openings. **Journal of Political Economy**, 2010. v. 118, p. 536-598.

HENDERSON, J. V.; ONO, Y. Where do manufacturing firms locate their headquarters? **Journal of Urban Economics**, 2008. v. 63, p. 431–450.

IDSON, T, L.; OI, W, Y. Workers are more productive in large firms, **The American Economic Review**, 1999. v. 89, n. 2, p. 104-108.

KOMAREK, M, T,; LOVERIDGE, S. Firm sizes and economic development: estimating long-term effects on U.S. county growth, 1990–2000. **Journal of Regional Science**, 2015. v. 55, n. 2, p.1-18.

KOO, J. How to analyze the regional economy with occupation data. **Economic development quarterly**, Nov. 2005. v. 19, n. 4, p. 356–372.

KRUGMAN, P. Increasing returns and economic geography. **Journal of Political Economy**, 1991. v. 99, n. 3, p. 483–499.

LAFOURCADE, M.; MION, G. Concentration, agglomeration and the size of plants. **Regional Science and Urban Economics**, 2007. v. 37, p. 46–68.

LAURINI, M.; ANDRADE, E.; VALLS, P. Income convergence clubs for Brazilian municipalities: a non-parametric analysis, **Applied Economics**, 2005. v. 37, p. 2099-2118.

LAZZARETTI, L.; BOIX, R.; CAPONE, F. Do creative industries cluster? mapping creative local production systems in Italy and Spain. **Industry and innovation**, out. 2008. v. 15, n. 5, p. 549–567.

LEE, K.; KIM, B.Y.; PARK, Y.Y.; SANIDAS, E. Big businesses and economic growth: Identifying a binding constraint for growth with country panel analysis, **Journal of Comparative Economics**, 2012. v. 41, p. 561-582.

LeSAGE, J, P.; PACE, R, K. Introduction to spatial econometrics. London: CRC Press/ Taylor & Francis, 2009.

LIMA, R, C, A.; SILVEIRA NETO, R, M. Physical and human capital and Brazilian regional growth: Spatial econometric approach for the period 1970–2010. **Regional Studies**, 2015. v. 50, n. 10.

LIU X.; SHU C. Determinants of exports performance: evidence from Chinese industries, **Economics of Planning**, 2003. v. 36, n. 1, p. 45-67.

LING-YEE, L; OGUNMOKUM, O. The influence of interfirm relational capabilities on export advantage and performance: an empirical analysis. **International Business Review**, 2001. v. 10, p. 399-420.

LOVERIDGE, S.; NIZALOV, D. Operationalizing the entrepreneurial pipeline theory: an empirical assessment of the optimal size distribution of local firms. **Economic Development Quarterly**, 2007. v. 21, n. 3, p. 244-262.

MARSHALL, A. Principles of economics. London: MacMillan, 1920.

McDONALD, S.; ROBERTS, J. Growth and multiple forms of human capital in an augmented Solow model: A panel data investigation. **Economics Letters**, 2002. v. 74, p. 271–276.

MANKIW, N, G.; ROMER, D.; WEIL, D, N. A contribution to the empirics of economic growth. **Quarterly Journal of Economics**, 1992. v. 107, p. 407–437.

MARKUSEN, J. R.; VENABLES, A. Functional specialization, sectoral specialization, and inter-city trade. **Working paper**, 2013.

MOHL, P.; HAGEN, T. Do structural funds promote regional growth? New evidence from various panel data approaches. **Regional Science and Urban Economics**, 2010. n. 40, p. 353-365.

MUELLER, P. Exploiting entrepreneurial opportunities: The impact of entrepreneurship on growth. **Small Business Economics**, 2007. n. 28, p. 355-362.

NAKABASHI L.; PEREIRA A.; SACHSIDA A. Institutions and growth: a developing country case study. **Journal of Economic Studies**, 2013. n. 40, p. 614–634.

PAGANO, P.; SCHIVARDI, F. Firm size distribution and growth. **The Scandinavian Journal of Economics**, 2003. v. 105, n. 2, p. 255-274.

PEROBELLI, F. S. *et al.* Estrutura de interdependência inter-regional no brasil: uma análise espacial de insumo-produto para os anos de 1996-2002. **Pesquisa e Planejamento Econômico - PPE**, 2010. v. 40, n. 2.

RAMAJO, J.; MÁRQUEZ, M, A.; HEWINGS, G, J, D.; SALINAS, M, M. Spatial heterogeneity and interregional spillovers in the European Union: Do cohesion policies encourage convergence across regions? **European Economic Review**, 2008. n. 52, p. 551-567.

REY, S, J.; MONTOURI, B, D. US regional income convergence: A spatial econometric perspective, **Regional Studies**, 1999. v. 32, n.2, p. 143-156.

RESENDE, G. Multiple dimensions of regional economic growth: The Brazilian case, 1991-2000, **Papers in Regional Science**, 2011. v. 90, p. 629-662.

SCOTT, A. J. Human capital resources and requirements across the metropolitan hierarchy of the USA. **Journal of economic geography**, 2008. v. 9, p. 207–226.

SHAFFER, S. Firm size and economic growth. **Economic Letters**, 2002. v. 76, p. 195-203.

SHAFFER, S. Establishment size and local employment growth. **Small Business Economics,** 2006a. n. 29, p. 439-454.

SHAFFER, S. Establishment Size by Sector and County-Level Economic Growth. **Small Business Economics**, 2006b. v. 26, n.2, p. 145-154.

SILVA, C. E. L. O impacto do bndesexim no tempo de permanência das firmas brasileiras no mercado internacional: uma análise a partir dos microdados, **Planejamento e Políticas Públicas**, 2012. n. 38, p. 9-36.

SILVA, C. E. L.; HEWINGS, G. J. D. The locational implications of management and production fragmentation. **Estudos Econômicos, São Paulo**, Jul. 2010. v. 40, n. 3, p. 515–533.

SILVEIRA-NETO, R.; AZZONI, C, R. Location and regional income disparity dynamics: The Brazilian case, **Papers in Regional Science**, 2006. v. 85, p. 599-613.

VAN STEL, A.; CARREE, M.; THURIK, R. The effect of entrepreneurial activity on national economic growth. **Small Business Economics, 2005.** n. 24, p. 311–321.

VENABLES, A. Equilibrium locations of vertically linked industries. **International economic review**, May 1996. v. 37, n. 2, p. 341–359.

WAN, J.; KIM, J. H.; HEWINGS, G. J. D. Inspecting regional economic structural changes through linking occupations and industries. **Environment and Planning A**, 2013. v. 45, p. 1–20.

ZWEIFEL, Peter. Services in Switzerland: Structure, performance, and implications of European economic integration, 1993. Available at http://www.getcited.org/pub/103104187 .Access on 05/01/2014.

Appendix A

Equation 1 was estimated via GMM system (Blundell and Bond, 1998 and Arellano and Bover, 1995) with the purpose of minimizing the endogeneity issue. These methods use instrumental variables to correct this problem, obtaining exogenous components through the independent variables.

According to Bond *et al* (2001), in the GMM system an equation system is estimated in first difference and in level, in which the instruments used in level equations are the lagged variables in first difference of the series. Therefore, the estimation through a two equation system causes the estimator to reduce bias and the GMM difference estimator to be efficient.

Table A.1 – GMM system estimations

Micro-regions	System GMM					
Estimation	one-step	two-step	one-step	two-step	one-step	two-step
Lag LN GDP per *capita*	-0.111	-0.087	-0.103	-0.082	-0.096	-0.097
	(-3.78)***	(-2.90)***	(-3.64)***	(-2.97)***	(-3.47)***	(-3.27)***
Education level	0.016	0.014	0.014	0.011	0.041	0.043
	(3.31)***	(2.78)***	(2.82)***	(2.28)**	(4.09)***	(4.13)***
Population growth rate	0.053	(0.170)	-0.045	0.110	-0.446	-0.605
	(0.12)	0.45	(-0.10)	(0.26)	(-0.95)	(-1.45)
Large firm (500)	0.256	(0.168)				
	(3.86)***	(2.41)**				
Large firm (250)			0.220	0.171		
			(3.14)***	(2.43)**		
Small firm					-0.259	-0.261
					(-3.39)***	(-3.52)***
Observations	2784	2784	2784	2784	2784	2784
Number of microrregiões	558	558	558	558	558	558
Test AR(2)	0.16	0.140	0.121	0.124	0.106	0.104
Hansen test	0.000	0.000	0.000	0.000	0.000	0.000

Note: Numbers between brackets are t statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels. In all estimations the explanatory variables were treated as potentially endogenous. Year dummies were included as control.
Source: IBGE, IPEADATA and RAIS. Prepared by the author.

The *p*-value of the AR test (2) for all estimations indicates that there is no endogeneity deriving from serial autocorrelation. On the other hand, the *p*-value of the Hansen test points to the presence of endogeneity, thus indicating that through the

GMM system estimations it was not possible to find exogenous variables capable of mitigating this problem.

Appendix B

Table B.1 - Spatial panel estimations with k-neighbor matrix (k=5)

Micro-regions Estimation	SEM			SAR			SDM		
Lag LN GDP per *capita*	-0.67 (-38.17)	-0.67 (-38.24)***	-0.67 (-38.29)***	-0.61 (-36.2)***	-0.61 (-36.29)***	-0.61 (-36.37)***	-0.6627 (-37.18)***	-0.66 (-37.26)***	-0.67 (-37.32)***
Education level	-0.01 (-2.18)**	-0.01 (-2.15)**	-0.01 (-2.3)**	-0.01 (-1.32)	-0.01 (-1.33)	-0.01 (-1.5)	-0.01 (-2.39)**	-0.01 (-2.37)**	-0.01 (-2.54)**
Population growth rate	-0.41 (-8.71)***	-0.41 (-8.75)***	-0.41 (-8.76)***	-0.39 (-8.47)***	-0.39 (-8.52)***	-0.39 (-8.58)***	-0.40 (-8.56)***	-0.41 (-8.6)***	-0.41 (-8.64)***
Large firm (500)	0.02 (-1.02)			0.03 (-1.52)			0.02 -1.15		
Large firm (250)		0.03 (2.2)**			0.04 (2.59)**			0.04 (2.22)**	
Small firm			-0.04 (-2.71)***			-0.05 (-3.29)***			-0.04 (-2.94)***
W*Lag LN GDP per capita							0.27 (8.03)***	0.27 (7.95)***	0.26 (7.77)***
W*Education level							0.03 (3.34)***	0.03 (3.29)***	0.03 (3.4)***
W*Population growth rate							0.16 (1.78)*	0.16 (1.81)*	0.15 (1.66)*
W*Large firm (500)							0.01 (-0.17)		
W*Large firm (250)								0.00 -0.11	
W*Small firm									-0.02 (-0.59)
λ	0.45002 (20.04)***	0.44991 (20.02)***	0.44992 (20.01)***						
ρ				0.34294 (17.01)***	0.34262 (17.01)***	0.34335 (17.06)***	0.44206 (19.53)***	0.44166 (19.48)***	0.44047 (19.4)***
Observations	2790	2790	2790	2790	2790	2790	2790	2790	2790.00
Log-likelihood (LIK)	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221	12. 8221

Note: Numbers between brackets are t statistics. ***, **, * indicate that estimated parameters are significantly different from zero at 1, 5 and 10% levels. In all estimations the explanatory variables were treated as potentially endogenous. Year dummies were included as control.
Source: IBGE, IPEADATA and RAIS. Prepared by the author.

Appendix C

Figure C.1 - Moran Scatterplot of the natural logarithm of GDP per capita in the starting year with k-neighbor matrix (k=5)

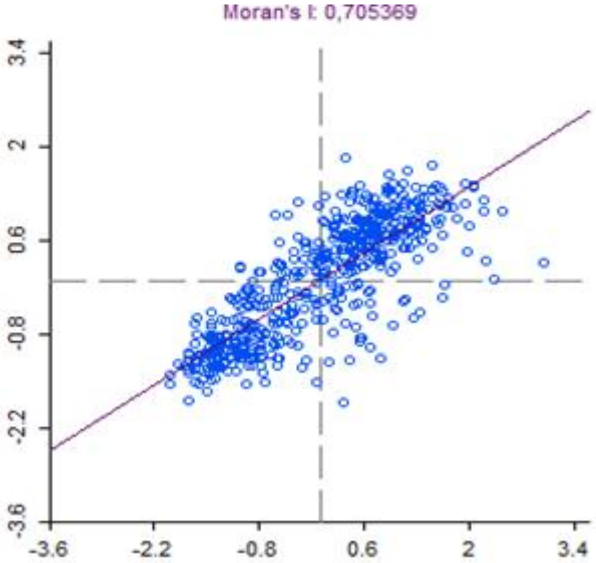
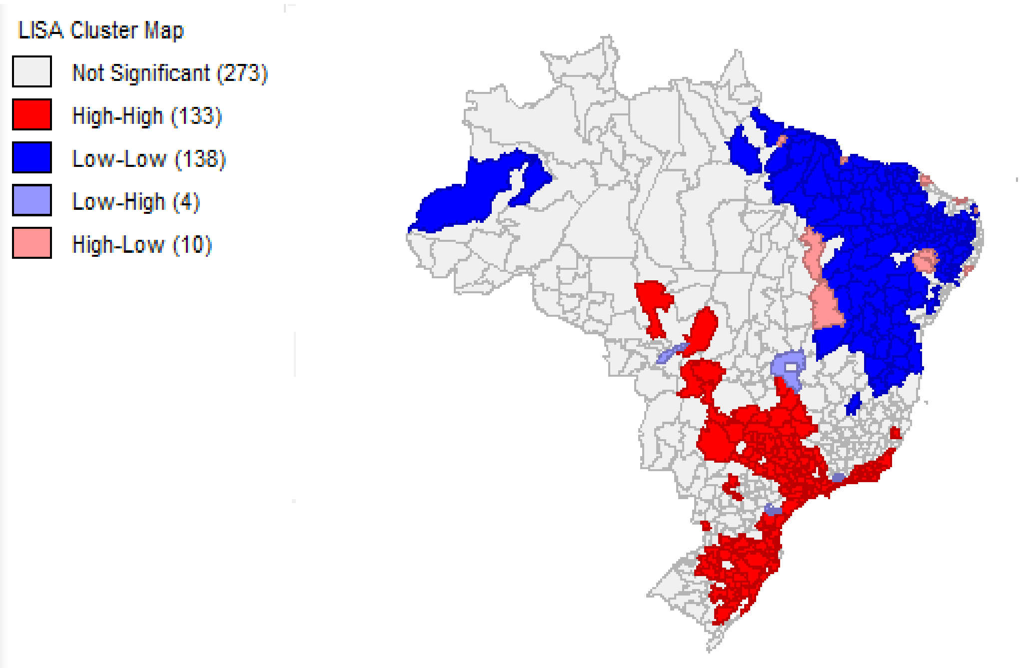


Figure C.2 - local Moran's I (LISA) of the natural logarithm of GDP per capita in the starting year with k-neighbor matrix (k=5)



Appendix D

Table D.1 - Results of spatial panel models for the North and Northeast regions

Micro-regions Estimation	SEM			SAR			SDM		
Lag LN GDP per *capita*	-0.6369 (-24.43)***	-0.6377 (-24.48)***	-0.6394 (-24.48)***	-0.6037 (-23.6)***	-0.6044 (-23.65)***	-0.6059 (-23.65)***	-0.6353 (-23.9)***	-0.6376 (-24.03)***	-0.6391 (-24.05)***
Education level	-0.0235 (-3.91)***	-0.0231 (-3.86)***	-0.0238 (-3.98)***	-0.0244 (-4.07)***	-0.0239 (-4)***	-0.0246 (-4.13)***	-0.0240 (-3.97)***	-0.0232 (-3.85)***	-0.0240 (-3.98)***
Population growth rate	-0.4006 (-6.66)***	-0.4005 (-6.66)***	-0.4019 (-6.68)***	-0.3697 (-6.24)***	-0.3703 (-6.25)***	-0.3725 (-6.29)***	-0.3999 (-6.61)***	-0.4007 (-6.62)***	-0.3995 (-6.59)***
Large firm (500)	0.0084 (0.33)			0.0059 (0.23)			0.0050 (0.19)		
Large firm (250)		0.0294 (1.43)			0.0298 (1.4)			0.0289 (1.38)***	
Small firm			-0.0231 (-1.3)			-0.0229 (-1.24)			-0.0212 (-1.16)
W*Lag LN GDP per capita							0.2349 (4.34)***	0.2363 (4.35)***	0.2401 (4.41)***
W*Education level							0.0160 (1.24)	0.0187 (1.46)	0.0189 (1.49)
W*Population growth rate							0.1448 (1.24)	0.1370 (1.18)	0.1382 (1.18)
W*Large firm (500)							-0.0731 (-1.28)		
W*Large firm (250)								-0.0191 (-0.39)	
W*Small firm									0.0348 (0.83)
λ	0.3332 (8.67)***	0.3335 (8.68)***	0.3350 (8.72)***						
ρ				0.2367 (6.96)***	0.2370 (6.98)***	0.2387 (7.02)***	0.3326 (8.65)***	0.3336 (8.68)***	0.3342 (8.7)***
Observations	1260	1260	1260	1260	1260	1260	1260	1260	1260
Log-likelihood (LIK)	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221	12.8221

Table D.2 - Results of spatial panel models for the South, Southeast and Central-West regions

Micro-regions Estimation	SEM			SAR			SDM		
Lag LN GDP per *capita*	-0.705 (-29.87)***	-0.706 (-29.9)***	-0.709 (-30.08)***	-0.634 (-28.47)***	-0.634 (-28.46)***	-0.640 (-28.75)***	-0.699 (-28.85)***	-0.699 (-28.83)***	-0.701 (-28.98)***
Education level	0.027 (2.45)**	0.026 (2.43)**	0.027 (2.51)**	0.035 (3.29)***	0.034 (3.18)***	0.035 (3.27)***	0.027 (2.47)**	0.027 (2.48)**	0.027 (2.53)**
Population growth rate	-0.396 (-5.2)***	-0.402 (-5.28)***	-0.399 (-5.25)***	-0.427 (-5.83)***	-0.432 (-5.89)***	-0.427 (-5.85)***	-0.392 (-5.14)***	-0.393 (-5.14)***	-0.392 (-5.15)***
Large firm (500)	0.031 (1.23)			0.054 (2.11)**			0.040 (1.55)		
Large firm (250)		0.042 (1.63)			0.053 (2.04)**			0.042 (1.63)	
Small firm			-0.083 (-3.02)***			-0.108 (-3.89)***			-0.088 (-3.21)***
W*Lag LN GDP per capita							0.258 (5.64)***	0.268 (-5.83)***	0.248 (5.28)***
W*Education level							0.022 (1.07)	0.019 (0.92)	0.020 (0.94)
W*Population growth rate							-0.038 (-0.27)	0.001 (0.01)	-0.010 (-0.07)
W*Large firm (500)							0.082 (1.55)		
W*Large firm (250)								-0.005 (0.09)	
W*Small firm									-0.051 (-0.91)
λ	0.484 (16.61)***	0.485 (16.67)***	0.482 (16.47)***						
ρ				0.377 (14.81)***	0.377 (14.81)***	0.375 (14.77)***	0.469 (15.89)***	0.473 (16.02)***	0.464 (15.54)***
Observations	1530	1530	1530	1530	1530	1530	1530	1530	1530
Log-likelihood (LIK)	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994	11.7994

Appendix E

The table E.1 shows the results of Moran’s I for all variables used in the regressions with different weights matrices.

Table E.1 – Moran’s I

	Income growth	Employment growth	ln income	ln employment	Human capital	Population density	Child mortality
Queen first	0.3042	0.2488	0.7908	0.3971	0.4638	0.5009	0.8431
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Queen second	0.2808	0.2362	0.7686	0.3581	0.4139	0.3323	0.8294
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Queen third	0.2602	0.2272	0.7472	0.3252	0.3797	0.2217	0.8103
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
k-nearest (k=5)	0.31	0.2491	0.7914	0.4023	0.4606	0.5785	0.8526
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
k-nearest (k=10)	0.2953	0.2437	0.7825	0.3871	0.4347	0.4545	0.8436
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
k-nearest (k=15)	0.2866	0.2429	0.7760	0.3744	0.4205	0.3981	0.8371
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

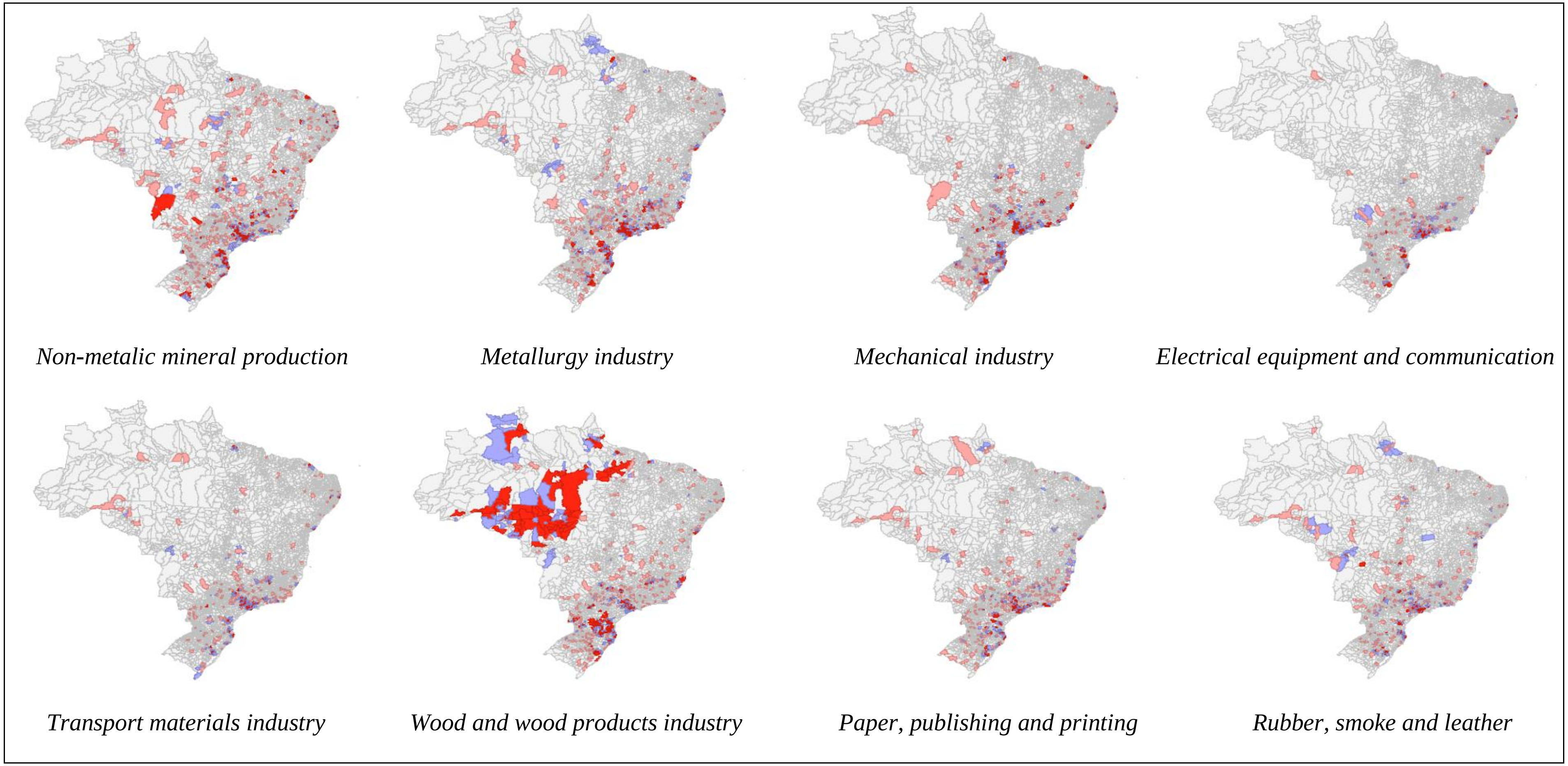
	Manufacturing				Service			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
Queen first	0.0831	0.1145	0.1516	0.1131	0.1063	0.0802	0.0802	0.2111
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Queen second	0.0723	0.1035	0.1251	0.0929	0.0886	0.0658	0.0831	0.2059
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Queen third	0.0583	0.0924	0.1143	0.0756	0.0849	0.0571	0.0791	0.1986
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
k-nearest (k=5)	0.0978	0.1271	0.1490	0.1105	0.1151	0.0901	0.0997	0.2353
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
k-nearest (k=10)	0.0860	0.1179	0.1400	0.0940	0.0939	0.0684	0.0908	0.2256
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
k-nearest (k=15)	0.0782	0.1135	0.1350	0.0973	0.0947	0.0688	0.0928	0.2238
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

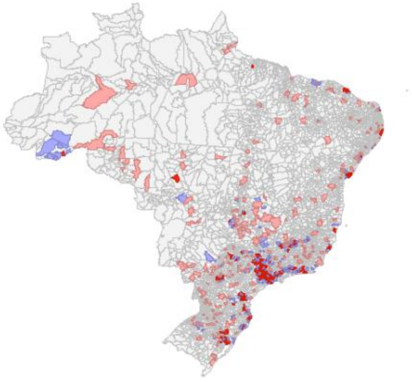
Note: Numbers between brackets are *p* values and indicate significance at 5 %.

Appendix F

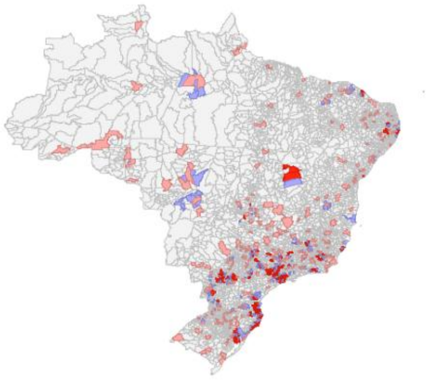
Appendix F

Figure F.1 – Local Moran's I (LISA) for white collar occupations in each manufacturing sector.

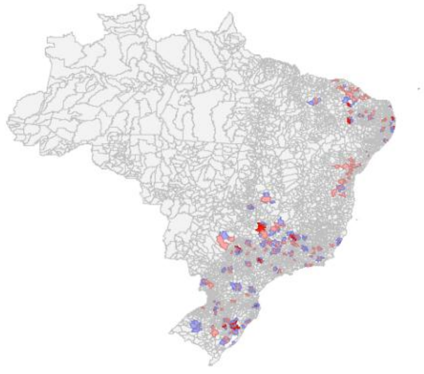




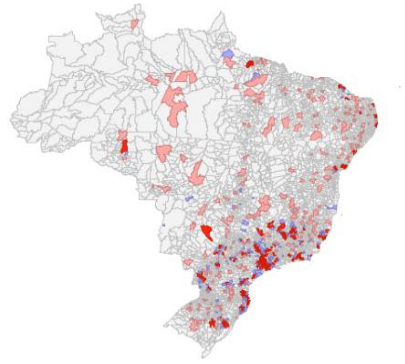
Chemical industry



Textile and clothes industry



Footwear industry

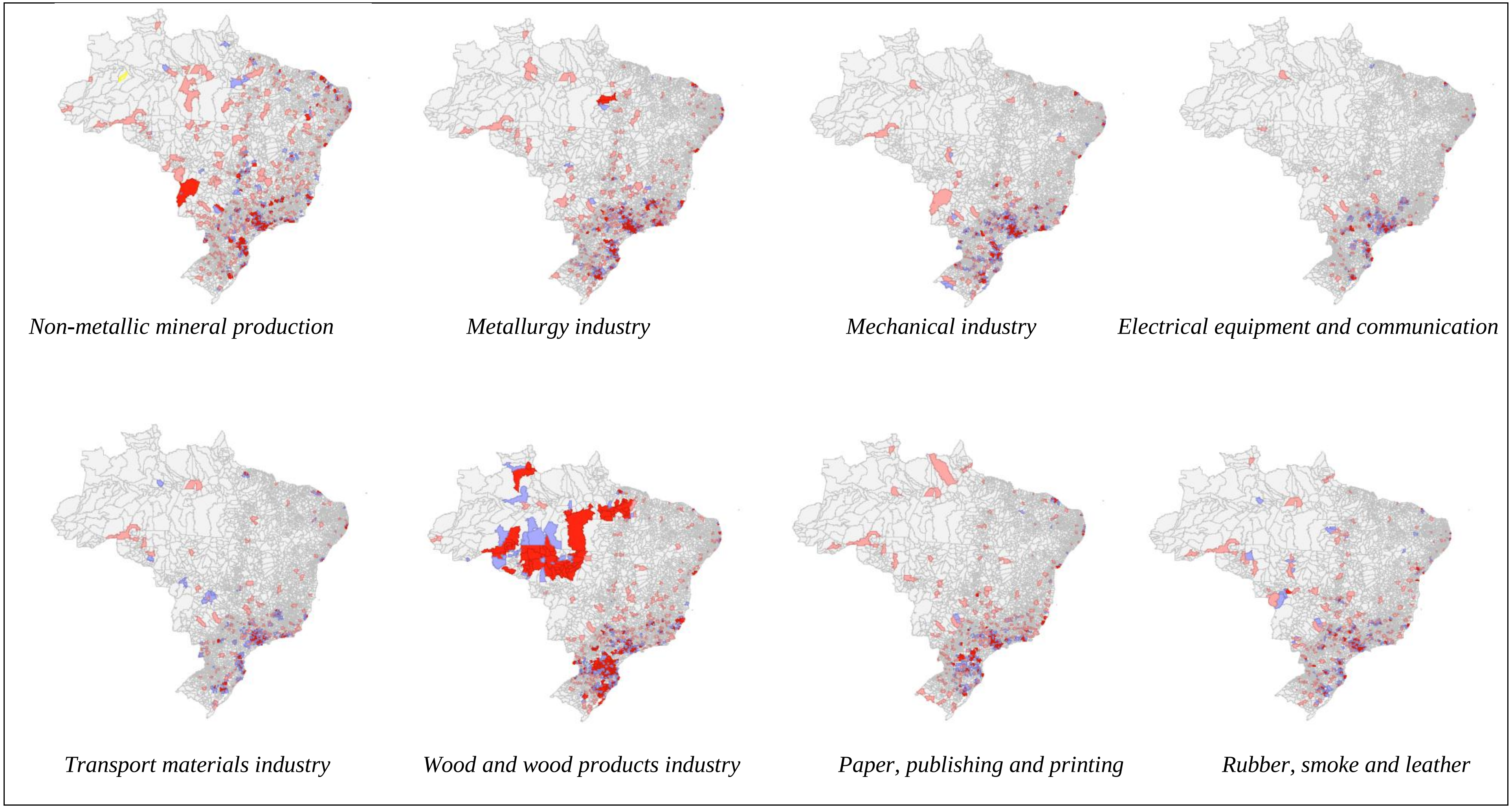


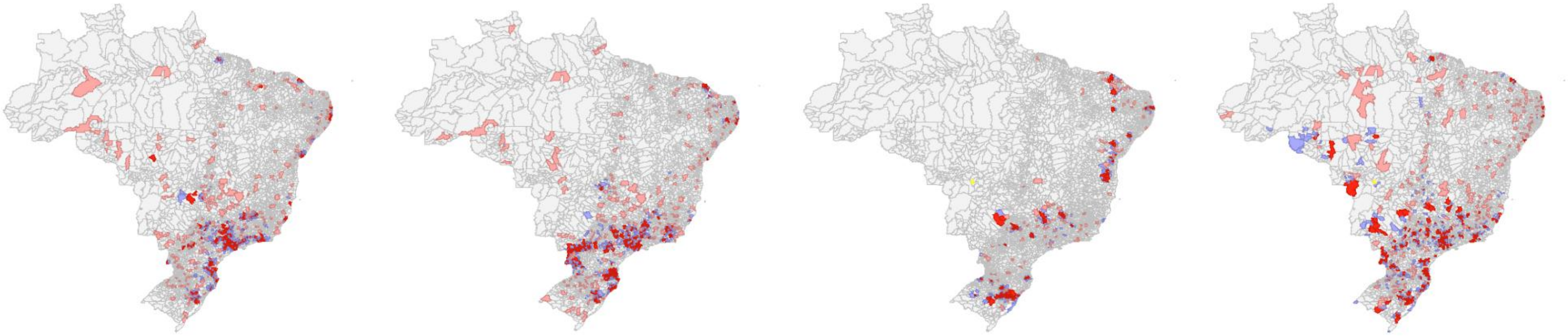
Food and beverage

Subtitle:	Not significant
	High-High
	Low-Low
	Low-High
	High-Low

Fonte: Elaborado pelos autore

Figure F.2 – Local Moran's I (LISA) for blue collar occupations in each manufacturing sector.





Chemical industry *Textile and clothes industry* *Footwear industry* *Food and beverage*

Subtitle:		Not significant High-High Low-Low Low-High High-Low

Fonte: Elaborado pelos autores