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Dependency ratio: a spatial analysis for brazilian municipalities

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Abstract
This paper analyzes the phenomenon of demographic transition in order to verify the existence and evolution of clusters in Brazilian municipalities, as well as capturing the social and economic indicators that influence this phenomenon. The dependency ratio is adopted as an indicator of demographic transition, which measures the relative participation of the inactive population, which should be sustained by the portion of the working age population. To this end, the Exploratory Spatial Data Analysis (ESDA) method and the estimation of spatial econometric models are used with data from the Demographic Censuses of 1991, 2000 and 2010. The results highlight that there is heterogeneity of the demographic transition in Brazilian municipalities, and the municipalities of the South and Southeast of the country are present at a more advanced stage. In spatial regression, the variables: life expectancy at birth, infant mortality rate, Gini coefficient and inadequate water and sanitation show a positive relationship with the dependency ratio. On the other hand, per capita income, expected years of schooling and MHDI indicate an inverse relationship.
Keywords: Demographic transition. Dependency ratio. Exploratory Spatial Data Analysis (ESDA). Spatial econometric.

Razão de dependência: uma análise espacial para os municípios brasileiros

Resumo

O trabalho analisa o fenômeno da transição demográfica com a finalidade de verificar a existência e evolução de *clusters* nos municípios brasileiros bem como capturar os indicadores sociais e econômicos que influenciam esse fenômeno. Adota-se como indicador da transição demográfica a razão de dependência, que mede a participação relativa da população inativa, que deveria ser sustentado pela parcela da população em idade ativa. Para esse fim, usa-se o método de Análise Exploratória de Dados Espaciais (AEDE) e a estimação dos modelos econométricos espaciais com dados dos Censos Demográficos de 1991, 2000 e 2010. Os resultados destacam que há heterogeneidade da transição demográfica nos municípios brasileiros, sendo que os municípios do Sul e Sudeste do país apresentam-se em um estágio mais avançado. Na regressão espacial, as variáveis: esperança de vida ao nascer, taxa de mortalidade infantil, coeficiente de Gini e água e esgoto inadequados mostram relação positiva com a razão de dependência. Já renda *per capita* média, expectativa de anos de estudo e IDHM indicam relação inversa.

Palavras–chave: Transição demográfica. Razão de dependência. Análise Exploratória de Dados Espaciais (AEDE). Econometria espacial.

Razón de la dependencia: análisis espacial de municipios brasileños

Resumen

El trabajo analiza el fenómeno de la transición demográfica con el fin de verificar la existencia y evolución de los clusters en los municipios brasileños, así como capturar los indicadores sociales y económicos que influyen en este fenómeno. El índice de dependencia se adopta como un indicador de la transición demográfica, que mide la participación relativa de la población inactiva, que debe ser sostenida por la parte de la población en edad de trabajar. Con este fin, se utiliza el método de Análisis Exploratorio de Datos Espaciales (AEDE) y la estimación de modelos econométricos espaciales utilizando datos de los Censos Demográficos de 1991, 2000 y 2010. Los resultados destacan que existe una heterogeneidad en la transición demográfica en los municipios brasileños. y los municipios del Sur y Sudeste del país se encuentran en una etapa más avanzada. En la regresión espacial, las variables: esperanza de vida al nacer, tasa de mortalidad infantil, coeficiente de Gini y agua y alcantarillado inadecuados muestran una relación positiva con la relación de dependencia. El ingreso promedio per cápita, la expectativa de años de estudio y el IDHM indican una relación inversa.

Palabras clave: Transición demográfica. Índice de dependência. Análisis Exploratorio de Datos Espaciales (AEDE). Econometría espacial.

1 Introduction

The demographic transition began in Western Europe from the urbanization process and was spread around the world in the 20th century. The main factors that influenced this process were the fall in the fertility and mortality rates (KIRK, 1996). However, these rates were not reduced simultaneously. In the first moment there was a fall in the mortality rate due mainly to the improvement in infrastructure, medicine and basic sanitation. The fertility rate subsequently decreased thanks to the emergence of a more urban population, industrial development, the insertion of women in in labour market among other causes. According to the United Nations (UN, 2004), between 1950 and 1970, the world average number of children per woman was close to 5 and after the 1970s was less than 3 (BRITO, 2007).

The demographic transition can be divided into four phases according to the Rosa (2006). The first is when there are high birth and death rates, so there is low population growth. The second occurs when the level of mortality decreases while the fertility level remains high. This phase is characterized by rapid demographic growth and a higher proportion of young people. The next phase is called population growth at decreasing rates, in which the decline in fertility is persistent and there is a substantive increase in the working age population (WAP) as a reflection of the fertility levels of the past. The last phase is when fertility and mortality rates are low. In this, population growth becomes low and sometimes zero. Therefore, there is a decrease in the proportion of the young population and an increase in the elderly population (BRITO, 2007). This phase is known as a "window of opportunity" CARVALHO; WONG, 2006) or demographic bonus (MASON, 2005; NASIR; TAHIR, 2011).

In Brazil, the demographic transition is happening more accelerated when compared to other countries (VASCONCELOS and GOMES, 2012). France doubled its proportion of the elderly population (from 7.0 to 14.0%) in 115 years, while in Brazil, the same proportional change took only 40 years to occur (from 5.1 to 10.8%). In addition, the demographic transition did not occur homogeneously across the country. Social and economic differences explain these variations in Major Regions. In the North and Northeast there is the largest proportion of the young population, while the participation of the elderly population occurs in higher values in the South and Southeast regions.

For Pereima and Porsse (2013), economic growth is driven at the time of demographic bonus, whose share of WAP (between 15 to 64 years) is greater than the share of the inactive population (0 to 15 and over 64 years old). Thus, to observe the demographic transition, the dependency ratio indicator is used which measures the relative participation of the inactive population that must be sustained by the working population[1]. According to the UN (2004), the bonus in Brazil began in 1995 and will go up to 2055. The biggest difference between the WAP percentage and the dependency ratio percentage would be 18.2% between 2020 and 2025. In this way, the window of opportunity will begin to close from 2025 until you lose all the benefits after 2055.

The hypothesis raised is that the dependency ratio of a municipality influences and can be influenced by the neighboring municipality, since municipalities in developed regions, such as those in the South and Southeast, have a lower dependency ratio. On the other hand, higher values of dependency ratio are observed in municipalities in less developed regions, such as the North and Northeast.

Within this context, the work seeks to verify the existence of possible spatial patterns of the dependency ratio for Brazilian municipalities, that is, to analyze whether the dependency ratio is a spatial phenomenon. In addition, to investigate whether there is a relationship between the dependency ratio and other economic and social variables, such as: life expectancy at birth, infant mortality rate, per capita income, expected years of schooling, Gini coefficient, percentage of the

[1] The closer the dependency ratio value of 1, the larger the portion of the dependent population that WPA should sustain.

population living in households with inadequate water and sanitation and Municipal Human Development Index (MHDI). For this purpose, it uses the methodology of Exploratory Analysis of Spatial Data (ESDA) and the estimation of spatial econometric models for years 1991, 2000 and 2010.

The study is justified given that the understanding of the levels of dependence of Brazilian municipalities may evidence the need for public policies aimed at better exploiting the "demographic bonus" and consequently increasing per capita income. Identifying regional factors make public policies more efficient, as well as recognizing which variables are associated with dependency ratio.

The article is divided as follows: in addition to this introduction, the second section presents the literature review, the third brings the variables and the database followed by the methodology and results in the fourth and fifth sections, respectively. The last section points out the final remarks.

2 Demographic transition

In Brazil, by the end of the 19th century, population growth was relatively low, mainly due to the African slave movement and little displacement of Europeans. After the end of slavery, migration flows from Europe increased through colonization policies, influencing the rates of population growth that exceeded 2% per year (SIMÕES; OLIVEIRA, 1998).

According to Rigotti (2012), the Brazilian population doubled between 1900 and 1940, with stable demographic rates over the years. However, this pace increased in the 1950s and 1960s, even when international immigration had already decreased. This was a time of intense internal flows, with many displacements to São Paulo, Rio de Janeiro and to the new agricultural frontiers. Society was agrarian and precariously urbanized, and fertility rates ranged from 7 to 9 children per woman, depending on the region.

From the 1950s, mortality levels declined, with the fall in infant mortality rates and increased life expectancy at birth. This happened due to improvements in the public health system, expansion of social security, urbanization process, advances in the chemical-pharmaceutical industry and import of medicines. This first phase of the demographic transition characterized by a decrease in the mortality rate combined with the high level of fertility resulted in high population growth rates of approximately 3% per year. Therefore, the population was very young, with a median age of only 18 years and the proportion of elderly people was low (VASCONCELOS; GOMES, 2012).

In the second phase, in the decades 1960s and 1970s, mortality levels continued to fall and the beginning of the aging process of the population was observed (DUARTE; BARRETO, 2012). From the 1960s, Brazil began a demographic revolution, in which birth, fertility and mortality indicators had their levels reduced. However, it was from 1970 that the degree of urbanization intensified, which allowed the urban population to overcome the rural. Urbanization, combined with industrialization, has provoked social transformations, such as the change in the role of women in society, which, when entering the labor market, contributed to the rapid reduction of the fertility rate in the face of late marriages, adoption of family planning, contraceptives and improvement in education conditions. The

Brazilian population went from, on average, 5.8 children per woman in 1970 to 4.4 between 1975 and 1980 (VASCONCELOS; GOMES, 2012).

The Brazilian demographic transition accelerated from the 1990s on, a consequence of a rapid decline in the fertility rate and aging of the population. According to Table 1, the fertility rate decreased in all regions, reaching low fertility levels in a relatively short period of time. Until the 1990s, there was a disparity between the rates of the more developed regions (South and Southeast) when compared to the less developed ones (North and Northeast). However, from the 2000s on, it is possible to notice a smaller discrepancy between the regions. In 2010, the North had the highest fertility rate (2.5 children per woman), while the Southeast region had the lowest (1.7 children per woman). The fertility rate in the country was 1.9 children per woman, lower than the average observed for the Americas (2.1 children per woman) and below the replacement level (2.1 children per woman) (DUARTE; BARRETO, 2012).

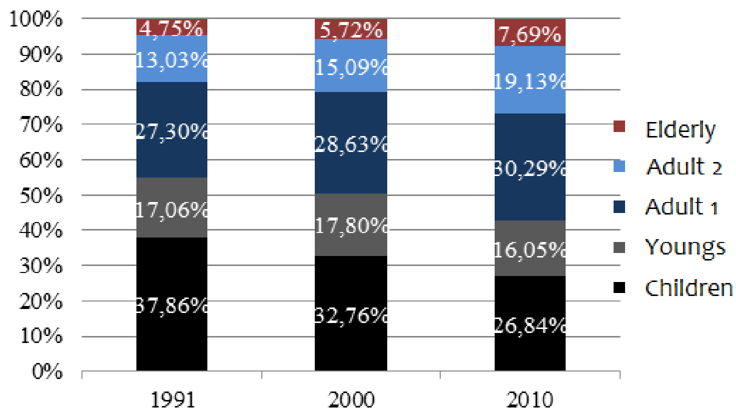
TABLE 1- Total fertility rates, by Regions – 1940/2010

Regions	1940	1950	1960	1970	1980	1991	2000	2010
North	7,2	8	8,6	8,2	6,5	4,2	3,2	2,5
Northeast	7,2	7,5	7,4	7,5	6,1	3,7	2,7	2,1
Southeast	5,7	5,5	6,3	4,6	3,5	2,4	2,1	1,7
South	5,7	5,7	5,9	5,4	3,6	2,5	2,2	1,8
Midwest	6,4	6,9	6,7	6,4	4,5	2,7	2,3	1,9
Brazil	6,2	6,2	6,3	5,8	4,4	2,9	2,4	1,9

Source: IBGE, Demographic Censuses 1940-2010.

According to Graph 1, this change, together with the fall in the mortality rate, reflected in the increase in the proportion of elderly people and a reduction in the proportion of the infant population. In the 2000s, the participation of working age population (WAP) increased, as in 1991 it corresponded to 57.4%, compared to 65.5% of the total population for the year 2010.

GRAPH 1- Participation of the population by age group: 1991, 2000 and 2010[2]



Source: authors.

[2] Children (< 15 years old), Young (between 16 and 24), adult 1 (between 25 and 44), adult 2 (between 45 and 64) and elderly (over 64 years old).

Moreover, the age composition of the Brazilian population is not equally related to genders. In both cases, there was a reduction in the participation of the child and youth age groups over the years. In the adult and elderly phases, females have the highest participation. . This is due to a woman's longer life expectancy, as a result of better health care, fewer traffic accidents and fewer homicides and suicides (SOUZA, 2005).

For Cutler et al. (1990), the temporary increase in the WAP can be beneficial, since it is this population that produces, saves, invests and contributes with taxes and to social security. Thus, the economy grows and increases the potential for redistribution of resources from productive age groups to dependents (children and the elderly). According to Miles (1999), although the population variable does not directly explain economic growth, demographic changes can have impacts on the rate savings rate, capital formation, labour supply, interest rate and real wages. Young and old produce less than they consume, while adults produce more than they consume. Thus, countries with high participation of the WPA tend to have higher levels of per capita income (GONÇALVES; RODRIGUES, 2012).

Rios-Neto (2005) confirms the positive relationship of per capita income with the demographic bonus. For Queiroz, Turra and Perez (2006), demographic changes have positive impacts on economic growth, but the lack of investment in human capital and institutions does not allow the full use of the bonus period. For Gonçalves and Rodrigues (2012), the bonus will depend on other determinants, such as the economic and institutional conditions of the State, the operation of the financial sector and the behavior of families.

According to Alves (2008), to ensure the favorable conditions of the bonus, public policies are needed to ensure the employment of the available labor. Brito (2007) emphasizes that for the best use of "demographic bonus" it is necessary to increase investments in education for a greater qualification of the population and increase productivity, because the trend is that in the future there will be a reduction in the number of available labor. On the other hand, the growth of the elderly population can increase public spending on health and social security. The growth in the proportion of elderly people and the fall in the social security support ratio[3] indicate that an increasing number of beneficiaries will depend on an increasing number of workers. According to Turra and Queiroz (2005), government spending on the population over 49 years grow exponentially.

3 Variables and database

As an indicator of the demographic transition, the dependency ratio is used (dependent variable), which measures the relative participation of the inactive population, which should be sustained by the portion of the working-age population. And as social and economic indicators (explanatory variables) it is used:

i. life expectancy at birth and infant mortality rate as health indicators. Life expectancy at birth corresponds to the average number of years a newborn would expect to live. This is a measure of mortality, not being affected by

[3] Ratio of the number of contributors to the number of beneficiaries.

the effects of the population's age structure, as with the crude mortality rate;

ii. the infant mortality rate corresponds to the number of deaths of children under one year of age per 1,000 live births. This indicator reflects the conditions of socioeconomic development and environmental infrastructure, as well as the access and quality of resources available for maternal and child health care. It is usual to classify the rate value as high (above 50 per thousand), medium (between 20 and 49 per thousand) and low (below 20) (RIPSA, 2009);

iii. the average per capita income measures the ratio between the sum of income of all individuals living in permanent private households and the total number of these individuals. Average per capita income is one of the main indicators of the ability to acquire goods and services and is related to economic growth of a region. The income calculation was corrected for all years based on the National Index of Consumer Prices (INPC) with values in *Reais* of August 2010;

iv. the expected years of schooling corresponds to the average number of years of schooling that a generation of children entering school should complete by reaching 18 years of age if current standards are maintained throughout their school life. This variable is used as an indicator of education.

v. the infrastructure variable is the percentage of people in households with inadequate water supply and sanitation. This is obtained by the ratio of the number of people living in households whose water supply does not come from the general network and that the sewage is not carried out by sewage collection network or septic tank, by the total population residing in permanent private households, multiplied by one hundred;

vi. the Gini coefficient is a social and economic indicator that measures the income distribution of the population in a given location. Its value varies from 0, when there is no inequality (the per capita household income of all individuals has the same value), to 1, when inequality is maximum (only one individual holds all income). This indicator provides information on the concentration of income and contributes to the analysis of the socioeconomic situation of the population, identifying segments that require greater attention from public policies; and,

vii. Municipal Human Development Index (MHDI). The index takes into account the same criteria as the Human Development Index (HDI): education, longevity and income. For the evaluation of the education dimension, the MHDI considers two indicators, with different weights: literacy rate of people over 15 years of age (weighing two) and the gross rate of school attendance (weighing one). To assess longevity, the MHDI considers the same indicator of the HDI of countries: life expectancy at birth. For the evaluation of income, per capita municipal income is used (UNDP, 2013).

The database consists of the Demographic Censuses of 1991, 2000 and 2010. The data are provided by the Brazilian Institute of Geography and Statistics. For the health indicators, DATASUS was used, computer record of the Unified Health

System, in which different health research is available. MHDI data are made available by the United Nations Development Programme (UNDP).

Since in 1991 there were 4,491 municipalities; and that in 2000, the number of municipalities was 5,507, and in 2010 it increased to 5,565 Brazilian municipalities, using the compatibility used by the Atlas of Human Development[4] of 2013, of the UNDP, possible to obtain data for the 5565 municipalities according to the municipal configuration of the 2010 Census.

4 Methodology

Exploratory Spatial Data Analysis (ESDA) is initially used as methodology. This is a tool used to describe and visualize spatial distributions, to verify the existence of different regimes or others forms of spatial instability (non-stationarity), identify atypical localities (outliers) and discover spatial association patterns (clusters) (ANSELIN, 1999).

With the univariate technique, the existence of clusters for the variable dependency ratio and the changes occurred over time is identified. With the bivariate technique seeks to map the relationship of the dependency ratio with other social and economic indicators. This method results in two effects: spatial dependence and spatial heterogeneity. The first occurs in all directions, but is inversely related to geographical distance. The second concerns the very characteristics of space units, which naturally differ from each other.

Spatial heterogeneity or randomness indicates that the dependency ratio values of a municipality are not influenced by the dependency ratio of neighboring municipalities (ALMEIDA, 2012). For this purpose, the Global[5] Moran's *I* value was used. This statistic has an expected value of $-[1/(n-1)]$, that is, the value that would be obtained if there was no spatial pattern in the data. I values higher than the expected value, as long as significant, indicate positive spatial autocorrelation, but do not inform the existing spatial regime. I values below the expected value suggest negative autocorrelation, that is, they denote the existence of spatial heterogeneity.

To carry out the study, the first step is to choose the spatial weights matrix (W). The matrix demonstrates the interactions related to the dependency ratio of each municipality, that is, it captures the spatial autocorrelation. The matrix is square and the spatial weights Wij represents the power of influence of the dependency ratio of the municipality j in municipality i. Soon, he was convinced: $Wii = 0$. Using the Baumont (2004) procedure, the neighborhood matrices were tested up to the twenty closest neighbors (K1, K2, K3, ..., K20), in addition to contiguity matrices (Rook and Queen).

As some local patterns can be missed by global analyses, it is necessary to use an indicator to verify the structure of the spatial correlation at the local level.

[4] The Atlas of Human Development is a platform linked to the data provided by the Demographic Censuses of 1991, 2000 and 2010. The Demographic Censuses allow the comparison between the municipalities, since the data were obtained through the same census process.

[5] Moran (1948) proposed the elaboration of a spatial autocorrelation coefficient using the measure of autocovariance in the form of a cross-product, where it verifies whether a particular variable in a region is affected by results from neighboring regions, thus testing spatial randomness.

The Local Indicators of Spatial Association (LISA) indicator is used. This spatial association measure provides four types of clusters, according to the values of a given variable in space. The patterns can be: i) High-High (HH): municipalities with high dependency ratio value surrounded by neighbors with high value; ii) Low-Low (LL): municipalities with low dependency ratio value surrounded by neighbors with low value; iii) Low-High (LH): municipalities with low value and neighbors with high value; iv) High-Low (HL): municipalities with a high dependency ratio value with neighbors with low (SIMÕES et al., 2004). Cluster maps are constructed to identify local spatial patterns.

Through the coefficient of bivariate local Moran's I it is possible to verify the existence of spatial dependence relationship between the dependency ratio variable and the other social and economic variables that can be viewed on bivariate clusters maps. The analysis of the Bivariate Local Indicator of Spatial Association (LISA) follows the same criteria as the Univariate LISA.

After the ESDA, spatial econometric models incorporating spatial components are performed, differentiating from "traditional" models that do not take into account the consequences of spatial autocorrelation and heterogeneity. These components refer to lags in the dependent variable (dependency ratio), explanatory variables and error term. Disregarding spatial autocorrelation implies impairments in the estimation of the model by the Ordinary Least Squares (OLS) method, as well as, if autocorrelation occurs in the dependent variable, OLS estimators are biased and inconsistent. When the correlation is present at the error term, there is no bias, however the OLS estimator is no longer the most efficient. In the presence of spatial autocorrelation, the estimation of the model should incorporate this spatial structure, since the dependency between observations alters the explanatory power of the model.

The spatial regression model corresponds to a linear regression with the incorporation of the spatial component into the dependent variable, according to the equation: $DR= \rho WRD + X\beta + \varepsilon$, where (DR) dependency ratio is the dependent variable, ρ is the autoregressive spatial coefficient (spatial correlation measure), W is the neighborhood matrix, WY expresses spatial dependence in RD, X is the observation matrix of explanatory variables, β is regression coefficient and ε is random error.

The following steps are adopted[6] as a procedure to define the specification of the best spatial model: i) estimation of the classic linear model by OLS, without any spatial lag, disregarding the spatial autocorrelation; ii) the residuals of the classical model are tested through Lagrange multiplier tests that provide the slope of the log-likelihood function, measuring the value of the restriction at the margin; iii) if there is no evidence of spatial autocorrelation, the traditional OLS model is used, but if there is spatial dependence, the regression of the SAR, SEM, SDM, SDEM, SLX and SARMA models is made; iv) the best model is chosen; the most appropriate model cannot present evidence of spatial autocorrelation in its residuals; v) the results of the best model are compared with the other ones.

[6] For more details see Almeida (2012).

The SAR[7] model (Spatial autoregressive) or Spatial Lag Model has as main characteristic the dependent variable interacting with each other in neighboring regions. In a simplified way, the model can be expressed as: $y=\rho Wy + \varepsilon$, where Wy is an n by 1 vector of lags for the dependent variable, ρ is the spatial autoregressive coefficient. The restriction on the spatial lag coefficient is between the range of: -1 and i ($|\rho| < 1$). If the parameter is positive indicates positive global spatial autocorrelation, otherwise there is negative global spatial autocorrelation.

The Spatial Error Model (SEM) or Spatial Autoregressive Error Model considers that in the spatial pattern the term of error is the result of the effects not modeled due to the lack of adequacy of measurement, in which they are not randomly distributed spatially, however, they have spatial autocorrelation. Formally: $u= \lambda Xu + \varepsilon$, in which the λ is the parameter of the spatial autoregressive error that accompanies the lag Xu and the errors associated with any observation are an average of the errors in neighboring regions plus a random error component.

The Spatial Durbin Model (SDM) contains the spatial lag of the dependent variable (Wy) and also the lags of the explanatory variables (Wx). In this model, it is assumed that the explanatory variables are exogenous and thus their spatial lags are also. The main problem lies in the existence of spatial endogeneity represented by the spatial lag of the dependent variable. In the Durbin spatial error model (SDEM) the same occurs, but with the lag in the error term.

The SLX model or Cross-Regressive Model considers that all the variables contained in the W matrix can overflow spatially. Formally: $y= X\beta + WX\tau + \varepsilon$, where τ is a vector and not a scalar, so the structural form of the model takes into account the impacts of overflows from neighboring regions without affecting the system.

The spatial autoregressive moving average (SARMA) model, or Spatial Autoregressive Error Spatial Lag Model, models phenomena in which they require the underlying spatial dependence to be more intricate, in which it manifests itself in the substantive form of a lag of the dependent variable and also in the form of spatial autocorrelation errors. It is the combination of SEM and SAR models and is specified in the form: $y= \rho Wy + X\beta + u$, whose residuals have an autoregressive structure, of the form: $u= \bar{\lambda} W\varepsilon + \varepsilon$, where W are the contiguity[8] matrices.

5 Results

To analyze the existence of spatial autocorrelation of the dependency ratio of the municipalities, Moran's *I* statistics for the years 1991, 2000 and 2010 are calculated. The Baumont (2004) indicates that the Queen contiguity spatial weights matrix is the one that will better captures the effects of spatial spillover. Table 2 contains the value of Moran's I statistics under the criterion of 999 permutations.

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[7] A detailed analysis of spatial models can be obtained from Almeida (2012).

[8] For more information on the steps in the iterative process for estimating the parameters in the SARMA model see in Anselin (1988) and Lesage and Pace (2009).

TABLE 2- Moran's *I* for the dependency ratio

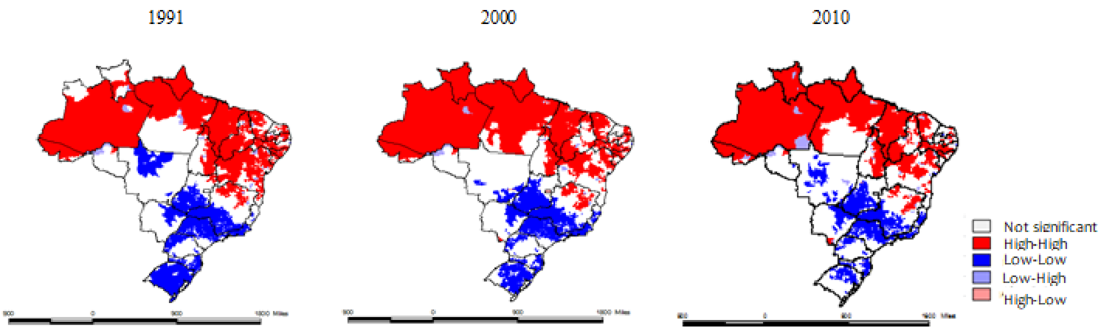
Year	Moran's *I*
1991	0,866***
2000	0,841***
2010	0,795***

Note: Queen contiguity spatial weights matrix.
Note: *** p<0,01, ** p<0,05, * p<0,1.
Source: authors.

For all years the variable dependency ratio is significant at 1%, which indicates the existence of global spatial autocorrelation. The year 1991 has the highest value and in 2010 the lowest, which indicates that the spatial phenomenon has lost magnitude over the years. The positive relationship of spatial dependence indicates that municipalities with a high dependence ratio are surrounded by municipalities with similar characteristics.

The cluster maps provide information on the positive autocorrelation of the dependency ratio of municipalities with their neighbors. Clusters are studied from a 5% significance level. The analysis of the LISA statistic points out that the spatial dynamics of dependency ratio is stable in Brazil during this period, and two clusters are identified in the spotlight: High-High that cover municipalities located in the North and Northeast regions, and Low-Low in the South and Southeast regions and in a small part of the state of Mato Grosso. In all years, it was possible to observe that the dependency ratio was not homogeneously distributed to Brazilian municipalities. However, this degree of heterogeneity decreases over the years (Figure 1).

FIGURE 1 – Dependency Ratio cluster maps



Source: authors.

In the years 2000 and 2010 the High-High (HH) cluster decreased in the Northeast region and increased in the North region, mainly in the states of Amazonas and Roraima, which indicates that these municipalities have a high dependency ratio surrounded by neighbors with the same characteristic, that is, they present a higher proportion of the inactive population. This result can be explained by the high proportion of children in the age composition of these municipalities. In the South, Southeast and north of the state of Mato Grosso, clusters of the Low-Low (LL) standard are forming in 1991, therefore, a low dependency ratio. This fact may have occurred because these regions have the lowest levels of fertility, because it is a more developed and urbanized area, so the dependency ratio is closer to zero. Over time this cluster is reduced, especially in the state of Rio Grande do Sul, which may show that there has been an aging of the population in this state, thus increasing, the proportion of the elderly population and consequently expanding the value of the dependency ratio.

Over time this cluster is reduced, especially in the state of Rio Grande do Sul, which may show that there has been an aging of the population in this state, thus increasing, the proportion of the elderly population and consequently expanding the value of the dependency ratio. Thus, it is perceived that the phenomenon loses strength in its spatial character, which can also be observed by Moran's *I* fall (Table 2).

Stampe, Porsse and Portugal (2011) also find concentration of the Low-Low cluster in the South and Southeast regions, which have the highest concentration of WAP, thus being more advanced regions in the process of demographic transition. However, this phenomenon may also be associated with migration, since the working age population tends to seek job opportunities in more developed regions.

To analyze the relationship between dependency ratio and socioeconomic indicators is used the bivariate Moran's *I.* According to Table 3, bivariate Moran's *I* of the dependency ratio with socioeconomic variables was significant at 1% for all years, except bivariate Moran's *I* of the dependency ratio with the Gini Coefficient that was not significant for the year 1991.

Another way to verify the relationship between dependency ratio and social and economic indicators is through the bivariate *Local Indicators of Spatial Association* (LISA). Clusters are analyzed from the significance level of 5%. Figure 2 shows the bivariate cluster map for dependency ratio and life expectancy at birth, where municipalities with low dependency ratio are expected to be surrounded by municipalities with high life expectancy at birth. This is in fact mainly happening in the Southern Region, part of the Southeast region and in some municipalities in the Midwest.

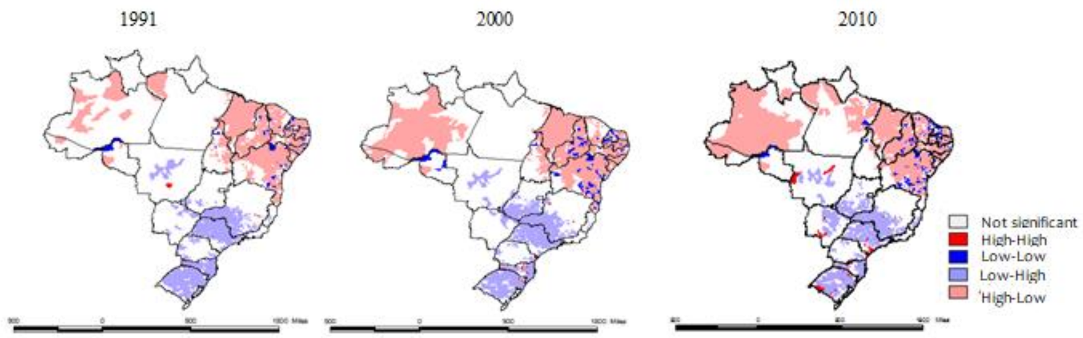
TABLE 3- Bivariate Moran's *I*

Variable	1991	2000	2010
Life expectancy at birth	-0,745***	-0,685***	-0,622***
Infant mortality rate	0,753***	0,684***	0,611***
Per capita income	-0,649***	-0,661***	-0,648***
Expected years of schooling	-0,710***	-0,691***	-0,447***
Gini coefficient	-0,004	0,359***	0,526***
Inadequate water and sanitation	0,625***	0,591***	0,627***
MHDI	-0,717***	-0,733***	-0,688***

Note: *** p<0,01, ** p<0,05, * p<0,1.
Source: authors

The High-Low standard constitutes the high dependency ratio value surrounded by municipalities with low life expectancy at birth. This pattern could be observed in the Northeast region and over the years expanded to the North region, mainly to the states of Amazonas and Pará (in year 2010), poor regions in health and sanitation.

FIGURE 2 – Dependency ratio clusters and Life expectancy at birth



Source: authors.

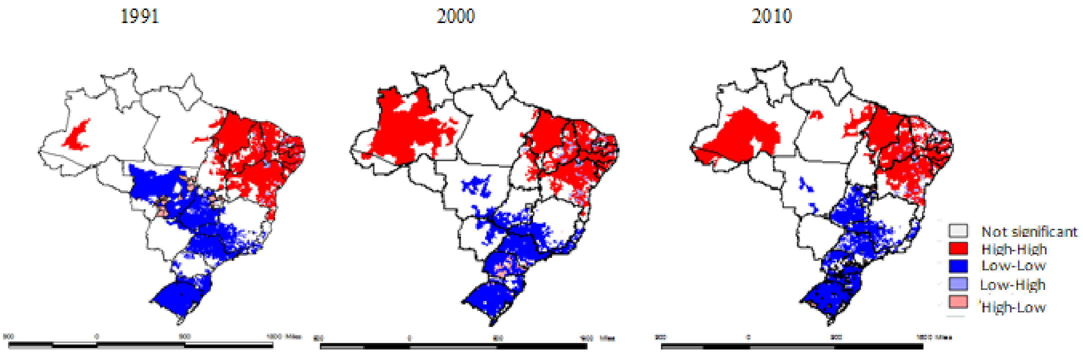
It is noteworthy that the growth of life expectancy at birth in the Southeast region, especially in the states of São Paulo and Rio de Janeiro, could be more significant, but they are localities that still have high mortality rates from external causes on the young and adult male population (MINISTÉRIO DA SAÚDE, 2009). The reduction rate of young dependency ratio is still higher than that of the increase in the old dependency ratio, which favors the reduction of total dependency ratio. However, there is a tendency of convergence to the pattern of the Southern region, since this is the region with the highest life expectancy at birth, thus being able to form the High-High standard as already evidenced in some municipalities of Santa Catarina and Rio Grande do Sul, especially in 2010. This is a characteristic of regions where the opportunity window begins to close.

In addition, in some municipalities in the Northeast and in the north of Rondônia there is the formation of the Low-Low standard indicating that despite the evolution of the demographic transition with low dependency ratio, which can be explained by the reduction in the fertility rate of these localities.

The infant mortality rate can be used as an indicator to assess the health and living conditions of the population, since most infant deaths result from preventable causes, as a consequence of biological, social factors and failures in the health system. In infant mortality, the post-neonatal period (from 28 days to one year) and the neonatal component (deaths occurring up to 27 days of life) are considered, which corresponds to about 70% of infant mortality. In addition, there is a heterogeneity in the national territory. In 2005, the neonatal mortality rate reached 20.7 per thousand in the Northeast, while in the South it was 9.4 per thousand (RIPSA, 2009).

When analyzing the bivariate clusters maps of the dependency ratio and the infant mortality rate (Figure 3), municipalities with low dependency ratio sit are expected to be surrounded by others with low infant mortality rates, constituting clusters of type Low-Low. This type of cluster is predominantly observed in the South, Southeast (only a small part of Minas Gerais) and Midwest. However, this relationship is not constant over the years, in which the clusters of municipalities in the Midwest region decrease and there is greater cluster agglomeration in the state of Paraná. The High-High standard that had a higher concentration in the Northeast in 1991 expands to the state of Amazonas, part of Acre in 2000 and for the state of Pará in 2010. These municipalities have a high dependency ratio and are surrounded by municipalities with a high infant mortality rate. According to IBGE data, these regions have the highest infant mortality rates in 2010, with the rate of the North region being 22.8 and in the Northeast of 32.1, contrasting with that of the Southeast and South, which in the same period was 16.1 and 14.6, respectively.

FIGURE 3 – Dependency ratio clusters and Infant mortality rate

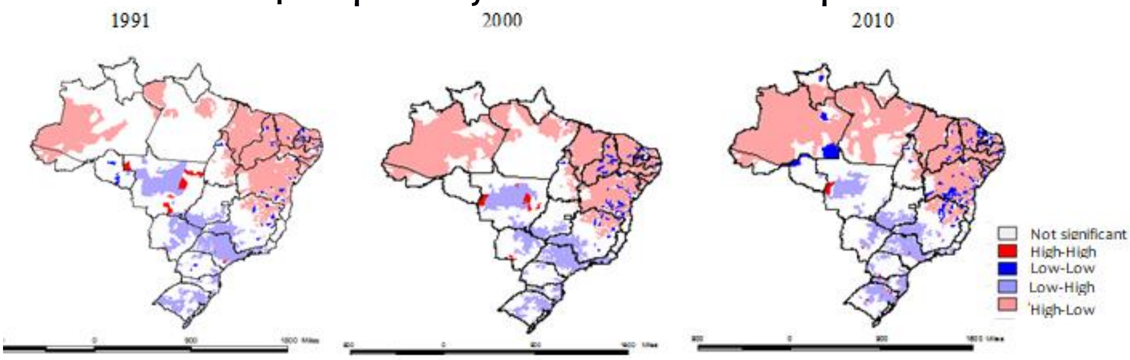


Source: authors.

Among the variables dependency ratio and per capita income, the relationship is expected to be negative, as the productivity of the economy tends to reduce as the population ages, reinforcing the negative effects on growth. As can be seen in Figure 4, in fact there is a negative spatial autocorrelation between dependency ratio and Per capita income. Between 1991 and 2000 there was an increase in statistics, which indicates a growth in the spatial autocorrelation between the two variables.

There is a concentration of the High-Low standard in the municipalities of the North and Northeast of the country and in the north of the state of Minas Gerais. That is, municipalities of high value of dependency ratio that are neighbors of municipalities of low per capita income. In the South and Southeast regions and in part of the state of Mato Grosso, low-high clusters are identified, so that municipalities of low dependency ratio are neighbors of municipalities with high per capita income, which happened, more frequently in the state of São Paulo in all years.

FIGURE 4 – Dependency ratio clusters and Per capita income

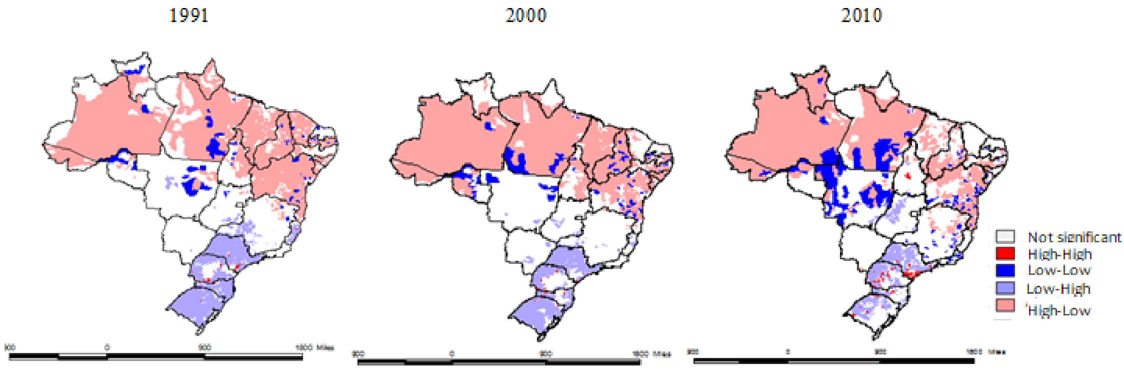


Source: authors

An interesting result is the formation of the High-High cluster in some municipalities of Mato Grosso, which evidences high dependency ratio surrounded by municipalities of high per capita income. In addition, some municipalities in the Northeast, north of Minas Gerais and in the states of Amazonas and Roraima (the latter two only in 2010) have the Low-Low standard, indicating that they are localities with low value for dependency ratio, which can be explained by the reduction in the young population, and are surrounded by municipalities of low per capita income.

When analyzing the bivariate clusters maps of dependency ratio and expected years of schooling (Figure 5), it is expected that the municipalities with low dependency ratio are surrounded by municipalities with high expected years of schooling and vice versa. Cochrane (1979) found that the fertility rate tends to fall with the increase in investments in education. For Jones (1990), the demographic structure tends to be less favorable for the development of education in countries with high population growth rates.

FIGURE 5 – Dependency ratio clusters and Expected years of schooling

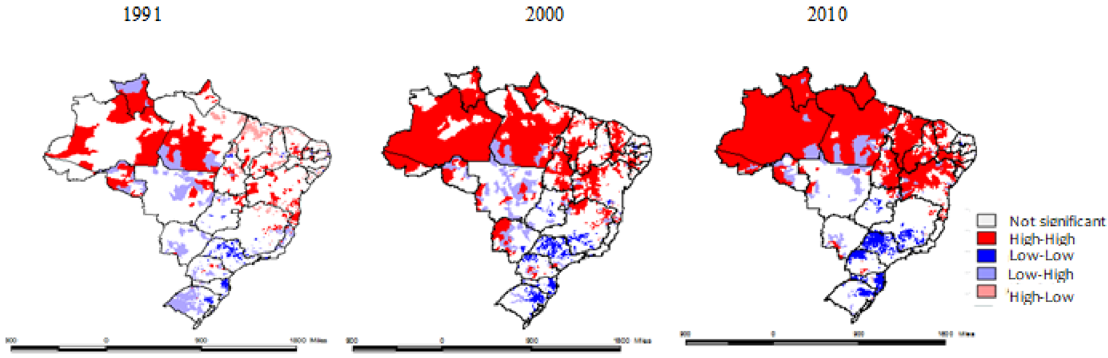


Source: authors.

The North and Northeast regions present the concentration of clusters of type High-Low, that is, with high dependency ratio surrounded by municipalities with low expected years of schooling. However, over the years this pattern decreases in much of the Northeast and there is an expansion to the states of the Acre, Amazonas, Pará and in 2010 to a northern part of the state of Minas Gerais. In this sense, it is essential to take up educational policies for these areas.

In the case of cluster maps of dependency ratio and Gini coefficient (Figure 6), there is emphasis on the High-High pattern, that is, a high value of dependency ratio surrounded by municipalities with high Gini coefficient value. It should be noted that the higher Gini coefficient, the greater the income distribution inequality. This pattern grows over the years, mainly in the North of the country, states of Maranhão, Bahia, Piauí, Pernambuco e Ceará.

FIGURE 6 – Dependency ratio clusters and Gini coefficient

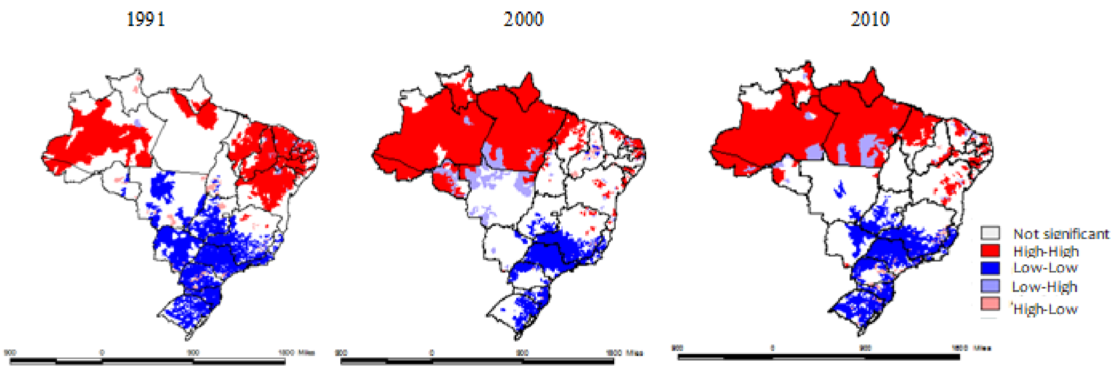


Source: authors.

Another result is the growth of the Low-Low standard, because in 1991 there were only 254 municipalities, in 2000, 611 municipalities and in 2010, 855 municipalities. This pattern is present in the states of Rio Grande do Sul, Santa Catarina, north of Paraná, south of Minas Gerais and a small central part of Goiás. In addition, there is a concentration of pattern Low-High in the Midwest, which indicates that in this region despite the evolution of the demographic transition with low dependency ratio, the Gini index is high, which points to being a region with income concentration. Sanitation and infrastructure indicators are directly related to the degree of urbanization of a municipality. Municipalities with a high degree of urbanization have higher proportions of the elderly population and lower levels of fertility. Thus, it is expected that the municipalities with the highest degree of urbanization have the lowest dependency ratio values.

Figure 7 shows the bivariate clusters maps of dependency ratio and the percentage of people in households with inadequate water supply and sewage. The best situation is the formation of Low-Low clusters present mainly in the South and Southeast regions. However, this phenomenon decreases from 1991 to 2000 and grows again in 2010. The opposite effect occurs for the High-High pattern, which indicates a high dependency ratio value surrounded by a high percentage of households with inadequate water and sewage supplies. This phenomenon decreases between 1991 and 2000, however, despite decreasing the number of municipalities in the Northeast with the participation of this cluster, there is expansion to municipalities in the North of the country.

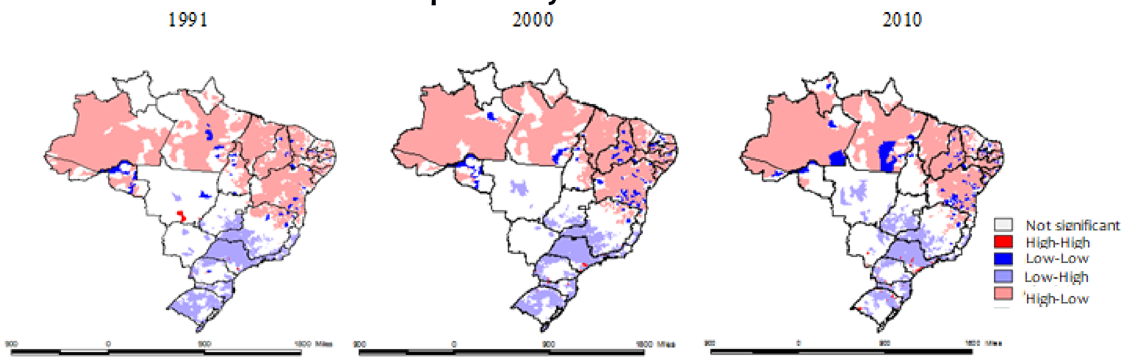
FIGURE 7 – Dependency ratio clusters and Inadequate water and sanitation



Source: authors.

Analyzing the bivariate clusters maps of dependency ratio and MHDI, it is observed that the North and Northeast region is marked by clusters of type High-Low, that is, municipalities with high dependency ratio value surrounded by municipalities with low MHDI. That is, they are areas where the MHDI is closer to zero and present problems in the area of health, education and low level of per capita income. The Low-High standard is in the South and Southeast region with higher concentration in the state of São Paulo, that is, municipalities with greater human development. It is worth mentioning the expansion of this pattern to the Midwest of the country, especially in the state of Goiás.

FIGURE 8 – Dependency ratio clusters and MHDI



Source: authors.

Table 4 presents the predominant clusters of variables according to each region. It is observed that the predominance of clusters remained unchanged for all regions in all years, even though in a few years the spatial phenomenon has lost strength, given the reduction of Moran's *I*. For the North and Northeast only the HH and HL standards were found. The opposite occurred to the South and Southeast, with the formation of the LL and LH clusters. However, for the Midwest, variations occurred, and the variables: Expected years of schooling and Gini coefficient obtained LL and LH results, respectively. For the other variables, the results were similar to those found in the South and Southeast regions. It is also observed that the bivariate clusters of dependency ratio with the variables Infant mortality rate and Inadequate water and sanitation have the behavior of predominance identical to that of the univariate clusters of the dependency ratio variable.

TABLE 4- Summary of cluster predominance by Region

Variable	1991					2000					2010				
	N	NE	MW	S	SE	N	NE	MW	S	SE	N	NE	MW	S	SE
Dependency ratio	HH	HH	LL	LL	LL	HH	HH	LL	LL	LL	HH	HH	LL	LL	LL
Life expectancy at birth	HL	HL	LH	LH	LH	HL	HL	LH	LH	LH	HL	HL	LH	LH	LH
Infant mortality rate	HH	HH	LL	LL	LL	HH	HH	LL	LL	LL	HH	HH	LL	LL	LL
Per capita income	HL	HL	LH	LH	LH	HL	HL	LH	LH	LH	HL	HL	LH	LH	LH
Expected years of schooling	HL	HL	LL	LH	LH	HL	HL	LL	LH	LH	HL	HL	LL	LH	LH
Gini coefficient	HH	HH	LH	LL	LL	HH	HH	LH	LL	LL	HH	HH	LH	LL	LL
Inadequate water and sanitation	HH	HH	LL	LL	LL	HH	HH	LL	LL	LL	HH	HH	LL	LL	LL
MHDI	HL	HL	LH	LH	LH	HL	HL	LH	LH	LH	HL	HL	LH	LH	LH

Source: authors.

Briefly, the results show that the municipalities of the South-Central region of the country have lower dependency ratio values and better socioeconomic indicators. Although the municipalities of the North and Northeast are also undergoing a period of demographic transition, with a fall in fertility levels and growth in life expectancy, still present obstacles in the area of health, education and infrastructure in relation to other regions.

Table 5 presents the results estimated by the OLS method using the queen matrix for the spatial autocorrelation tests. The table contains the estimated coefficients, their standard deviations and the probability value. Only the variables life expectancy at birth and infant mortality rate were not significant in the years 2000 and 2010, respectively. The loss of significance in life expectancy at birth in 2000 may be related to the deceleration of the increase in this indicator from 2000 onwards compared to previous years, no longer directly impacting the dependency ratio.

The loss of significance of the infant mortality rate may be related to the "Programa Saúde da Família" (PSF) which aims to prioritize prevention, faster detection and constant monitoring of the population, with special attention to the reduction of infant mortality. According to Gomes, Bastos and Morais (2015), the expansion of PSF coverage is associated with a reduction in infant mortality rates. The per capita income, the expected years of schooling (except in 2010) and the MHDI presented an inverse relationship with the dependency ratio, that is, the higher the coefficients, the lower the dependency ratio.

The second part of Table 5 presents the diagnosis of heteroscedasticity, verified through the Breusch-Pagan and Koenker-Bassett tests. Thus, there is evidence that the errors are homoscedastic, and it is necessary to make the correction using the White matrix. In addition, through the Jarque-Bera test, the null hypothesis for the normality of the residuals is rejected, so the estimates may not be efficient and present greater standard error, which may be caused by the omission of explanatory variables in the model or incorrect mathematical formulation.

TABLE 5- Dependency Ratio - Ordinary Least Squares (OLS)

Variables	1991	2000	2010
Constant	46,9048*** (8,3002)	72,0499*** (4,9447)	53,2276*** (7,7430)
Life expectancy at birth	0,5895*** (0,1162)	0,0635 (0,0669)	0,2300** (0,0980)
Infant mortality rate	0,3392*** (0,0227)	0,0788*** (0,0171)	-0,0087 (0,0339)
Per capita income	-0,0073*** (0,0015)	-0,0091*** (0,0009)	-0,0077*** (0,0006)
Expected years of schooling	-1,2176*** (0,1107)	-0,8089*** (0,1060)	0,5891*** (0,0786)
Gini coefficient	11,8453*** (1,6507)	26,5787*** (1,2944)	33,6289*** (1,0862)
Inadequate water and sanitation	0,0625*** (0,0074)	0,1716*** (0,0064)	0,1644*** (0,0065)
MHDI	-57,8483*** (3,1100)	-45,0527*** (3,1269)	-57,9917*** (2,9872)
Heteroscedasticity and normality tests	**1991**	**2000**	**2010**
Breusch-Pagan test	1201,7576 [0,0000]	1654,4865 [0,0000]	2410,8446 [0,0000]
Koenker-Bassett test	425,9241 [0,0000]	611,0806 [0,0000]	591,2869 [0,0000]
Jarque-Bera test	3294,8558 [0,0000]	3049,1675 [0,0000]	9735,0213 [0,0000]
R^2	0,7416	0,7582	0,7500

Note: *** p<0,01, ** p<0,05, * p<0,1.
Source: authors.

Table 6 exposes the diagnosis for spatial autocorrelation, according to the queen matrix. Lagrange multiplier (LM) tests for the spatial lag of the dependent variable (SAR) and for the error term lag (SEM), and considering the autocorrelation in both cases (SARMA), in the classical and robust versions, evidenced the spatial autocorrelation. The test value was higher for SARMA, indicated as the best model capable of dealing with spatial dependence.

Table 7 reports the results of the SARMA model, whose values in parentheses are the standard deviations of each variable. To correct the problems caused by heteroscedasticity, the final model was estimated through the White matrix. All variables were significant in the analysis period (except for the Gini coefficient in 1991), which indicates that they had effects on the dependency ratio. In addition, the MHDI is the variable that has the greatest impact on the dependency ratio and the average per capita income the lowest. The expected years of schooling in 2010 had a change in the sign of the coefficient, starting to have a positive relationship with the dependency ratio. The variable life expectancy at birth did not present the expected coefficients, since the values were positive, the opposite of what was found in Global Moran's *I* analysis. In general, the variables: Life expectancy at birth, Infant mortality rate, Gini Coefficient, Inadequate water and sanitation showed a spatially positive relationship with the dependency ratio, while Per capita income, Expected years of schooling and MHDI presented an inverse relationship. In order to corroborate the importance of treating spatial dependence, all models presented in the methodology were estimated, with SARMA being the best of them.

TABLE 6- Diagnostic tests for spatial dependence

Tests	1991	2000	2010
Lagrange multiplier (lag)	4203,6217 [0,0000]	3204,6635 [0,0000]	2222,2118 [0,0000]
Robust LM (lag)	461,1130 [0,0000]	174,5471 [0,0000]	49,9543 [0,0000]
Lagrange multiplier (error)	4765,4614 [0,0000]	4553,1802 [0,0000]	3594,4943 [0,0000]
Robust LM (error)	1022,9526 [0,0000]	1523,0638 [0,0000]	1422,2368 [0,0000]
Lagrange multiplier (SARMA)	5226,5744 [0,0000]	4727,7274 [0,0000]	3644,4487 [0,0000]

Source: authors.

TABLE 7- Dependency Ratio – SARMA model

Variables	1991	2000	2010
Constant	35,9591*** (9,4455)	53,0699*** (6,3857)	42,9120*** (8,2375)
Life expectancy at birth	0,2535* (0,1444)	0,1545* (0,0826)	0,3534*** (0,1032)
Infant mortality rate	0,1526*** (0,0361)	0,0906*** (0,0238)	0,08537** (0,0393)
Per capita income	-0,0045*** (0,0014)	-0,0056*** (0,0008)	-0,0062*** (0,0006)
Expected years of schooling	-0,2789** (0,1211)	-0,3246*** (0,0889)	0,4998*** (0,0683)
Gini Coefficient	0,2764 (1,7053)	12,9284*** (1,0551)	20,9102*** (1,0915)
Inadequate water and sanitation	0,0457*** (0,0080)	0,0779*** (0,0065)	0,0967*** (0,0069)
MHDI	-43,7248*** (2,8875)	-47,3384*** (2,4325)	-60,2228*** (2,6239)
R^2	0,8657	0,826	0,7819

Note: *** p<0,01, ** p<0,05, * p<0,1.
Source: authors.

6 Final remarks

Brazil is undergoing a demographic transition at a more intense pace than in industrialized countries. This can be explained mainly by the fall in fertility and the increase in life expectancy. Other indicators such as reducing infant mortality, urbanization and the change in the role of women in society also contribute to the change in the age structure of the population.

This phenomenon will intensify over the years, in which population growth will follow low levels with the tendency of the elderly population overcome the young population. However, the current demographic situation is identified as the "window of opportunity" or “demographic bonus ", in which the dependency ratio reaches its lowest values. The opportunity is that with the greater participation of working age population it is possible to boost economic growth, since it is this population that produces, saves and invests. However, demographic changes have been occurring in a heterogeneous way among municipalities, and the South and Southeast regions have lower fertility rates and higher life expectancy.

The study analyzed the phenomenon of demographic transition in order to verify the formation of clusters for Brazilian municipalities and capture the changes that have occurred over the years. It was adopted as an indicator of the demographic transition to dependency ratio, which measures the relative participation of the inactive population, that should be supported by the share of the working age population. We also sought to capture the social and economic indicators that influence this phenomenon.

The ESDA results showed a North-South spatial disparity of the country, in which the North and Northeast regions present the formation of the High-High cluster, i.e., South, Southeast and Midwest form the Low-Low cluster, with low dependency ratio value. However, over the years the phenomenon has lost its spatial strength. What drew attention was the decrease in this pattern in the South, which can be explained by the growth of the elderly population, which consequently also increases the dependency ratio, which should also modify the clusters of other regions in the future.

In the bivariate results, the variables: Life expectancy at birth, Per capita income, Expected years of schooling and MHDI showed a negative spatial relationship in relation to the dependency ratio. For variables: Infant mortality rate, Gini coefficient and percentage of people in households with inadequate water supply and sewage positive spatial relationship.

In spatial regression, from Lagrange multiplier tests it was found that the SARMA model better treats spatial dependence. The main results showed that the variables were significant for all years (except Gini coefficient in 1991). In general, life expectancy at birth, Infant mortality rate, Gini coefficient and inadequate water and sewage had positive coefficients, indicating a positive relationship with dependency ratio. On the other hand, average per capita income, expected years of schooling and MHDI obtained negative coefficients indicating an inverse relationship.

Thus, aspects in the area of health, education, economics and infrastructure have a direct relationship in demographic indicators. In addition, it was possible to verify the heterogeneity of the Brazilian demographic transition, in which the municipalities of the South-Central region of the country are more advanced compared to the North and Northeast regions.

It is pointed out as one of the main challenges for the new Brazilian demographic profile the health area, public policies are needed to meet the growing demand for these services. Health care with elderly population is differentiated because they require greater investments, such as medicines, trained personnel and technological procedures. An older population will also bring new challenges to the area of social security, given the decrease in the population that contributes to social security, increasing public spending.

However, the reduction of the young population can be used to boost educational programs, given the fall in demand in this sector. Nonetheless, basic indicators of education, such as the illiteracy rate and expected years of schooling are still below what has been achieved by other economically similar countries. Investments in education increase the qualification of the workforce, which can overcome the future deficiency of fewer people in the labour market by increasing productivity.

REFERENCES

ALMEIDA, E**. Econometria Espacial Aplicada**. Campinas: Alínea Editora, 2012.

ALVES, J. E. D. A transição demográfica e janela de oportunidade**. Pesquisas Braudel**, São Paulo, 2008. Available: <http://pt.braudel.org.br/pesquisas/arquivos/downloads/a-transicao-demografico-e-a-janela-de-oportunidade.pdf>. Access: 04 jan.2016.

ANSELIN, L. **Spatial Econometrics**. **Methods and Models**. Kluwer Academic, Dordrecht, 1988

_____. **Spatial econometrics**. School of Social Science, University of Texas, Dallas, 1999.

BRITO, F. A transição demográfica no Brasil: as possibilidades e desafios para a economia e a sociedade**. UFMG/CEDEPLAR**, Belo Horizonte, Texto para discussão, n.318, 2007.

BRITO, F.; CARVALHO, J., A., M.; BAENINGER, R.; TURRA, C.; M.; QUEIROZ, B. M. **A Transição Demográfica e as Políticas Públicas no Brasil: Crescimento Demográfico, Transição da Estrutura Etária e Migrações Internacionais.** Belo Horizonte, 2007.

CARVALHO, J. A.; WONG, L. R. O Rápido Processo de Envelhecimento Populacional do Brasil: sérios desafios para as políticas públicas. **Revista Brasileira de Estudos de População**, São Paulo, v. 23, n.1, p. 05-26, jan.-jun. 2006.

CUTLER, D. M.; POTERBA J, M.; SHEINER L. M.; LAWRENCE S. "An Aging Society: Opportunity or Challenge?" **Brookings Papers on Economic Activity**. 1990. 1, pp. 1–73.

DUARTE, E.C; BARRETO, S. M. Transição demográfica e epidemiológica: a Epidemiologia e Serviços de Saúde revisita e atualiza o tema. **Epidemiol. Serv. Saúde**. Brasília, v.21, n4, p 529-532, out-dez, 2012.

GOMES, B. S. M.; BASTOS, S. Q. A; MORAIS, A. M.P. Impacto do PSF na mortalidade infantil nos municípios brasileiros (1993/2012). In: **Encontro Nacional de Economia**, 2015, Florianópolis.

GONÇALVES S. L; RODRIGUES T. A. P. Dividendo demográfico e razão de dependência infantil: uma análise exploratória espacial para os municípios mineiros. **UFMG/CEDEPLAR**, Diamantina, 2012.

KIRK, D. Demographic Transition Theory. **Population Studies.** 50, PP. 361-187. Printed in Great Britain. 1996.

LESAGE, J. P.; PACE, R. K. **Introduction to Spatial Econometrics.** CRC Press, Boca Raton, 2009.

MASON, A. Demographic transition and demographic dividends in developed and developing countries. **United Nations Expert Group Meeting on Social and Economic Implications of Changing Population Age Structure**, Ciudad del Mexico, 2005.

MILES, D. Modeling the impact of demographic change upon the economy. **Economic Journal**, 109, 1–36. 1999.

MINISTÉRIO DA SAÚDE. **Saúde Brasil 2008: 20 Anos de Sistema Único de Saúde (SUS)** Brasil. Brasília: Ministério da Saúde, 2009.

MORAN, P.A.P. The Interpretation of Statistical Maps. **Biometrika**, 35, 255-60. 1948.

NASIR, J. A.; TAHIR, M. H.A Statistical Assessment of Demographic Bonus Towards Poverty Alleviation.**Pak. J. Commer. Soc. Sci**, v. 5, n. 1, p. 01-11, 2011.

PEREIMA, J. B; PORSSE, A. Transição Demográfica, acumulação de capital e progresso tecnológico: desafios para o crescimento brasileiro**.** **RevistaEconomia&Tecnologia**. Paraná, v.9, n. 1, p. 49-60, jan-mar. 2013.

QUEIROZ, B. L.; TURRA, C. M.; PEREZ, E. R. The opportunities we cannot forget: economic consequences of population changes in Brazil. In: **ENCONTRO NACIONAL DE ESTUDOS POPULACIONAIS,** 15. Anais... Caxambu: Abep, 2006.

RIGOTTI, J. I. R. Transição Demográfica. **Educação e Realidade**. Porto Alegre, v. 37, n. 2, p. 467-490, mai.- ago.2012.

RIOS-NETO E. L. G. Questões emergentes na análise demográfica: o caso brasileiro. **Revista Brasileira Est. Pop**. São Paulo, v.22, n.2, p.371- 408, jul.- dez. 2005.

RIPSA – REDE INTERAGENCIAL DE INFORMAÇÕES PARA A SAÚDE. **Demografia e Saúde: Contribuição para Análise de Situação e Tendências.** Brasília, 2009.

SIMÕES, C. C. S.; OLIVEIRA, L. A. P. Perfil Estatístico de crianças e mães no Brasil: a situação da fecundidade; determinantes gerais e características da transição recente. **Fundação Instituto Brasileiro de Geografia e Estatística**. Rio de Janeiro, 1998.

SIMÕES R, GUIMARÃES C, GODOY N, VELLOSO T, ARAÚJO T, GALINARI R. Rede urbana da oferta de serviços de saúde: uma aná lise espacial multivariada para Minas Gerais. **In: Seminário sobre a Economia Mineira.** Belo Horizonte: Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais; 2004. p. 1-27.

SOUZA, E. R. Masculinidade e violência no Brasil: contribuições para a reflexão no campo da saúde. **Ciência & Saúde Coletiva**. Rio de Janeiro, v.10, n.1, p. 59-70, jan.-mar. 2005.

STAMPE, M. Z; PORSSE, A. A; PORTUGAL, M. S. Mudança Demográfica e crescimento econômico no Brasil: uma análise exploratória de dados espaciais. In: **Encontro Nacional de Economia**, 39, 2011, Paraná.

TURRA, C. M.; QUEIROZ, B. L. **Before it's too late: demographic transition, labour supply, and social security problems in Brazil**, UN Population Division, México, 2005.

UNITED NATIONS (UN). **World Population Prospects: The 2004 Revision.** Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. 2004.

VASCONCELOS, A.; GOMES, M. Transição demográfica: a experiência brasileira. **Epidemiol. Serv. Saúde**. Brasília, v. 21, n. 4, p. 539-548, out.-dez. 2012.

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