PRODUCTION FACTORS, REGIONAL ECONOMIC DEVELOPMENT AND AGRICULTURE IN BRAZIL: A SPATIAL ECONOMETRICS APPROACH

Submitted: July 7, 2023

Accepted: June 11, 2024

Published: July 8, 2024

Isabela Romanha de Alcantara[1]; Lucir Reinaldo Alves[2]

PRE-PROOF

(as accepted)

This is a preliminary and unedited version of a manuscript that has been accepted for publication in Revista Desenvolvimento em Questão. As a service to our readers, we are providing this initial version of the manuscript as accepted. The manuscript will still undergo revision, formatting, and approval by the authors before being published in its final form.

http://dx.doi.org/10.21527/2237-6453.2024.60.14781

ABSTRACT

Agriculture has a great effect on the development process of a region and production land, labor, and technology are determinant factors in its dynamism. This work carries out a spatial analysis for each production factor of Brazilian municipalities in 2006 and 2017 and intends to verify if there are patterns of association and agglomerations. This work is applied research of quantitative and exploratory nature. The Exploratory Analysis of Spatial Data (ESDA) was used to perform spatial analysis for each production factor in Brazilian municipalities in 2006 and 2017 and to check the patterns of association and agglomerations. The main agricultural activities and practice are related to exports as proposed by North. The formation of clusters verified both in the use of the factors of land, labor and technology, and in the value of agricultural production has a polarized role in the Brazilian space, as described by Perroux. This polarization and the formation of clusters expanded at certain points over time, indicating the

[1] Universidade de São Paulo (USP). Piracicaba/SP, Brasil.
https://orcid.org/0000-0001-9172-4271

[2] Universidade Estadual do Oeste do Paraná (UNIOESTE). Cascavel/PR, Brasil.
https://orcid.org/0000-0001-5703-623X

formation of new links with neighboring municipalities (*a la* Hirschman). The spatial association pattern was significant in all analyzed variables, with emphasis on the non-physical technology factor, presenting the highest spatial autocorrelation coefficient in both periods analyzed.

Keywords: Land; Labor; Technology; Exploratory Spatial Data Analysis.

FATORES DE PRODUÇÃO, DESENVOLVIMENTO ECONÔMICO REGIONAL E AGRICULTURA NO BRASIL: UMA ABORDAGEM ECONOMÉTRICA ESPACIAL

RESUMO

A agricultura possui grande efeito no processo de desenvolvimento de uma região, sendo os fatores de produção terra, trabalho e tecnologia determinantes no dinamismo deste setor. Este trabalho tem como objetivo efetuar uma análise espacial para cada fator de produção dos municípios brasileiros, em 2006 e 2017, e verificar se há padrões de associação e aglomerações. Este trabalho é uma pesquisa aplicada de natureza quantitativa e explicativa. A Análise Exploratória de Dados Espaciais (ESDA) foi utilizada para realizar análises espaciais para cada fator de produção nos municípios brasileiros em 2006 e 2017 e para verificar os padrões de associação e aglomerações. As principais atividades e práticas agrícolas estão relacionadas às exportações conforme proposto pelo North. Percebe-se que a formação de clusters verificada tanto no uso dos fatores de terra, trabalho e tecnologia, quanto no valor da produção agrícola exerce uma figura polarizada no espaço brasileiro, assim como descrito por Perroux. Essa polarização e a formação de clusters expandiram-se em certos pontos ao longo do tempo, indicando a formação de novos encadeamentos com os municípios vizinhos (*a la* Hirschman). O padrão de associação espacial foi significativo em todas as variáveis analisadas, com destaque para o fator tecnologia não física, apresentando o maior coeficiente de autocorrelação espacial nos dois períodos analisados.

Palavras chave: Terra; Trabalho; Tecnologia; Análise Exploratória de Dados Espaciais.

JEL Code: R12, O13, Q10.

1 INTRODUCTION

Food production and other agricultural activities have a great effect on the economic development process of a region. Locational aspects – such as such as edaphoclimatic characteristics, politics, market and other conditions – can influence this process because development is closely related to regional characteristics that stimulate diverse economic movements (PIACENTI; FERRERA DE LIMA; EBERHARDT, 2016). Regional development is conceptually multidisciplinary and has changed its 'guise' several times over time. Despite the situation, it is reckoned that development is a long-term process marked by economic growth and structural changes, the expansion of the market economy, the general increase in productivity, and the level of well-being of the population as a whole (DRUCIAKI, 2017).

In the development process, the agricultural sector is approached directly and indirectly by several classic authors of economics and economic geography. This suggests that agriculture can contribute to economic and regional development. Theories of regional economic development point out that locational aspects contribute in several ways to economic development (ALVES, 2016). Agriculture is a strategic sector that contributes to the regional economic development process, aided by an innovative process (VIEIRA FILHO; FISHLOW, 2017).

Research in agribusiness is crucial for innovation and improvement of existing technologies and for understanding the participation of each of these elements in the regions. Innovation and technology applied in agriculture have the capacity to reduce poverty in a region and also to improve the competitiveness and development rates of developed regions of a country. In other words, agriculture is a key sector for the connection between food security and economic development (DE JANVRY; SADOULET, 2009; VIEIRA FILHO; FISHLOW, 2017).

In production systems, farmers make decisions based on accumulated knowledge, as well as the choice of the best production model and the combination of factors. According to Alves, Souza, and Marra (2017), land, labor, and technology are the production factors that determine Brazilian agriculture. Factors may be physical or not. Physical factors are land, labor, and certain types of technologies, such as agricultural machinery, high-yield cultivars, pesticides, fertilizers, etc. A non-physical factor is knowledge (DUARTE; ALVES, 2016).

In Brazil's case, the development of agriculture is based mainly on productivity gains. The increase in productivity is highly related to the innovation process, which is dependent on certain stimuli (GASQUES et al., 2012) and location aspects of each Brazilian region. Brazilian agriculture is a strategic activity and of global importance. Brazil is the main producer of several products – such as sugar, orange, coffee – and is among the world leaders in soybean, corn, cotton and beef, pork, and poultry productions (FAOSTAT, 2019).

Given the importance of agriculture in Brazil as the motor of innovation and regional development, and in addition to the different ways of using the factors of production in each region, this work carries out a spatial analysis for each factor of production in Brazilian municipalities between 2006 and 2017 and check for patterns of association and agglomerations.

Thus, the importance of this research lies in the identification and analysis of strategic information regarding the geographical distribution of production factors – land, labor, and technology, which has classical economics as a reference, as well as Smith (1983) and Ricardo (1982) – as well as their evolution over time. It serves as a guiding tool for public policies and investment decisions. Furthermore, by examining patterns of association, clustering, and the interconnection among these factors, the research identifies specific geographical areas that are more conducive to certain types of production. This can drive innovation and regional development by concentrating efforts and resources in regions with higher agricultural potential.

This article is divided into five topics, including this introduction. The theoretical foundation, topic two, presents studies on the factors of production, agriculture, and regional development with an approach to regional development. Topic three presents the methodology used in this study, highlighting the procedures of Exploratory Analysis of Spatial Data (ESDA). Topic four presents a spatial analysis of the production factors in Brazilian agriculture. The conclusion summarizes this work.

2 THEORETICAL FOUNDATION

2.1 Spatial economics

Economic development refers to the dynamic process of growth and economic transformation that occurs in specific regions, taking into account the unique characteristics of each locality, including its natural resources, politics, economy, infrastructure, human capital, and culture. Several authors distinguish between spatial and economic theories when elaborating syntheses on the evolution of development theories. The first manifestations of the development problem are restricted to theories about spatial differences and territorial and productive concentration (DALLABRIDA, 2010). The space economy had been marginalized from economic thought for a long time. The studies were based on a kind of ideal country and without dimension. The introduction of space in economic analysis forced the expansion of certain existing theories, instead of simple generalizations. Models became more complex and more variables were considered (BENKO, 1999). Keeble (1975) summarizes the main works on models of economic development and classifies them based on spatial and non-spatial approaches.

Spatial economics studies the entities that form the basis of economic process dynamics. Its main objective is the study of the location of economic activities, the spatial behavior of companies, territorial accounting, etc. (BENKO, 1999). In the economic sense, the notion of space encompasses all effects caused by dimensions, limitations, location, and distances, such as the size of arable land surfaces, climate, location of industries, sources of raw materials and consumer market, legal limitations on ownership and use of nature. Von Thünen was one of the pioneers in the study of the spatiality in economic relations in the early 19th century. Von Thünen's theory analyzes how the economy organizes the use of territorial space in the face of income, land, quality, and transportation costs.

The disposition of economic activities tends to form a gradient starting from the urban center, whose lands are more valued due to the greater concentration of consumers, even to the most peripheral regions. Therefore, it is suggested that producers of more perishable items tend to pay more for land use because of the necessary central location. Producers of greater durability items tend to choose cheaper land in peripheral regions (FUJITA; KRUGMAN; VENABLES, 2002). Therefore, the type of economic activity is related to its location in the face of spatial heterogeneity.

In the 20th century, other geographers used the precepts of geometry to explain the concentration of productive activities organized in the form of hexagons, as well as the geographic layout of markets and transportation costs. It is worth to mention Weber (1929), Christaller (1966), and Lösch (1939; 1957), the latter being considered a modern precursor of the regional and urban economy.

Locational characteristics play a decisive role in the success of an activity and in the development of regions. Authors such as Perroux (1955), North (1955), and Hirschman (1958) are important references in this study. Likewise, the agricultural activities of a given territory and its subsequent industrialization / technification are capable of triggering a development process, hitherto inexistent in that location. This triggering motivation can also be explained based on the precepts of innovation by Schumpeter (1961; 1982).

In the case of the polarization theory, François Perroux (1955) points out that growth / development does not happen everywhere uniformly. It occurs in poles, with different intensities and spreads through different channels, and varying effects on the economy (PERROUX, 1955). The growth poles become development poles when they interfere in their own environment, creating positive effects that propagate in the territory.

Polarization is induced by a certain driving force (mainly industrial), which leads the agglomerations and encourages the emergence of satellite activities and the supply of inputs for the main activity. Furthermore, this driving force has an influence on the economic space of the region, in which the intensity of these internal relations is greater in comparison with other regions that do not have driving activities (PAELINCK, 1977). For Schultz (1953), the economic organization works best at or near a given economic development matrix. In other words, the growth pole owes its existence to the central location of a driving industry.

The growth of the driving industry attracts other related industries due to the external economies created in the region. As these industries grow under the impetus of the driving force, the pole as a whole expands further. Paelinck (1977) describes two facts that condition this regional expansion: i) the intensity of personal income flow; ii) the intensity of technical and commercial relations between companies in the region.

When comparing the theory of Perroux (1955) with agriculture, it is clear that the development of specialized cultures may present a polarized behavior in space, given the geographical characteristics, availability of technical assistance, and adapted local culture and infrastructure. Agribusiness is related to the driving industry.

On the other hand, analyzing the American context, Douglass North starts his studies focusing on the agricultural territory used for subsistence and self-sufficiency with little investment in trade. With improvements in transport and other local infrastructures, the region starts to develop some specialization, resulting from the initial exploration of agriculture. An attraction of labor and a stimulus to innovation and technology are happening in the region. Hereby there has been a trend towards an increase in interregional business. Through a process of large-scale industrialization and production growth and development, consolidating the region's specialty and its base export activity became evident (NORTH, 1955).

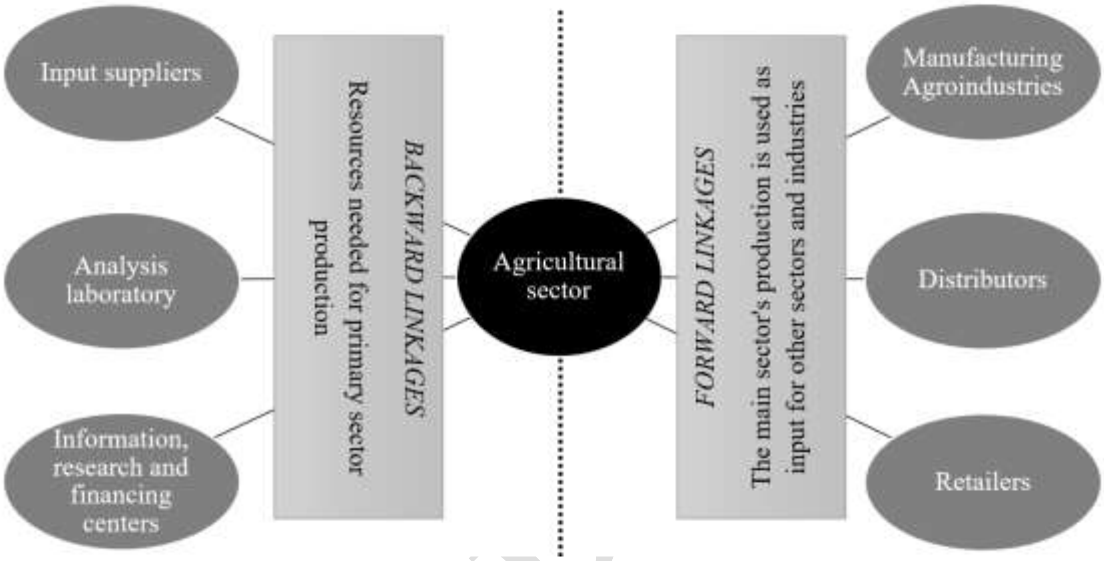
The export base influences regional development based on how the basic sectors are dynamic and diversified over time and how the institutional matrix relates to these sectors. The dynamism of the basic sectors occurs as a result of the reduction in production costs over time and the type of product exported in relation to the income elasticity of demand. The production costs are affected by the reduction of transport costs, through the improvement of infrastructure, by the increase in the productivity of the factors of production (which will be a consequence of technological innovations) and by the flows of factors, mainly the human one (NORTH, 1955).

In the same way that the driving industry generates a series of positive regional effects and the consolidation of export activities, highlighting the effects related to the generation of jobs and the integration of the transport network. North (1955) and Perroux (1955) theories are similar regarding the premise that the success of a region is related to its locational characteristics, making the region more competitive, and in relation to the importance of agricultural production, developing process, and the consolidation of regional specialization.

The regional development described by North (1955) exemplifies a spillover effect, which is the development under an export base that stimulates the growth of the foreign economy; the improvements in organizations specializing in marketing, credit, and transportation; the availability of specialized labor; and the formation of networks of companies with complementary activities. Such network formations can be better understood according to Hirschman's theorem (1958) presented below.

Hirschman (1958) found that the development of the export sector is based on backward and forward linkages. The backward link is the result of an autonomous growth of a certain sector motivated by new investment or use of the previously existing productive capacity. Due to demand pressures, this chain stimulates the growth of other related sectors. The effects of forwarding chain are motivated by the increasing production of a certain factor and, consequently, it causes an increase in the production of other related sectors due to the increase in the product offer. Both chains can form a regional productive chain. This process could be better understood in Figure 1.

Figure 1 – Agricultural sector linkages



Source: prepared by the authors, based on Hirschman (1958).

The performance of the agricultural sector generates backward linkages and forward linkages. This sector demands resources to generate its production, among them the suppliers of inputs (such as fertilizers, fertilizers, seeds, machinery, etc.), the analysis laboratories (whose function is to analyze the quality and point out the results of the agricultural production), information centers, research and financing (such as centers that present meteorological, market and other information and credit institutions, such as banks and cooperatives). In contrast, the agricultural sector offers inputs that are later used as inputs for manufacturing agribusinesses, demanding services of storage and distribution centers, and supplying retail stores to the final consumer.

As well as the effects of supply and demand imbalance on the production chain (as proposed by Hirschman), the innovation of an agent (as well as the driving industry, according to Perroux's ideas) also has a strong influence on its related sectors (it can also be around a base export activity, according to North). Joseph Schumpeter's ideas propose methods for the process of innovation as modernization, complementing previous theories.

In Schumpeter's (1982) theory of economic development, innovation can occur through new combinations, e.g.: i) introducing a product or adding a new quality to a good; ii) introduction of a new production method or a new way of presenting the commercial product; iii) operating in a new market; iv) negotiation with a new supplier of raw materials or semi-manufactured products; v) creation of a new industry, such as the creation of a monopoly or the breaking of a competing monopoly.

Schumpeter (1982) emphasizes that the innovative agent breaks with the circular and stationary flow of economic life. When this agent brings new products to the market, either through new production combinations or through the application of some invention or technology, consumers are encouraged to desire new things (which differs from the stationary habit of the past). In addition, it is a process that occurs from a creative idea, from the creation or alteration of an activity developed in the past. This can result in improvements both internally, such as increasing efficiency, and externally, such as the formation of positioning of the brand. Thus, the process of 'creative destruction' is prescribed, in which old products, patterns, and habits are replaced by new ones.

Innovation applied in agriculture can have several effects that benefit the region, society, the local and global economy, and the market. Vieira Filho and Silveira (2011) corroborate that innovation in agriculture depends on the accumulation of knowledge. Over time, the farmer's learning process is responsible for increasing productivity and reducing production costs. The success of this process depends on the producer's ability to interpret and assimilate the new information and the managerial ability to use technological knowledge. Therefore, according to the authors, innovation is an element that propels the overflow effect, that is, the spillover effect.

In general, a region's economic development is closely related to its location factors. Agriculture strongly influences the development and is listed by several classic authors. Innovation is one decisive character for the success of a region, since a driving industry (*a la* Perroux) works as a catalyst, amid a chaining effect (*a la* Hirschman) that makes a regional pole (*a la* Perroux) and / or an export base for a given product (*a la* North). The innovation process is motivated according to Schumpeter's ideas.

3 METHODOLOGY

This section presents the general characteristics and details the main procedures necessary to carry out the Exploratory Analysis of Spatial Data (ESDA) to perform spatial analysis for each production factor in Brazilian municipalities in 2006 and 2017 and check the patterns of association and agglomerations. This work is applied research of quantitative and exploratory nature. Moreover, this work is bibliographic and documentary in technical procedures.

In the perspective of the functional model proposed by Alves, Souza, and Marra (2017), proxies were selected to describe the factors of land, labor, and technology, whose observations came along through all municipalities in Brazil for the years 2006 and 2017. According to Duarte and Alves (2016), technologies can be physical and not physical. Hence the physical character technology is portrayed through the *proxy* number of tractors existing in agricultural establishments; the non-physical character through the percentage *proxy* of establishments whose producer has a higher education level. These variables are described in Table 1. Secondary data from all municipalities in Brazil in the years 2006 and 2017 were used according to the Agricultural Censuses (IBGE, 2006a; 2017a) and Municipal Agricultural Production (IBGE, 2006b; 2017b).

Table 1 – Variables

Variable	Description	Data source
GVA	Value of agricultural production - Gross Value Added (Thousand Reais,Brazilian currency)	Municipal Agricultural Production (IBGE, 2006b; 2017b)
TER	Area of agricultural establishments (hectares)	2006 Agricultural Census. (IBGE 2006a; 2017a)
TRA	Number of persons employed in agricultural establishments (persons)	2006 Agricultural Census. (IBGE 2006a; 2017a)
TECNF	Percentage of establishments whose producer has college education (establishments)	Agricultural Census (IBGE, 2006a; 2017a)
TECF	Number of tractors in agricultural establishments (units)	Agricultural Census (IBGE, 2006a; 2017a)

Source: Prepared by the authors.

To meet the proposed objective, it was necessary to verify the presence of a spatial association pattern for each production factor using a spatial weighting matrix (contiguity), based on the results of Moran's Statistics *I*, and finally the application of the ESDA (Exploratory Analysis of Spatial Data). Subsection 3.1 gives a presentation of the essential procedures for carrying out the ESDA. The results were presented in Section 4, aided by thematic maps that allow the verification of the transformation of space over time and the formation of *clusters*.

3.1 Exploratory Analysis of Spatial Data (ESDA)

ESDA is a method that specifies models related to heterogeneity and spatial dependence. This process depends on the variation of interactions across space. Through this method, it is possible to verify patterns of spatial associations in the context of global or local autocorrelation, univariate or multivariate, estimated by Moran's *I* statistics, using a spatial weighting matrix (*W*). The global spatial autocorrelation identifies the existence of association patterns for the variable considering the entire territory. The analysis of local spatial autocorrelation is more appropriate when the researcher is seeking specific information to a location, such as agglomeration patterns or clusters.

The first step in an ESDA study is to verify the hypothesis that spatial data is randomly distributed. The spatial randomness of a regional value attribute indicates the non-correlation's attribute with neighboring regions. Spatial autocorrelation refers to a set of data ordered according to a spatial sequence. Such information can be presented on a map that indicates the attributes of a variable and provides information on arrangements and agglomerations of these attributes in space (ALMEIDA, 2012).

The spatial autocorrelation coefficient, Moran's *I*, was first proposed by Moran (1948), who used the measure of autocovariance in the cross product form. This indicator obtains the spatial autocorrelation from the result of the deviations from the mean and the statistic is algebraically presented according to Equation 1.

$$I = \frac{n}{\sum\sum w_{ij}} \left(\frac{\sum\sum W_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum(y_i - \bar{y})^2} \right) \quad (1)$$

Where *n* is the number of regions (spatial units); $\sum\sum w_{ij}$ is the sum of all the weighting elements of the matrix for the pair of spatial units *i* and *j*; $(y_i - \bar{y})(y_j - \bar{y})$ are the deviations from the mean, in which y_i it is the variable of interest. This calculation turns possible to estimate the autocorrelation function for each neighborhood order, whose null hypothesis (H_0) is that of spatial independence, being necessary to establish statistical significance. The result of Moran's *I* varies in a range from -1 to +1, with 0 (zero) being the value that indicates spatial randomness. The values closer to -1 indicate negative (inverse) spatial autocorrelation because of the existence of dissimilarity between the values of the attributes and the spatial location of these attributes. The positive spatial autocorrelation indicates a similarity between the values of the attributes and the spatial location of these attributes, whose Moran's *I* values are close to +1 (FOTHERINGHAM; BRUNSDON; CHARLTON, 2002).

In short, Moran's *I* statistic provides three types of information: i) the significance level provides information about the random or standardized distribution of data; ii) the sign (positive or negative) indicates the type of relationship of the attributes between the spatial units (direct or indirect); iii) the magnitude of the statistics provides the strength of the spatial autocorrelation, that is, the closer to +1, the stronger the concentration; the closer to -1, the more dispersed the data is; and zero indicates spatial randomness (ALMEIDA, 2012).

The spatial weighting matrix (*W*) seeks to reflect a given spatial arrangement of the interactions resulting from a given phenomenon. Based on the assumption of Tobler (1970), regions connected to each other have greater interaction than regions less connected. The spatial weighting matrix is a square matrix of dimension $n \times n$. Each connection between regions is represented by a cell of this matrix, being called spatial weight. This means that w_{ij} spatial weights represent the degree of connection of region *j* over region *i* (ALMEIDA, 2012).

There are several types of spatial weighting matrices, among them geographical proximity and socioeconomic proximity. The geographic proximity matrix can be determined by contiguity or geographic distance. The socioeconomic proximity matrices are based on the concepts of similarity, dissimilarity, and flows. This work focuses on describing the characteristics of the geographic proximity matrix.

The spatial weighting matrices were built based on the idea of contiguity in which two neighboring regions have a common borderline. So the spatial weights are assigned in the matrix *W* in a binary sequence, where:

$$w_{ij} = \begin{cases} 1 \; if \; i \; and \; j \; are \; contiguous \\ 0 \; if \; i \; and \; j \; are \; not \; contiguous \end{cases} \tag{2}$$

By convention, $w_{ii} = 0$, because a region must not be neighboring itself. Therefore, the diagonal of this matrix is composed of null (zero) values. Conventionally the contiguity typologies allude to the movements of the pieces of a chess game. The “queen” contiguity convention considers the interaction relationship whose spatial units have edges and vertices in common. The “rook” contiguity convention discusses the neighborhood relationship only in polygons whose contact occurs at its edges. The “bishop” contiguous relationship only affects the interaction between space units whose contact occurs at their vertices. Regarding the queen convention, Anselin (2005) notes that the number of neighbors for a given space unit will be equal to or greater than using the tower convention. The difference in the number of neighborhoods between the queen and rook relationship corresponds to the number of contiguous bishop-type interactions.

Among the main characteristics of these binary spatial weight matrices are:

- Multidirectionality: interactions occur in all directions and unbalanced connectivity (existence of regions with different numbers of neighbors);
- Possibility of clearly defining spatial orders: first-order neighborhoods are polygons that have direct contiguity, second-order neighborhoods have indirect contiguity, as they consider neighbors of neighbors, while third-order neighbors assume an interaction relationship with neighbors of neighbors of neighbors, and so on.

Another criterion for defining the spatial weighting matrix is the geographical proximity to the *k* closest neighbors, $w_{ij}(k)$. So a binary matrix whose convention can be defined as follows:

$$w_{ij} = \begin{cases} 1 \; if \; d_{ij} \le d_i(k) \\ 0 \; if \; d_{ij} > d_i(k) \end{cases} \tag{3}$$

Where $d_i(k)$ is the shortest distance to region i specifically, so that i has exactly k neighbors. That is, all space units will have the same number of neighbors, but the distance between such neighbors varies from region to region. This ensures that there is no formation of "islands" (regions without neighbors). Besides, the diagonal values in the matrix are also null, $w_{ij}(k) = 0$.

From the application of ESDA is possible to see how the variables land, labor, and technology are related in space, which municipalities have high / low value for each variable, and whether these are surrounded by municipalities with the same characteristic or opposite ones. These results will help to identify which regions of Brazil is more pronounced for each variable and could be subject to comparison.

4 RESULTS AND DISCUSSIONS

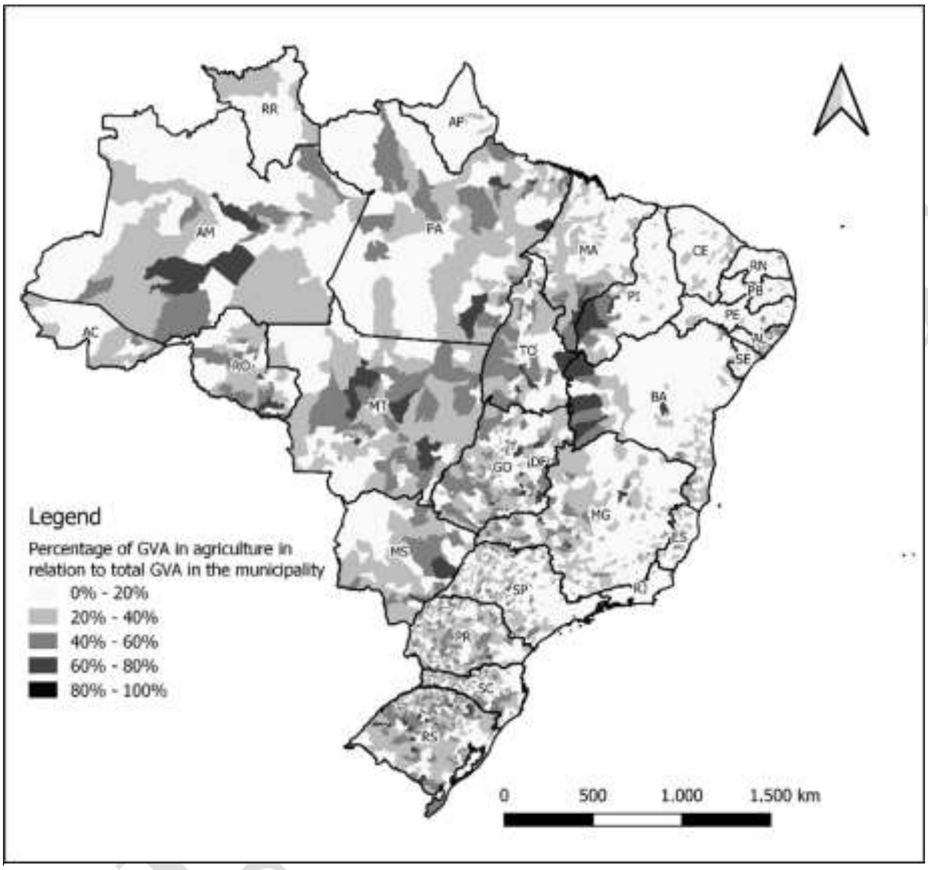
There are several approaches that define the production function. According to the model proposed by Alves, Souza, and Marra (2017), the agricultural production function is formed by land, labor and technology factors.

The following topics present the results of the ESDA on the value of agricultural production and land, labor, and technology factors, as well as a general analysis of the Brazilian context. The spatial weight matrix chosen was that of 4 neighbors (based on the shortest Euclidean distance), given to the fact it presents greater contiguity among other tested matrices, verified by means of Moran's *I* statistics. This topic is divided into four sessions, starting with the value of agricultural production, followed by the variables of land, labor, and technology (physical and non-physical).

4.1 Value of agricultural production

Agricultural activity is important for many municipalities in Brazil. In 2006 the value of Brazilian agricultural production was R$ 99 trillion. This value experienced a 70% growth over the next 11 years, reaching R$ 317 trillion in 2017. Given the different regional and locational characteristics of Brazilian municipalities, the value of agricultural production was heterogeneous in space. Figure 2 shows the percentage of agriculture Gross Value Added (GVA) (*Valor adicionado bruto* – VAB) in relation to the total GVA of the municipality.

Figure 2 – Percentage of agricultural GVA under the total GVA of the municipality, Brazil – 2017

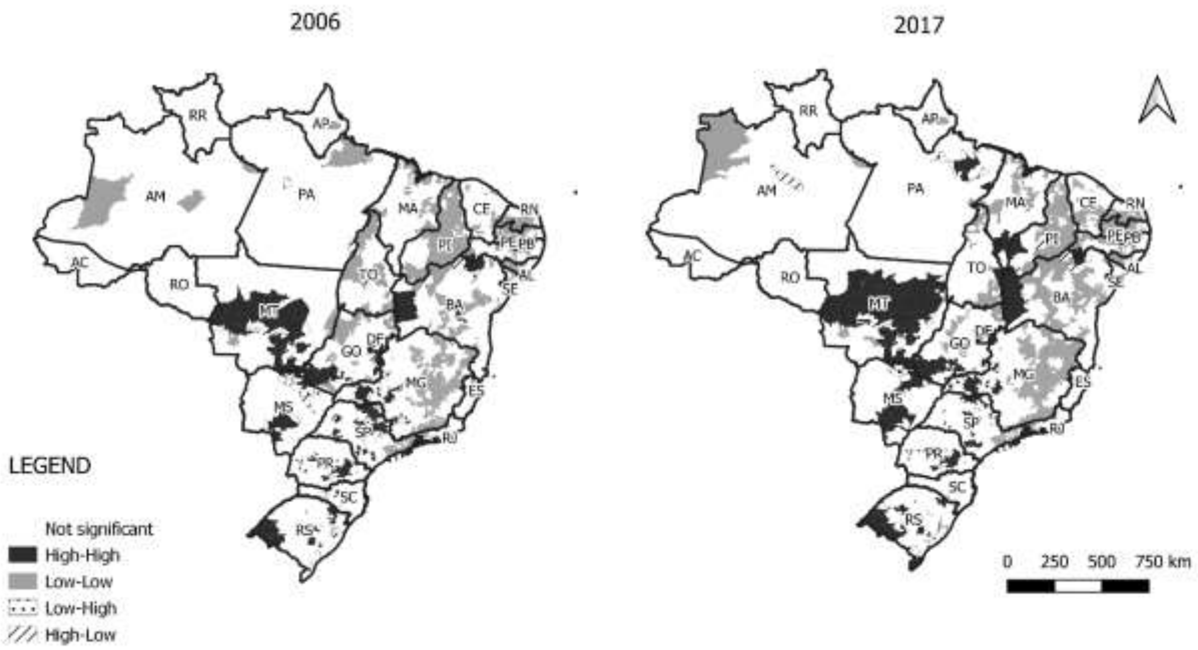


Source: prepared by the authors, based on data from IBGE (2017c).

Although the municipal economies have a heterogeneous behavior, there is a predominance of GVA participation in agriculture settled in municipalities in the western portion of the country. The GVA of 21% of Brazilian municipalities corresponds to more than 1/3 of the total GVA. This phenomenon may be related to favorable conditions for agricultural production in this region, such as the availability of land and topographies conducive to mechanization, suitable edaphoclimatic conditions, and productive specialization sustained by an export market.

Figure 3 shows the result of the application of the local Moran *I*, the *clusters*, whose spatial autocorrelation coefficient was 0.37 and 0.39 for the years 2006 and 2017 respectively. It indicates the presence of autocorrelated data in the space in a positive way. The positive spatial autocorrelation reveals the presence of similarity between the values and the spatial location of the municipalities. In other words, municipalities with a high agricultural production value are surrounded by municipalities with a high GVA, while municipalities with low values tend to be surrounded by neighbors who also have low GVA. This positive variation in the spatial association indicator indicates that the spillover effect intensified between 2006 and 2017.

Figure 3 – Local Moran I of GVA, by municipality, Brazil – 2006/2017



Source: prepared by the authors, based on data from the IBGE Municipal Agricultural Production (2006b; 2017b).

It is noted that the spatial distribution of GVA in Brazilian municipalities underwent certain transformations between 2006 and 2017. The HH *cluster* in the southwestern Rio Grande do Sul, a region known for rice production, expanded over the period analyzed due to the spillover effect. In 2017, 31% of the value of rice production in Brazil came from the southwestern mesoregion of Rio Grande do Sul.

The expansion of *cluster* HH in the central portion of Mato Grosso do Sul, Mato Grosso, and MATOPIBA was also verified. In 2017, the states of Mato Grosso and Mato Grosso do Sul were responsible for 25% and 7% of the value of Brazilian soybean production. In general, the

MATOPIBA region has undergone an inversion process, although *cluster* HH has perpetuated itself in the extreme west of Bahia. The agglomeration of this mesoregion of Bahia increased over the period analyzed. Furthermore, it is clear that certain LL *clusters* that existed in the states of Tocantins, Maranhão, and Piauí disappeared in 2017. This region has attracted a lot of attention from researchers due to the increased productivity, whose geographic characteristics are favorable for the cultivation of grains and fibers. According to Buainain, Garcia, Vieira Filho (2017), from the 2000s onwards, MATOPIBA represents a new agricultural frontier with significant productive potential, and its activities have contributed to structural changes in the region.

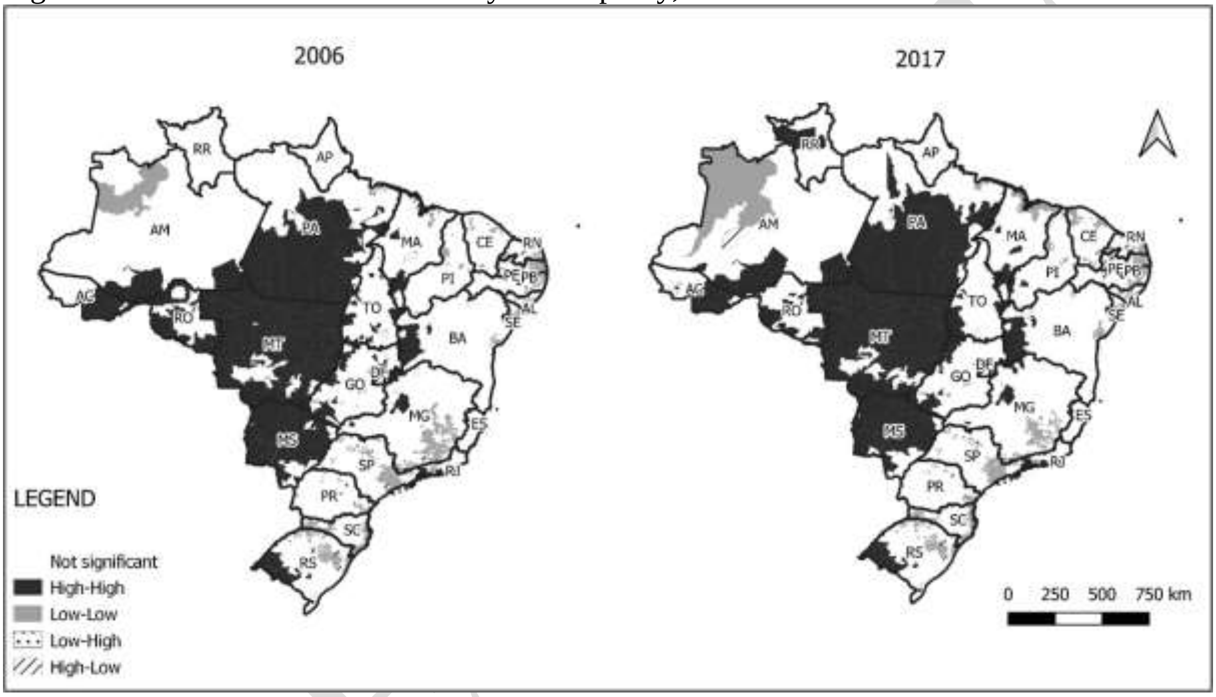
The value of agricultural production grew, in general, in several municipalities in the states of the South, São Paulo, Mato Grosso, Goiás, Pará, MATOPIBA, the western portion of Minas Gerais and in certain regions of Mato Grosso, Rondônia, Espírito Santo, Amazonas, and Roraima. This tendency is related to the type of culture produced in the region. In 2017, 35% of the Brazilian agricultural value production was soybean, 17% sugarcane, 10% corn, and 6% coffee.

Given the large proportion of the value of soybean production in relation to the total GVA, the spatial layout of the municipalities' GVA is similar to the figure that indicates the spatial layout of soybean farming municipalities. The highest values of soybean production, the main product of Brazilian agro-exports, are prevalent throughout the Midwest, South, MATOPIBA, and western potions in the Southeast (*a la* North). In a global context, Brazil has become the largest producer of soybeans, producing 126 million tons of this oilseed in the 2019/20 season. This phenomenon was a historic landmark because it was the first time that Brazilian production surpassed the United States' production (which produced 96.7 million tons in that same season) due to productivity gains. In 2020/21 Brazil remained in the leadership position, breaking its own record and producing 131 million tons, which corresponds to 36% of world production. American production was 112 million tons, 31% of world production (USDA, 2020). Biotechnology has considerably benefited soybean production in Brazil because it has contributed to increased production without the need for more cultivation areas and thus avoiding pressure for more deforestation.

4.2 Land Factor

Production factors and spatial autocorrelation coefficient for the land point at a greater positive spatial standardization. For the land factor, Moran's *I* coefficients were 0.38 for 2006 and 0.42 for 2017. Figure 4 shows the local Moran *I* in the area of agricultural establishments in 2006 and 2017.

Figure 4 – Moran I local land factor by municipality, Brazil – 2006/2017



Source: prepared by the authors, based on data from the IBGE Agricultural Census (2006a; 2017a).

On the one hand, there is the formation of a single HH *cluster* that covers almost all the states of Mato Grosso, Mato Grosso do Sul, Pará, Rondônia, Acre, which lasted from 2006 to 2017. Other isolated HH *clusters* verified in the rest of the Brazilian space have remained relatively stable. On the other hand, the LL *cluster* in the north and southwest of Amazonas increased over the period analyzed. This indicates that municipalities with small areas of agricultural establishments and are surrounded by neighbors with the same characteristic have increased in these Amazonian mesoregions.

The municipalities with the largest areas of agricultural establishments are located in the states of the Midwest, Pará, and in the MATOPIBA region. The area of agricultural establishments is related to the type of activity that is practiced in the space.

According to Bezerra and Cleps Junior (2004), at the beginning, the expansion of agricultural production in the Midwest took place through the use of labor and the incorporation of new lands in the border area (1930s). In a second moment, after the 1960s, the development of this region took place through the participation of the Brazilian State as an inducer of this process. Only from the 1990s, the Midwest began to develop with its own means based on the incorporation of technical progress in agriculture.

Based on data from the IBGE Agricultural Census (2017a), it appears that municipalities with agricultural establishments occupy between 60% and 80% of the total area of the municipality is predominant in Brazil. In the northern region, agricultural establishments occupy a low percentage of the total area of the municipality, mainly in the states of Amazonas, Acre, Roraima, Amapá, and southwest Pará and lower Amazons. This behavior may be related to environmental conservation laws in the Amazon biome.

The use of the land factor has undergone profound changes over the last few decades in Brazil. A mapping with geocoded images, generated by the Rural Environmental Registry (*Cadastro ambiental rural* – CAR), allowed the identification of land use throughout the national territory segmenting into area for protected and preserved vegetation, agricultural use, and infrastructure. The relative predominance of the agricultural occupation establishments obeys a pattern of spatial distribution related to the environmental aspects of the region and the environmental protection legislation.

In Brazil, there are two realities that coexist in agricultural areas: exploited areas, where native vegetation has been replaced by agrosilvopastoral systems; and unexplored areas, where native vegetation is maintained at various levels of conservation and protection. CAR data indicate that land use in the agricultural sector is 30.2% of the national territorial space, which is less than a third predominantly formed by planted pastures (13.2%), followed by native pastures (8%), crops (7.8%), and planted forests (1.2%). Moreover, 66.3% of the territory of Brazil corresponds to areas of protected and preserved vegetation, subdividing into areas intended for the preservation of native vegetation in rural properties (25.6%), native vegetation in vacant and unregistered lands (16.5%), indigenous lands (10.4%) and integral conservation units (10.4%) (MIRANDA, 2017).

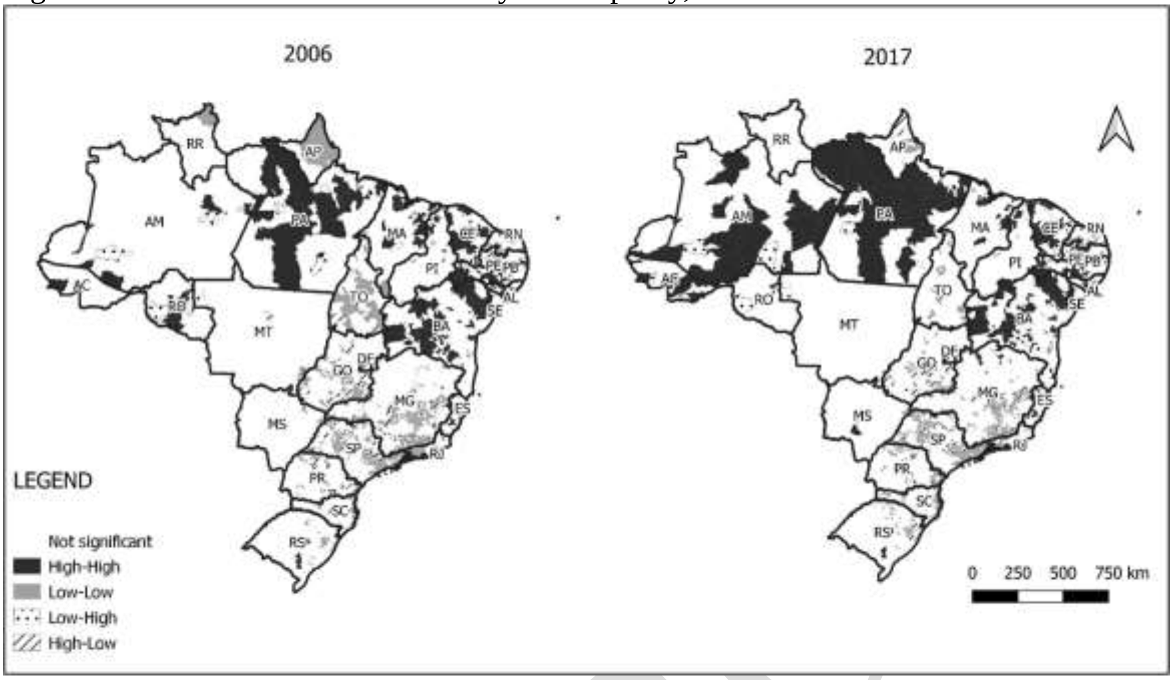
Land use management contributes to the protection of watersheds, prevents erosion, and mitigates climate change. Agricultural expansion has been disaggregated by deforestation in recent decades. The studies by Lapola et al. (2013) and Tollefson (2010) point out that since the 2000s deforestation rates have decreased while agricultural production has increased.

In the past, the main concern of agribusiness in Brazil was the expansion of borders and monocultures. Agricultural researchers are currently debating intensification, no-till farming, crop rotation, and agroforestry aiming food providing for the world market, without harming the environment (TOLLEFSON, 2010). Brazilian agriculture has intensified and is increasingly oriented towards large-scale production of *commodities* (especially soybean, sugar cane, and corn).

4.3 Labor Factor

Figure 5 shows the local Moran's *I* for the number of people employed in agricultural activities by municipalities in relation to the contiguity of the labor factor for the years 2006 and 2017. In Brazil, the autocorrelation coefficient was 0.35 and 0.38 for 2006 and 2017 respectively.

Figure 5 – Moran I local labor factor by municipality, Brazil – 2006/2017



Source: prepared by the authors, based on data from the IBGE Agricultural Census (2006a; 2017a).

Although the number of workers in agricultural establishments has reduced to 1.6 million people, it is clear that an HH agglomeration formed in the North and Northeast regions of Brazil between 2006 and 2017. The MATOPIBA region has both HH and LL agglomerations. On the other hand, the Center-South region is predominantly characterized by municipalities whose establishments have low numbers of workers and neighbors with this same LL characteristic. In Goiás, it is noticed the presence of some municipalities that have a high number of people engaged in agricultural activities, whose contiguity is of municipalities with opposite characteristics (HL) both in 2006 and in 2017.

The expansion of HH *clusters* in the North and Northeast can also be compared to the increase in the number of people engaged in agricultural activities in these regions. Besides, there are few changes in the Center-South region.

According to Alves, Souza, and Marra (2017), it was estimated that in 1970 there were 2.4 rural residents for each rural worker in Brazil, with regard to the ratio of rural population / employed personnel. This number was reduced to 1.6 in 1985. This phenomenon can be explained by the number of employed persons, which grew significantly between 1970 and

1985 and contributed to the drop in the relative proportion of resident / rural workers. The growth of employed persons occurs because of the increase in rural wages in relation to urban wages, inducing residents of both rural and urban areas to seek employment in the countryside.

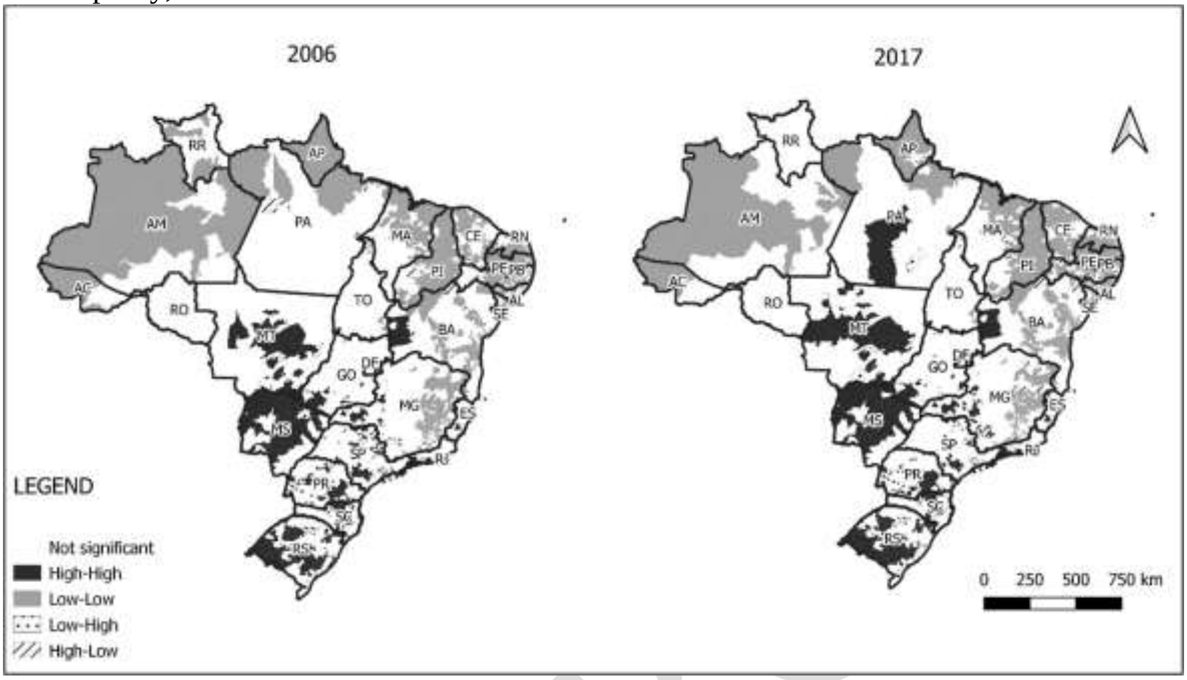
In 1996, the decrease in the number of employed persons brought the proportion of resident / rural workers to 2.0. This means that rural residents have taken on more urban jobs, even though maintaining rural residency. However, in 2006 this ratio dropped to 1.8. Such a phenomenon can be explained by rural wages that attracted more urban workers, with urban residency, and also those from the rural environment, previously unemployed or with urban employment (ALVES; SOUZA; MARRA, 2017).

4.4 Technological Factor

Regarding technology, the literature proposed by Duarte and Alves (2016) describes that this factor can have a physical and non-physical typology. In this work the number of tractors is used as a *proxy* for the physical typology technology factor and the percentage of establishments whose producers have college education is used as a *proxy* for the non-physical typology technology factor.

Figure 6 shows the local Moran's *I* of the number of tractors in agricultural establishments by municipalities in Brazil during 2006 and 2017. The spatial autocorrelation coefficient was 0.42 for both periods, indicating a positive spatial association pattern. This indicates that the concentration pattern was the same throughout the analyzed period.

Figure 6 – Moran's I location of the number of tractors in agricultural establishments by municipality, Brazil – 2006/2017



Source: prepared by the authors, based on data from the IBGE Agricultural Census (2006a; 2017a).

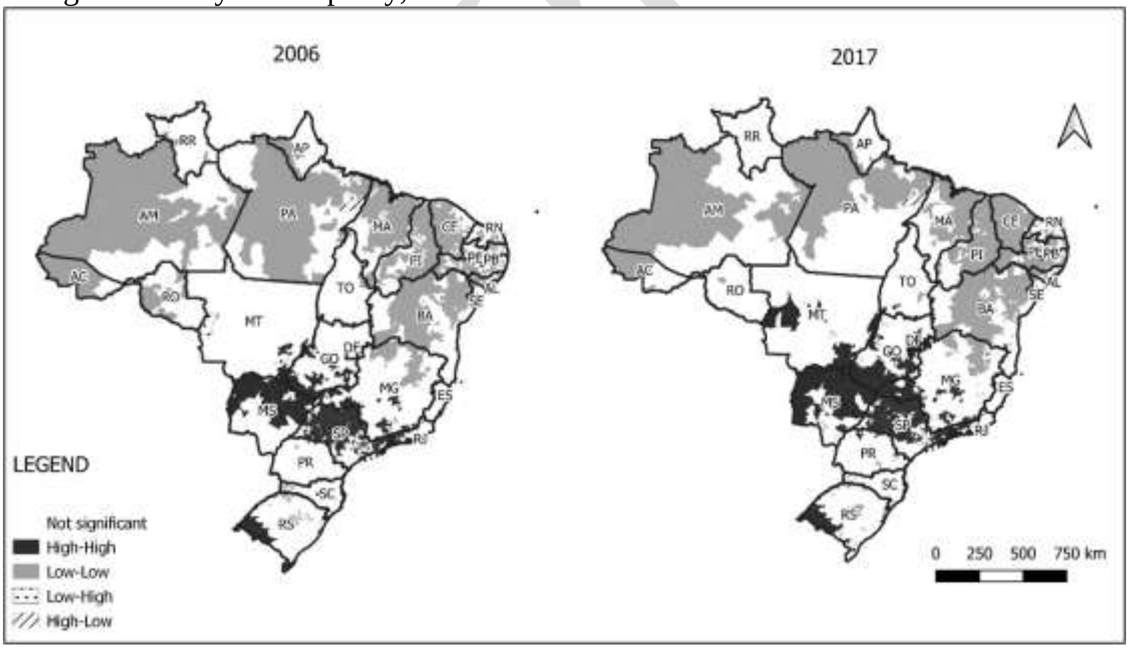
Between 2006 and 2017 there was a transformation in the space related to the formation of physical technology *clusters*. The predominance of HH *clusters* was in the Center-South region in both periods analyzed. In the states of the Midwest, there was an expansion of HH *clusters*, while in certain points of the North and Northeast there was a reduction of BB *clusters*. The states of Minas Gerais and Bahia presented municipalities with a high number of tractors surrounded by neighbors with the same characteristic (HH) in the western portion and the opposite situation (LL) in the eastern portion.

Between 2006 and 2017, it is observed that the number of tractors in agricultural establishments increased significantly in several Brazilian municipalities. This phenomenon highlights the process of mechanization in agricultural activities – which has contributed to productivity gains – and may be related to public policies and incentives, such as rural credit and the Moderfrota program (Agricultural Tractor Fleet Modernization and Associated Implements and Harvesters). Of the existing tractors in agricultural establishments, 42% are located in the South (of which 47% are in Rio Grande do Sul), 30% in the Southeast, 16% in the Midwest, and 12% in the Northeast and North.

According to data from the IBGE Agricultural Censuses (2006a; 2017a), there is a considerable reduction over time when considering the average size for each tractor unit, indicating that the rural space has become more mechanized. In 2006, the average size of agricultural establishments per tractor unit was 406.6 hectares. In 2017, that number increased to 285.6 hectares. In addition, the power of the tractors has also increased over time. In 2006 there were 250,068 tractors with more than 100 horsepower in agricultural establishments. In 2017 that number rose to 328,865.

Regarding non-physical technology, Figure 7 shows the local Moran *I* by municipalities in Brazil in 2006 and 2017. The percentage of agricultural establishments whose producers had higher qualifications was used as a *proxy*. The spatial autocorrelation coefficient was 0.61 for 2006 and 0.71 for 2017 (the highest verified in this work). In other words, the percentage of agricultural establishments with a higher education level for the producer is ordered according to a positive spatial sequence.

Figure 7 – Moran's I location of the percentage of establishments whose producer education is of higher level by municipality, Brazil – 2006/2017



Source: prepared by the authors, based on data from the IBGE Agricultural Census (2006a; 2017a).

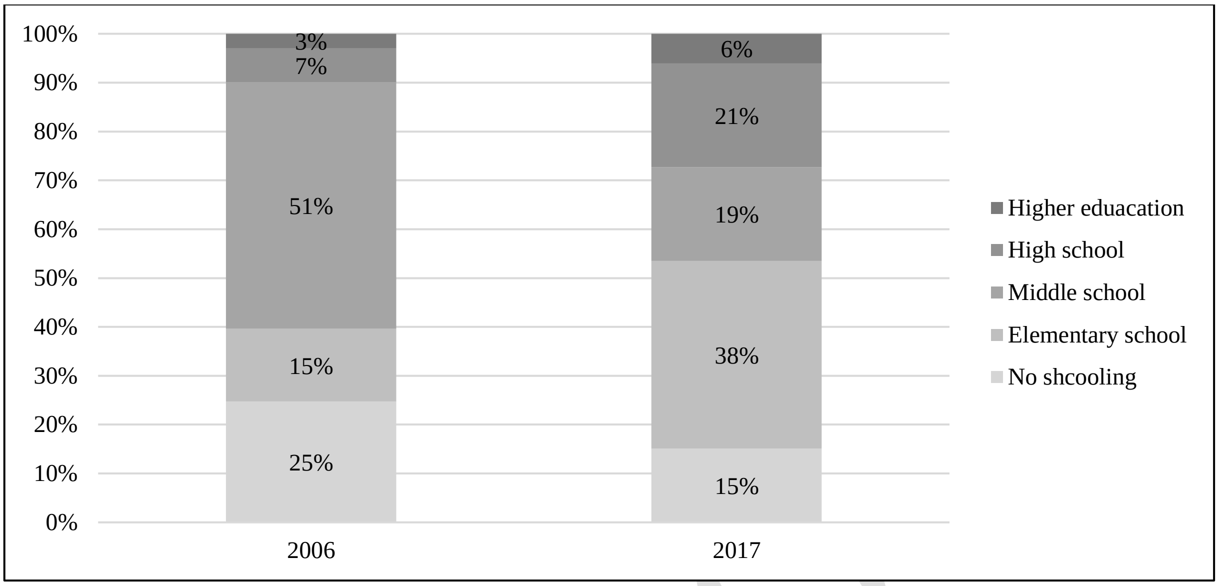
When analyzing the local spatial association pattern regarding the non-physical technology factor, it is noticed that the North and Northeast regions have predominantly LL-type *clusters*. This means that these municipalities have low non-physical technology whose contiguity is of municipalities with the same characteristic.

In the Center-South region, however, the formation of HH *clusters* is predominantly observed. Over the period analyzed, this type of *cluster* expanded along the axis between the states of Mato Grosso do Sul, Goiás, Minas Gerais, and São Paulo. A certain expansion was also seen in the Southwest of Rio Grande do Sul.

It is noticed that in addition to the percentage of agricultural establishments whose educational level of the producer has college education has also spread in the space between 2006 and 2017. In 2006 the predominance of agricultural establishments with non-physical technology was on the Goiás, São Paulo, Minas Gerais, and Mato Grosso Sul axis and in certain points of Mato Grosso and Rio Grande do Sul. In 2017 non-physical technology intensified in the aforementioned regions and began to cover all states in the South, Southeast, Midwest, Rondônia, Roraima, Tocantins, Amapá, and part of the other states in the North and Northeast of Brazil.

Figure 8 shows the number of establishments according to the level of rural producer education in 2006 and 2017.

Figure 8 – Percentage of agricultural establishments according to the level of rural producer education in 2006 and 2017



Source: prepared by the authors, based on data from the IBGE Agricultural Census (2006a; 2017a).

Between 2006 and 2017 the percentage of agricultural establishments whose producers have no schooling decreased from 25% to 15%. Such a phenomenon may be related to the advance in producer studies since primary education increased from 15% to 38% over the same period. The percentage of agricultural establishments whose producer has a basic education was predominant in 2006 (51%) and risen to 19% in 2017. The percentage of agricultural establishments whose producer has a basic education has tripled over the period analyzed, with the level showing the greatest growth from 7% to 21%. The percentage of agricultural establishments whose producers have higher education doubled from 3% to 6% between 2006 and 2017, suggesting that the family succession process has occurred along with a higher level of schooling for the owners of the establishments.

The rural family strongly values the education of their children, especially higher education. In recent years, the growing rural mobility, the advancement of Information and Communication Technologies (ICT) (*Tecnologias de Informação e Comunicação* – TIC) and the access of farmer children to higher education are boosting the rural environment and giving leverage to new perspectives of social ascension. In this perspective, educational policies have gradually provoked a process of social transformation in the Brazilian countryside (REDIN, 2017), even though they are still accessed by the minority of rural youths.

Agriculture knowledge impacts production more than inputs. 'It is by writing that the production of potatoes increases' says a French writer (DUARTE; ALVES, 2016). Non-physical technology is decisive for productivity gains. Citing Vieira Filho and Fishlow (2017: 61), “it is not the distribution of land that will increase productivity, but rather the use of technology which depends on the ability to absorb new knowledge”. In Brazil, the productivity gain is related to the advance of non-physical technology.

It seems that the locational factors and spatial disposition are associated with the economic development of Brazilian municipalities. The main agricultural activities and practice is related to exports, as proposed by North. The formation of *clusters* is verified in relation to land, labor, and technology – physical and non-physical – and concerns to the value of agricultural production, exerting a polarizing figure in the Brazilian space, as described by Perroux. This polarization and the formation of *clusters* expanded over time, indicating the formation of new links with neighboring municipalities (*a la* Hirschman). These effects stimulate the spread of regional economic development through space and contiguity relationships.

5 FINAL CONSIDERATIONS

This article analyzed the use of production factors in Brazilian agriculture and its spatiality in 2006 and 2017. Regional economic development is related to the use of production factors. It is important to identify the spatiality of agricultural production factors in Brazilian municipalities to understand the development process. This work analyzed the factor combination of land, labor, and technology – physical and non-physical – and their effects on regional economic development for Brazilian municipalities in 2006 and 2017.

The phenomenon of Brazilian agriculture is also related to the regional development approach, according to the thoughts of North, Perroux, and Hirschman. The regions that showed the highest value of agricultural production coincide with those that have the highest value for agro-exports (*a la* North). The main exported product is soybeans and China is Brazil's main trading partner. The factors of land, labor, physical and non-physical technology, and the value of agricultural production in the municipalities presented polarized agglomerations (*clusters*), as Perroux proposed in his theory. The transformations of these agglomerations and the phenomenon of expansion indicated the formation of new chains with contiguous municipalities in space (*a la* Hirschman). In short, the trajectory of agriculture contributes to understanding the dynamism of the Brazilian economy and space.

The spatial association pattern was significant in all analyzed variables, with emphasis on the non-physical technology factor, presenting the highest spatial autocorrelation coefficient in both periods analyzed. Brazilian agriculture is marked by profound transformations, which have made Brazil stop being a net food importer and become one of the global leaders in agro-exports. The country has become one of the main *players* in global agribusiness. Several events stimulated the advancement of science and technology, rendering expressive gains in productivity. Agricultural activities are decisive for the economic performance of several Brazilian municipalities stimulated by exports.

Over the past few decades, environmental protection and urban development laws have established a territorial limit for agricultural production in Brazil. The intensification of urbanization, the growth of the service sector and the increasingly intensive use of technologies resulted in the decrease of labor supply in rural areas. The incorporation of technological innovations in modern agriculture has become crucial to achieve productivity gains and sustainable progress. Technological innovation requires knowledge and Brazilian agriculture is becoming a science-based sector.

This analysis has the potential to facilitate participatory planning and suggests the importance to bring farmers to the table for discussions since the knowledge economy has become a determining factor for the good performance of the agricultural sector. Based on the proposed discussion, it is expected that the growing use of technology and the dialogue between institutions and producers will enhance agricultural productivity.

REFERENCES

ALMEIDA, E. *Econometria espacial aplicada*. Campinas: Alínea, 2012.

ALVES, E.; SOUZA, G. S.; MARRA, R. Uma viagem pelas regiões e estados guiada pelo Censo Agropecuário 2006. *Revista de Política Agrícola*, v. 26, n. 1, 113-150, 2017.

ALVES, L. R. *Reestruturação produtiva e desenvolvimento local*: o caso do município de Toledo. 2016. Tese (Doutorado em Geografia, especialidade em Planejamento Regional e Urbano) - Universidade de Lisboa, Lisboa, 2016.

ANSELIN, L. *Exploring spatial data with GeoDaTM*: a workbook. Urbana-Champaign: Center for Spatially Integrated Social Science, 2005.

BENKO, G. *A ciência regional*. Oeiras: Celta, 1999.

BEZERRA, L. C.; CLEPS JUNIOR, J. O desenvolvimento agrícola da região Centro-Oeste e as transformações no espaço agrário do estado de Goiás. *Caminhos de Geografia*, v. 2, n. 12, p. 29-49, 2004.

BUAINAIN, A. M.; GARCIA, J. R.; VIEIRA FILHO, J. E. R. Dinâmica da Economia e da Agropecuária no Matopiba. *Texto para discussão IPEA 2283*. Rio de Janeiro: IPEA, 2017.

CHRISTALLER, W. *Central places in Southern Germany*. Englewood Cliffs: Pretince-Hall, 1966.

DALLABRIDA, V. R. *Desenvolvimento regional*: por que algumas regiões se desenvolvem e outras não? Santa Cruz do Sul: EDUNISC, 2010.

DE JANVRY, A.; SADOULET, E. Agricultural growth and poverty reduction. *World Bank Research Observer*, v. 25, n. 1, p. 1-20, 2009. DOI: 10.1093/wbro/lkp015.

DRUCIAKI, F. P. Desenvolvimento territorial: conceitos e elementos. In: BIDARRA, B. S.; VOLL, F. A.; FERRERA DE LIMA, J. *Economia e desenvolvimento territorial*. Foz do Iguaçu: Parque Itaipu, 2017.

DUARTE, J.; ALVES, E. O elemento invisível no progresso tecnológico. *Revista de Política Agrícola*, v. 25, n. 1, p. 122-124, 2016.

FAOSTAT - Food and Agriculture Organization of United Nations. *Food and agriculture data.* 2019 Disponível em: http://www.fao.org/faostat/ Acesso em: 8 ago. 2019.

FOTHERINGHAM, A.; BRUNSDON, C.; CHARLTON, M. *Geographically weighted regression:* the analysis of spatially varying relationships. Chichester, UK: Wiley, 2002.

FUJITA, M.; KRUGMAN, P.; VENABLES, A. J. *Economia espacial:* urbanização, prosperidade econômica e desenvolvimento humano no mundo. São Paulo: Futura, 2002.

GASQUES, J. G.; BASTOS, E. T.; VALDES, C.; BACCHI, M. R. P. Total factor productivity in Brazilian agriculture. In: FUGLIE, K. O.; WANGS, S. L.; BALL, V. E. *Productivity growth in agriculture:* an international perspective. Oxfordshire: CAB International, 2012.

HIRSCHMAN, A. *The strategy of economic development.* New Haven: Yale University Press, 1958.

IBGE - Instituto Brasileiro de Geografia e Estatística. *Censo Agropecuário 2006*. Sidra - Sistema de Recuperação Automática. 2006a. Disponível em: https://sidra.ibge.gov.br/pesquisa/censo-agropecuario/censo-agropecuario-2006. Acesso em: 01 jul. 2019

______. *Produção Agrícola Municipal*. SIDRA - Sistema de Recuperação Automática. 2006b. Disponível em: https://sidra.ibge.gov.br/pesquisa/pam/tabelas. Acesso em: 01 jul. 2019.

______. *Censo Agropecuário 2017*. Sidra - Sistema de Recuperação Automática. 2017a. Disponível em: https://sidra.ibge.gov.br/pesquisa/censo-agropecuario/censo-agropecuario-2017. Acesso em: 01 jul. 2019.

______. *Produção Agrícola Municipal.* SIDRA - Sistema IBGE de Recuperação Automática. 2017b. Disponível em: https://sidra.ibge.gov.br/pesquisa/pam/tabelas. Acesso em: 01 jul. 2019.

______. *Produto Interno Bruto dos Municípios*. SIDRA - Sistema de Recuperação Automática. 2017c. Disponível em: https://sidra.ibge.gov.br/pesquisa/pib-munic. Acesso em: 01 jul. 2019.

KEEBLE, D. E. Modelos de desenvolvimento econômico. In: CHORLEY, R. J.; HAGGETT, P. *Modelos sócio-econômicos em geografia.* Rio de Janeiro: Livros Técnicos e Científicos Editora S.A., 1975.

LAPOLA, D. et al. Pervasive transition of the Brazilian land-use system. *Nature Climate Change,* v. 4, p. 27-35, 2013. DOI: https://doi.org/10.1038/nclimate2056.

LÖSCH, A. *The economics of location*. New Haven: Yale University, 1939.

______. *Teoría económica espacial*. Buenos Aires: Ateneo, 1957.

MIRANDA, E. E. Meio ambiente: a salvação pela lavoura. *Ciência e Cultura*, v. 69, n. 4, 2017. DOI: http://dx.doi.org/10.21800/2317-66602017000400013.

MORAN, P. The interpretation of statistical maps. *Journal of the Royal Statistical Society*, v. 10, n. 2, p. 243-251, 1948. DOI: https://www.jstor.org/stable/2983777.

NORTH, D. Location theory and regional economic growth. *Journal of Political Economy*, v. 63, n. 3, p. 243-258, 1955.

PAELINCK, J. A teoria do desenvolvimento regional polarizado. In: SCHWARTZMAN, J. *Economia regional*. Belo Horizonte: CEDEPLAR, 1977.

PERROUX, F. Note sur la notion des poles de croissance. *Economie Appliquee*, v. 8, p. 307-320, 1955.

PIACENTI, C. A.; FERRERA DE LIMA, J.; EBERHARDT, P. H. *Economia e desenvolvimento regional*. Foz do Iguaçu: Parque Itaipu, 2016.

REDIN, E. Políticas educacionais e juventude rural no ensino superior. *Educar em Revista*, n. 63, p. 237-252, 2017.

RICARDO, D. *Princípios de economia política e tributação.* São Paulo: Abril Cultural, 1982.

SCHULTZ, T. *Economic organization of agriculture*. New York: McGraw-Hill Book Company Inc., 1953.

SCHUMPETER, J. A. *Capitalismo, socialismo e demografia*. Rio de Janeiro: Editora Fundo de Cultura, 1961.

______. *Teoria do desenvolvimento econômico:* uma investigação sobre lucros, capital, crédito, juro e ciclo econômico. São Paulo: Abril Cultural, 1982.

SMITH, A. *A riqueza das nações:* investigação sobre sua natureza e suas causas. Vol. I. São Paulo: Abril Cultural, 1983.

TOBLER, W. R. A computer movie simulating urban growth in the Detroit region. *Economic Geography*, v. 46, p. 234-240, 1970. DOI: 10.2307/143141.

TOLLEFSON, J. Food: the global farm. *Nature,* v. 466, p. 554-556, 2010. DOI: 10.1038/466554a.

USDA - United States Department of Agriculture. Value added years by State. *Stats By Commodity.* 2020. Disponível em: https://apps.fas.usda.gov/psdonline/app/index.html#/app/statsByCommodity. Acesso em: 06 ago. 2020.

VIEIRA FILHO, J. E. R.; FISHLOW, A. *Agricultura e indústria no Brasil:* inovação e competitividade. Brasília: IPEA, 2017.

VIEIRA FILHO, J. E. R.; SILVEIRA, J. M. Modelo evolucionário de aprendizado agrícola. *Revista Brasileira de Inovação,* v. 10, n. 2, p. 265-300, 2011.

WEBER, A. *Theory of the location of industries*. Chicago: University of Chicago, 1929.

Corresponding Author:

Isabela Romanha de Alcantara

Universidade de São Paulo (USP).

Av. Pádua Dias, 11 - Agronomia, Piracicaba/SP, Brazil. CEP 13418-900

E-mail: isabelaralcantara@gmail.com