

COOPERATIVES AND BRAZILIAN AGRICULTURAL PRODUCTION: A SPATIAL ANALYSIS

Área ANPEC: Área 11 - Economia Agrícola e do Meio Ambiente

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Resumo:

Como importantes elos de ligação entre os produtores e o mercado, e respondendo direta ou indiretamente por relevante parte do Produto Interno Bruto agropecuário nacional, as cooperativas carecem de estudos que mensurem o quanto são capazes de influenciar a produção no meio rural, considerando as diferenças regionais brasileiras. Assim, com este trabalho visou-se avaliar a existência e a magnitude do efeito das cooperativas na produção agropecuária das regiões brasileiras. Para tanto, foi construída uma função de produção, tendo as cooperativas como um fator deslocador da função de produção, considerando correção espacial, em nível municipal, para as regiões brasileiras. Os resultados evidenciam dependência espacial nos dados utilizados, justificando a abordagem metodológica utilizada neste trabalho. Verificou-se efeito positivo do cooperativismo no Valor Bruto da Produção da agropecuária nos municípios das regiões Sudeste, Centro-Oeste e Sul, ao passo em que se notou influência restritiva da associação às cooperativas no Norte e Nordeste do país. Conclui-se, portanto, que a expansão do cooperativismo pelas regiões do país não foi um processo homogêneo, havendo ainda um longo caminho a ser percorrido para que se tenham níveis mais elevados de cooperação no meio rural brasileiro.

Palavras-Chave: Cooperativismo; Econometria Espacial; Função de Produção.

Abstract:

Cooperatives are important linkages between producers and the market, responding directly or indirectly for a relevant portion of the agricultural gross domestic product. There is a lack of studies that measure how much cooperatives influence production in the rural environment, considering the Brazilian regional differences. Thus, the objective is to identify the influence of cooperatives in the agricultural production of Brazilian regions. Therefore, a production function considering cooperatives as one of its inputs was constructed, considering a spatial correction at the municipal level for the Brazilian regions. The results show that there is spatial dependence on the data used, justifying the methodological approach used in this work. There was a positive effect of cooperatives on the Gross Value of Agricultural Production in the municipalities of the Southeast, Center-West and South regions, while the restrictive influence of the cooperative association in the North and Northeast of the country was noted. It is concluded, therefore, that the expansion of cooperatives by the regions of the country was not a homogeneous process, and that there is still a long way to go in order to have higher levels of cooperation in the Brazilian countryside.

Keywords: *Cooperatives; Spatial Econometrics; Production Function.*

JEL: Q13, C21

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1. Introduction

Cooperatives¹ in rural areas primarily comprise farmers seeking to alleviate the anxiety associated with their activities. In Brazil, according to data taken from the last Agricultural Census, approximately 41% of the gross value of agricultural and livestock production (GVP) passes through a cooperative (IBGE, 2016). Thus, cooperatives coordinate the activities of actors in the primary sector of the economy and provide important market access routes.

Although relevant in terms of agriculture, few studies assess the influence of agricultural and livestock cooperatives in Brazil from economic or production perspectives. Internationally, authors such as McNamara et al. (2001), Folsom (2003), Zeuli et al. (2003), Zeuli and Deller (2007), Rodrigo (2012), Cazzuffi (2013), and Jardine et al. (2014) have evaluated the economic effects of cooperatives in rural areas. These studies consider the impacts of cooperatives on, among other things, the value of production and the gross domestic product (GDP)². However, none consider cooperatives in the context of Brazilian agriculture.

Studies on cooperativism in Brazilian agriculture need to consider the characteristics of regions, as reflected in the rural environment. The findings of studies by, for example, Helfand and Brunstein (2001), Silva et al. (2003), FGV (2010), Kageyama et al. (2013), Helfand et al. (2014), and Belik (2015) reinforce the differences in productive patterns and the inequalities in agricultural areas. Such inequalities are not restricted to the large property versus small property dichotomy. Profound heterogeneity exists even among the smaller establishments in the various regions of Brazil.

Therefore, in this study, we examine the influence of cooperatives on agricultural production in Brazilian regions, which is markedly heterogeneous in terms of production, socioeconomic factors, and “social capital”, in the sense shown by Putnam (1995). Given this objective, we employ a production function that includes spatial corrections, and takes inputs commonly used in rural production, considering the cooperatives and its influence in the productive process.

The article consists of four sections besides this introduction. In the second section, we briefly discuss the cooperativism in the Brazilian agricultural sector. In the third section, we present the empirical strategy used, and the data source. In the fourth section, we bring the discussion about the results. Finally, the fifth section deals with the final considerations about the established problem.

2. Cooperativism in Rural Brazil: Relevance and Heterogeneity

The literature on the economics of organizations explains the existence of agricultural cooperatives in terms of their ability to: a) generate economies of scale; b) access new markets, including international markets; c) reduce costs through vertical integration; d) reduce risks in joint actions; e) enable members to access and adopt technologies and inputs through technical assistance services; f) provide members with greater bargaining power to obtain better prices; and g) dilute the risk of economic activities by undertaking joint actions (Bonus, 1986; Sexton, 1986; Staatz, 1987; Hansmann, 1988, 1996; Sexton and Iskow, 1988; Bialoskorski Neto, 2000; Valentinov, 2007).

These characteristics explain the spread of cooperativism in several countries. In Japan, agricultural cooperatives include around 90% of all farmers, while in Canada and Norway, 4 out of 10 farmers are members of cooperatives. Furthermore, in New Zealand, cooperatives account for 95% of the dairy market and 22% of GDP (Namorado, 2013).

In Brazil, the use of the cooperative model dates back to the end of the 19th century in the states of São Paulo and Pernambuco. In 1902, the first rural credit cooperative (or credit unions) of the Raiffeisen model emerged (Nova Petrópolis, RS), followed in 1907 by the first agricultural cooperative (Minas Gerais). During the first half of the 20th century, these were the most relevant agricultural cooperatives in terms of

¹ Although the word “cooperative” can be applied to different types of collectively developed activities, we use the term to describe a democratically controlled and managed business model. In many countries, as in Brazil, cooperatives are defined legally as a specific type of corporation, and are subject to specific federal legislation (Zeuli and Radel, 2005).

² Similar works can be found in Zeuli and Deller (2007) and Uzea and Duguid (2015). Both analyze the nuances of the economic impact of cooperatives, highlighting the methodologies used in such studies.

volume of business, and were largely responsible for the diffusion of the cooperative ideology throughout the country (Silva et al., 2003).

Pinho (1996) and Presno (2001) assert that cooperatives were fomented by the government since the 1930s as instruments for the application and dissemination of public policies oriented to the agrarian sector (e.g., technical assistance, market access, etc.). However, no prior studies have examined the sustainability of most cooperatives created as a result of these policies. Additionally, the 1980s were characterized by a slowdown in national economic activity and state interventionist policies, coupled with growing demand for more modern management practices. These factors led to the disappearance of many agricultural cooperatives, as well as a growing fear of such organizations (Pinho, 1992; Presno, 2001; Bialoskorski Neto, 2005).

Today, after overcoming the crises of the 1980s and 1990s, Brazilian agricultural cooperatives have become one of the most prominent branches of cooperativism, and are important players in many parts of the agrifood chain. According to the Organization of Brazilian Cooperatives (OCB; 2014), agricultural cooperatives made up 23.5% of all active cooperatives in 2013³.

According to the OCB (2011, 2014), the agricultural cooperative movement registered a decrease in the number of cooperatives until 2004, but then gained strength thereafter, surpassing 1 million members in 2013 (see Figure 1). In terms of economic participation, agricultural cooperatives played a major role. For example, in 2013, they were directly responsible for 340,000 jobs and accounted for 6% of the national GDP (OCB, 2014).

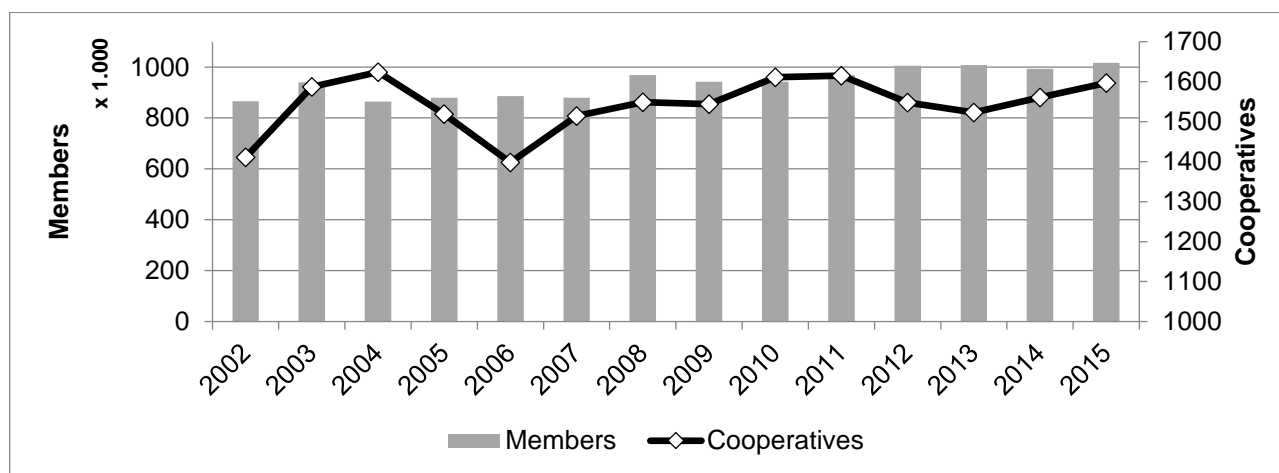


Figure 1 - Number of cooperatives affiliated to the OCB and its members, agricultural sector, 2002 to 2015
Source: Authors, with data from OCB (2013) and OCB (2017).

However, the distribution of these cooperatives throughout the national territory is somewhat heterogeneous. This reflects the marked regional differences in Brazil (see Table 1).

Table 1 - Percentages of agricultural farms, farms associated with cooperatives and gross value of production (GVP), Brazilian regions, 2006

	North	Northeast	Southeast	South	Midwest	Brazil
Farms (%)¹	9	47	18	19	7	100
Gross Value of Production (%)¹	6	17	32	27	18	100
Associated to Cooperatives (%)²	3.8	4.3	18	31.9	12	14.4

Notes: ¹ Percentages obtained considering the participation of each region in the total.

² Percentages obtained considering the proportion of associated farms in each region and in Brazil.

Source: IBGE (2012).

³ In addition to the OCB, other organizations that comprise groups of cooperatives directly linked to agriculture are the National Union of Cooperatives for Family Agriculture and Solidarity Economy (UNICAFES) and the Confederation of Cooperatives for Agrarian Reform in Brazil (CONCRAB). These organizations have significant numbers of cooperatives and associates. For example, in 2012, UNICAFES had 789 affiliated cooperatives and 365,145 members (according to the organization's own data).

According to data taken from the 2006 Agricultural Census, on average, 14.4% of farms were associated with cooperatives. In addition, there is an evident disparity between the Brazil regions, not only in terms of the consolidation of the cooperative movement, but also in terms of the number of farms and the agricultural GVP. According to Helfand and Brunstein (2001), these regional differences are recurrent in analyses of Brazilian agriculture. This reflects the diverse conditions in the infrastructure, labor market, and distances from consumer centers and other points, as well as case-specific cooperation, cultural, and historical issues.

In 2006, only 3.8% of the rural establishments in the North Region were associated with cooperatives. In the Northeast, where a little over 4% of the establishments were associated with cooperatives, there was a significant contrast between the proportion of establishments (47%) and their participation in the GVP (17%). In contrast, the South and Southeast Regions had the highest percentages of establishments associated with cooperatives (31.9% and 18%, respectively). These two regions also showed the highest participation in the gross value of agricultural production (GVP), leading to the question of whether, in fact, cooperatives aid the production of agricultural establishments.

Although it does not completely explain the magnitude, these regional differences in Brazilian cooperativism were strongly influenced by immigrants. Germans, Italians, and Japanese settled in the South and Southeast Regions. Many of these immigrants had some experience with associativism, instilling the culture, cooperative education, and high level of social capital⁴ necessary to serve as a foundation for a competitive cooperativism structure (Silva et al., 2003). In addition, governmental aid contributed to these regional discrepancies, with the greatest flow in recent decades going to the Southeast Region (Duarte, 1986).

3. Empirical Strategy

3.1. Production Function

We employ a generic production functional relationship, $Y = f(W, L, K \dots)$, as described in Humphrey (1997), where Y is the output resulting from the combination of the factors of work W , land L , capital K , and so on, and adapt it to the objective of this work, as follows:

$$Y_i = f(W_i, L_i, I_i, K_i, C_i), \quad (1)$$

where Y_i is the gross value of agricultural production, W_i refers to the work units used, L_i is the cultivated area (in hectares), I_i represents the amount spent on inputs (in USD⁵), K_i refers to farm buildings (in USD), and C_i is the proportion of farmers who are members of cooperatives. These variables all refer to the agricultural establishments in municipality i .

The cooperatives C_i in this function are not a direct factor of production, but act as dislocators of the production function⁶. For example, they would allow rural producers access to new inputs and markets. As defined by Curi (1997), investments in access to information, modern industrial parks, technical assistance, and rural extensions can be understood as modernizing agriculture, promoting these elements and leading to changes in the level of Brazilian agriculture.

The theoretical adequacy of this functional relationship was proposed by Cobb and Douglas (1928). The Cobb–Douglas functional form is commonly used because it is a simple model with a restricted number of properties, such as elasticity and constant returns to scale (Coelli et al., 1998). According to Baumol (1977) and Castro (2002), despite its limitations, the Cobb–Douglas specification provides results that are easy to interpret (the estimated coefficients are the model's own elasticity), as well as good statistical qualities in terms of adherence to the data. The model is also useful in the estimation process, because it becomes linear when rewritten using the logarithmic form of each variable:

⁴ As defined in Putnam (1995), this capital is a coalition of elements, namely, trust, reciprocity, social cohesion, and civism.

⁵ The average exchange rate in 2006 was R\$2.17/USD.

⁶ Here, we perform a cross-sectional analysis, based on the importance of technology, as in the innovation model induced by Hayami and Ruttan (1971), where technology is as an endogenous variable in the process of production growth.

$$\ln Y_i = \ln A + \alpha \ln W_i + \beta_1 \ln L_i + \beta_2 \ln I_i + \beta_3 \ln K_i + \beta_4 \ln C_i. \quad (2)$$

This function minimizes the number of coefficients to be estimated and avoids possible multicollinearity problems. Then, we add the spatial characteristics of the final model used in this work to the function. Because the perspectives involve geographical disaggregation at the municipal level, we consider the possibility of spatial dependence between the regions. In other words, a municipality might be affected by the characteristics of neighboring municipalities, and vice versa, which would make it impossible to interpret the results from the ordinary least squares (OLS) method.

3.2. Spatial Aspects

The first step in the investigation is an exploratory spatial data analysis (ESDA). The ESDA uses Moran's I , which considers both global and local perspectives on the variables.

The second step is a conventional estimation of the models using the OLS method. Here, the Moran test is also applied to the residual values of the MQO model in order to verify the existence of spatial autocorrelation. If found, the model developed in the third step needs to eliminate this problem by including spatial lags/interactions. More specific tests, such as the Lagrange multiplier and its robust versions, are used to identify the type of spatial lag to be included in the estimated model⁷.

The final specification of the spatial model is given in equations (3a) and (3b):

$$y_{it} = \alpha + \rho W y_{it} + X_{it} \beta + W X_{it} \tau + \xi_{it} \quad (3a)$$

$$\xi_{it} = \lambda W \xi_{it} + \varepsilon_{it}, \quad (3b)$$

where τ , ρ , and λ are coefficients to be estimated; y represents the dependent variable, namely, the gross value of agricultural production; X is a vector of the control variables defined in the previous subsection; W denotes the spatial weighting matrices; and ξ corresponds to the error term.

Imposing restrictions on the spatial parameters of equation (3), we determine several spatial models. For $\tau = \lambda = 0$ and $\rho \neq 0$, we obtain the SAR model. For $\tau = \rho = 0$ and $\lambda \neq 0$, we have the SEM mode. For $\lambda = 0$, $\tau \neq 0$, and $\rho \neq 0$, we obtain the SDM model. For $\rho = 0$, $\tau \neq 0$, and $\lambda \neq 0$, we have the SDEM model, and for $\rho = \lambda = 0$ and $\tau \neq 0$, we have the SLX model⁸.

In addition to information on given contiguous areas, spatial models generate coefficients of partial correlations between variables. LeSage and Pace (2009) show that it is possible to divide these coefficients as direct, indirect, and total effects. For this, it is necessary that the spatial dependence be observable, as in the SAR, SDM, and SLX models. If this is possible, using the technique increases the quality of the information on the influence of cooperatives on agricultural production in the various regions of Brazil.

3.3 Data

The data used in this study are taken from the 2006 Brazilian Agricultural Census, the last year of this study in Brazil (IBGE, 2016). The Census covered the period January 1 to December 31, 2006, and provides cross-sectional data (IBGE, 2012). Note that the model discussed in the previous sections is not estimated using farm-level data.

The results of the 2006 Agricultural Census are disclosed at the level of administrative units (i.e., municipalities) in order to aggregate agricultural establishments. This aggregation preserves the identities of farmers. Therefore, the basic unit of analysis of the data used for the operationalization of the restricted profit function are farms, aggregated by municipalities in the Brazilian macro-regions.

Considering the 5,500 municipalities that make up the units of analysis, we assume that this is the maximum number of observations. According to Helfand et al. (2015), the aggregation of the data leads to

⁷ The literature lists other procedures that facilitate the estimation of spatial models. Among the commonly employed there are the classic, the hybrid, the Hendry (Florax et al., 2003) and the complete (Almeida, 2012).

⁸ If the spatial parameters of equation (3) are null, the model obtained is the conventional OLS.

an assumption of homogeneity between the observations. Here, each of the 5,500 “representative farms”⁹ reflect the average behavior of a group of individual farms in a given municipality. These 5,500 municipalities encompass 5,175,636 farms, according to data taken from the IBGE (2016).

To estimate the production function, the GVP in 2006 (production), in USD, is defined as the output variable. The factors of production are defined by the following variables: a) productive area (land, in hectares (ha)), as the sum of the areas used for agriculture, livestock, and agroforestry, used as a proxy of the land factor; b) total value (in USD), of farm goods (capital), used as a proxy for capital goods; c) the sum of the number of family work units (wu) and contracted workers (work)¹⁰, used as a proxy for the work factor; and d) non-productive expenditure (inputs), which is the sum (in USD) of expenses related to soil correctives, fertilizers, pesticides, animal medicines, seeds and seedlings, salt/feed, fuel, and energy, used as a proxy for the inputs.

The variable of interest, cooperative membership, is used here based on evidence that these organizations can influence the optimal choices of rural producers. Thus, an important issue in this work is finding a way to represent this variable. Because the 2006 Agricultural Census does not provide micro-level data, one alternative is to consider the percentage of farmers who answered “yes” to the question, “Are you a member of a cooperative?” Therefore, this variable is represented by the proportion of all farms in each municipality that provided positive responses.

In Brazil, cooperativism is strongly influenced by the Rochdale Principles¹¹, from the first legislation on cooperatives to the “Cooperative Law” of 1971, as noted by Pinho (1992). Thus, by legal imposition, cooperatives have free entry, except for technical limitations on accepting additional members. Similarly, there is no restriction on the departure of members. However, in order for a rural producer to be part of a cooperative, he must live in the region where the cooperative operates and must contribute to capital. Thus, the decision to join a cooperative by a rural producer is complex and involves several factors: the availability of cooperatives and other capital companies offering equivalent services, prices, and cultural and historical aspects. These factors all influence the number of rural producers who opt to join a cooperative.

It is important to consider the regional differences of Brazil when analyzing the production function for the municipalities. According to Buainain et al. (2007), in addition to the natural conditions, the Brazilian territory is heterogeneous by other factors, such as those related to the historical process of colonization. With this in mind, the regression is estimated by considering fixed effects at regional levels in an attempt to control this spatial heterogeneity. To do so, the variable of interest was being regressed on dummies for each macro-region of the country (North (DN), Northeast (DNE), Southeast (DSE), and Central–West (DMW), with the South region as base category). The dummy variables take the value one when the municipality belongs to a unit of the federation, and zero otherwise. Thus, these variables are included in the model to represent the level of cooperative membership in the municipalities of each region in Brazil.

Note that all aggregations, data generation, and analyses are carried out using STATA®, Geoda®, GeodaSpace®, and R.

4. Results

4.1. Descriptive Statistics

⁹ For a discussion of the consequences of using “representative farms” in rural economy studies, refer to Nerlove and Bachman (1960), Barker and Stanton (1965), and Sharples (1969).

¹⁰ According to the methodology of the 2006 Brazilian Agricultural Census, the family work unit (wu) is calculated as the sum of the number of persons, men or women, 14 years of age or older and with ties of kinship (including the person who runs the farm), more than half the number of persons with ties of kinship and who are under the age of 14, the number of employees in “other” condition aged 14 years or over, and half the number of employees in the “other” condition under the age of 14 years. The contracted work unit is the sum of the number of men and women who are permanent employees and 14 years of age or older, half the number of permanent employees under the age of 14 years, partner employees over the age of 14 years, and half the number of employees younger than 14 years of age, plus the result of dividing the number of days paid in 2006 by 260, and that of dividing the days of work by 260 (IBGE, 2012).

¹¹ In 1966, on the occasion of the Congress of the International Cooperative Alliance in Vienna, the “Principles” of the Rochdale Pioneers (first cooperative, created in this British district) were established.

Table 2 shows the general characteristics of the aforementioned variables used in the estimation of the econometric model. The table shows the municipal values for each variable. For example, the average value of production (USD 10,502,285.70) refers to the average agricultural GVP for the Brazilian municipalities. On average, there are 2,160 units of equivalent work in the municipalities of Brazil.

Table 2 – Descriptive Statistics

	(×1,000)				
	<i>Production (USD)</i>	<i>Work (wu)</i>	<i>Land (ha)</i>	<i>Inputs (USD)</i>	<i>Capital (USD)</i>
Average	10,502.29	2.16	55.58	3,931.24	82,869.36
Std. Deviation	19,446.94	2.47	123.89	18,861.56	132,000.63
Min	0.00	0.00	0.00	0.00	7.79
Max	404,608.29	32.31	4,986.19	599,078.34	1,682,027.65
Total	57,762,582.65	11,901.20	305,679.31	21,621,802.69	455,781,479.06

Source: Prepared from IBGE (2016) data.

With regard to Table 2, the total values of each variable refer to the sum of the data for all 5,500 Brazilian municipalities considered. Thus, the GVP (production) of Brazilian agriculture and cattle raising was approximately USD 58 billion in 2006.

Next, we examine the spatial distribution of the variable of interest, namely, association with a cooperative (Table 1). Figure 2 shows that the South Region, with a traditionally high proportion of cooperative organizations, has a greater concentration of such organizations, being an important agricultural and livestock region.

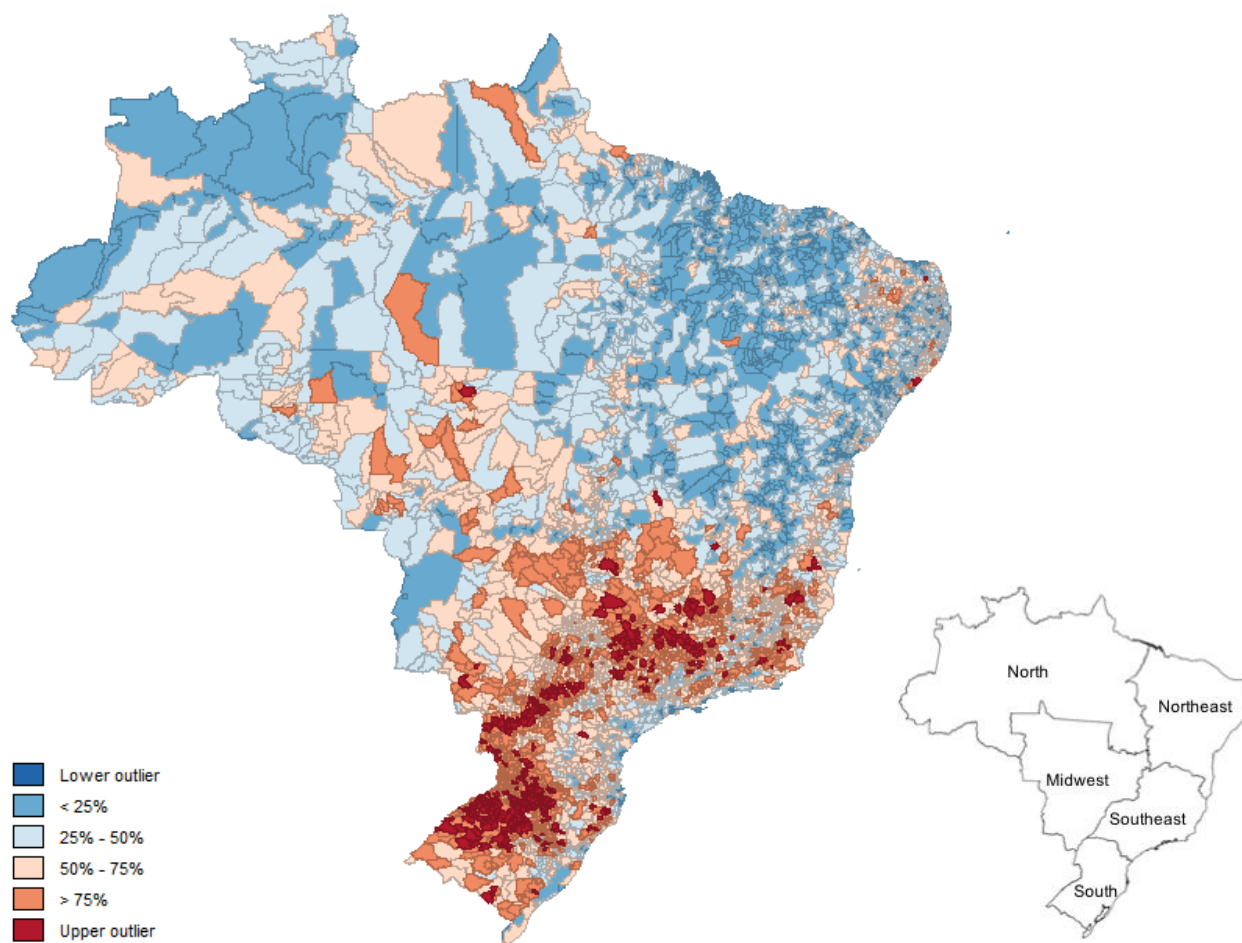


Figure 2 - Spatial distribution of the proportion of farms associated with cooperatives in Brazilian municipalities, 2006

Source: Prepared from IBGE (2016) data.

In the Southeast Region, which has an average of 18% of agricultural establishments associated with cooperatives, there is a concentration of municipalities with a proportion of members above 0.20 in the state of Minas Gerais and in the state of São Paulo. Then, Goiás and Mato Grosso do Sul also have high proportions of establishments in cooperatives in the Central–West Region, which has a lower concentration of municipalities and high rates of association with cooperatives. In the municipalities of the North and Northeast of the country, it is clear that most of these belong to the lower quantiles of rates of association with cooperatives (Ceará, Maranhão, Piauí, Amazonas, and Roraima).

4.2. Spatial Data Analysis

The exploratory spatial data analysis (ESDA) performed on the dependent and control variables is divided into two parts: global and local. In both analyses, it was necessary to determine the most appropriate types of spatial weighting matrices (W). The choice of matrices for these procedures is based on the procedure proposed in Baumont (2004)¹².

In the overall evaluation, the matrices chosen were those of type k neighbors. The grading of the matrices per variable is shown in Table 3, which also shows the results of the Moran test. In general, regardless of the variable analyzed, the p -values are statistically significant at the 1% level, which indicates the existence of spatial patterns in the variables selected at the municipal level for Brazil.

Table 3 - Moran's I statistics for the dependent and control variables

Matrixes	Variable	Values	Average	Std. Deviation	Z	p -values
k-4	<i>capital</i>	0.4115	0.0000	0.0090	45.9204	0.0000***
k-7	<i>work</i>	0.3190	0.0000	0.0068	46.6213	0.0000***
k-2	<i>cooperatives</i>	0.7876	0.0000	0.0124	63.7351	0.0000***
k-2	<i>land</i>	0.4337	0.0000	0.0124	35.0992	0.0000***
k-5	<i>production</i>	0.2264	0.0000	0.0081	28.1154	0.0000***
k-3	<i>inputs</i>	0.1282	0.0000	0.0103	12.5167	0.0000***

Source: Prepared by the authors.

Note: * Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Indicating the existence of spatial autocorrelation, the results also provide clues on determining how these patterns manifest themselves. Signals of the coefficients indicate the presence of positive spatial dependence, which configures geographic concentration by two modes. In the first, municipalities with high production values, for example, will make border with municipalities with similar values. In the second, municipalities with low land values will be contiguous with municipalities with similar characteristics.

The local research is conducted using local indicator of spatial association (LISA) maps, operating nearby $k-2$ matrices. In this case, we chose the mapping for the variable of interest (association to cooperatives) only, as shown in Figure 3. This analysis allows us to observe the majority of the two types of clusters (high–high and low–low), in addition to several municipalities whose indicators of local spatial autocorrelation are not statistically significant.

The high–high clusters indicate municipalities and neighboring municipalities with high rates of association with cooperatives (above average). This cluster is concentrated in the Southeast, South, and Central–West Regions, historically marked by the existence of a greater number of farms associated with cooperatives. Strong and comprehensive cooperatives operating in the headquarters and adjacent municipalities are common in the South Region, primarily in the states of Paraná and Santa Catarina, as well as in the milk supply cooperatives of the Southeast (Neves and Braga, 2014). Added to this is the important role of credit unions in providing credit to many rural producers in these regions.

On the other hand, clusters of the low–low type are located in the North and Northeast, with the greater quantity being in the latter region. These are regions where cooperativism is still not as widespread as it is

¹² The procedure is to perform spatial autocorrelation tests, such as Moran's I , on OLS residual values. The option for the matrix is chosen based on the test result with the largest statistically significant spatial autocorrelation. Thus, the Baumont (2004) procedure prevents the existence of bias associated with the way the spatial matrices are selected.

in the Central–West and South Regions of Brazil. This pattern is very similar to that established by the spatial dispersion of Figure 2.

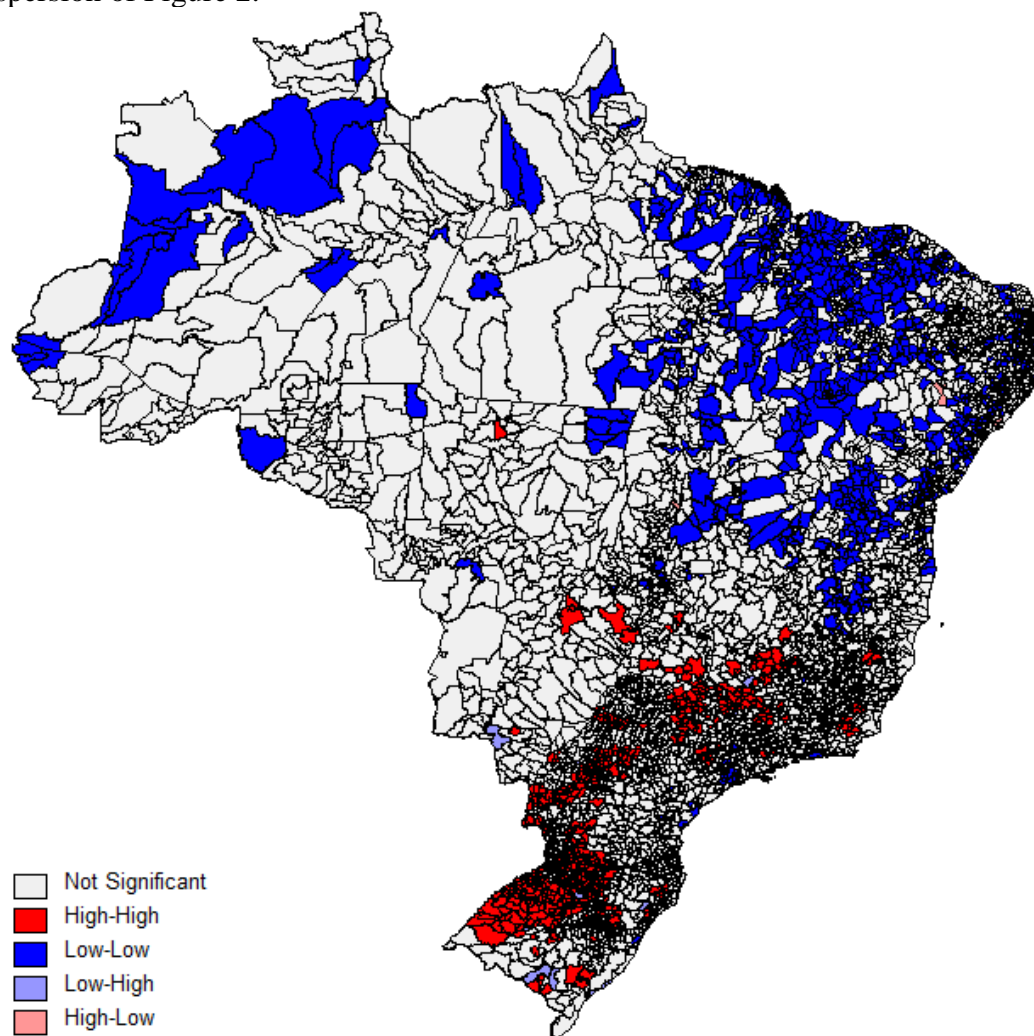


Figure 3 - LISA cluster map for the variable of interest (cooperative membership), 2006.

Source: Prepared by the authors.

4.3. Effect of cooperative membership

Following the analysis proposed in the empirical strategy, the model was initially estimated using the OLS approach (see Table 4)¹³. The results reported in the second column (OLS model) show that all control variables are statistically significant at the 1% level. This includes the dummies that capture the regional membership rate of cooperatives. However, a verification of the diagnostic tests reveals traces of spatial dependence. This confirms the results of the ESDA, just as the residual values were heteroscedastic and non-normal. Thus, as predicted, the OLS model proved to be poorly specified, which makes it impossible to interpret its coefficients.

In order to expand the types of spatial autocorrelation, we perform Lagrange multiplier tests for the lag (ML_{ρ}) and for the autoregressive error (ML_{λ}). These tests were all statistically different from zero, which suggests, preliminarily, that the spatial model of interest may be one of SAR, SEM, SDM, or SDEM.

To determine the most adequate of the suggested models, we apply the method of Stakhovych and Bijmolt (2009). This criterion compares the *Akaike* statistics provided by the estimated models, which use different spatial lag matrices. The best choice is the model that presents the lowest *Akaike* value and that, at the same time, eliminates the problem of spatial dependence.

¹³ Note that for the estimation of the econometric models, we interpolate the interest variable (cooperative member rate) using dummies for each region of Brazil (DN, DNE, DSE, and DMW, with the South Region as the base category).

Table 4 - Estimates of the model, with and without spatial control

Variable	OLS	SAR	Effects-SAR		
			Direct	Indirect	Total
Constant	0.4533*** (0.0380)	0.2074*** (0.0502)	- -	- -	- -
<i>work</i>	0.4102*** (0.0140)	0.4051*** (0.0139)	0.4054*** [32.4649]	0.0216*** [6.4091]	0.4270*** [31.4563]
<i>land</i>	-0.2423*** (0.0144)	-0.2425*** (0.0143)	-0.2427*** [-17.3142]	-0.0130*** [-5.9487]	-0.2556*** [-16.9994]
<i>input</i>	0.4466*** (0.0126)	0.4281*** (0.0128)	0.4284*** [33.7585]	0.0229*** [6.5458]	0.4512*** [33.5825]
<i>capital</i>	0.4413*** (0.0136)	0.4439*** (0.0135)	0.4442*** [32.5619]	0.0237*** [6.4608]	0.4679*** [31.8584]
<i>DN</i>	-0.0446*** (0.0123)	-0.0506*** (0.0123)	-0.0507*** [-3.9638]	-0.0027*** [-3.2767]	-0.0534*** [-3.9568]
<i>DNE</i>	-0.0605*** (0.0073)	-0.0657*** (0.0073)	-0.0657*** [-9.1106]	-0.0035*** [-5.0006]	-0.0692*** [-9.0195]
<i>DSE</i>	0.0415*** (0.0099)	0.0336*** (0.0099)	0.0336*** [3.3574]	0.0018*** [3.1915]	0.0354*** [3.3700]
<i>DMW</i>	0.1716*** (0.0147)	0.1650*** (0.0147)	0.1651*** [11.5876]	0.0088*** [5.9655]	0.1739*** [11.6702]
ρ	-	-0.0231* (0.0964)	-	-	-
Model Test Statistics					
R ²	0.8709	0,8711	-	-	-
SC	4,384.3800	-	-	-	-
Jarque–Bera	134,774.9440	-	-	-	-
<i>p</i> -value	0,0000***	-	-	-	-
Koenker–Bassett	152.6676	-	-	-	-
<i>p</i> -value	0,0000***	-	-	-	-
Moran's <i>I</i>	0.2359	-	-	-	-
<i>p</i> -value	0,0000***	-	-	-	-
ML ρ	50.8475	447.3830	-	-	-
<i>p</i> -value	0,0000***	0.0593*	-	-	-
ML λ	528.5852	-	-	-	-
<i>p</i> -value	0,0000***	-	-	-	-
ML ρ *	7.7715	-	-	-	-
<i>p</i> -value	0,0053***	-	-	-	-
ML λ *	485.5092	-	-	-	-
<i>p</i> -value	0,0000***	-	-	-	-
Matrix	<i>k</i> -3	<i>k</i> -3	-	-	-

Source: Prepared by the authors.

Notes: Standard deviations are shown in parentheses, and Z-statistics are shown in brackets.

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Table 4 shows that the best option is the SAR model. Estimated using the maximum likelihood¹⁴, it controls the spatial dependence at the 5% level of significance, as we can see by the ML ρ test. The estimation of the SAR model also includes corrections for heteroscedasticity, using White's robust variance and covariance matrices.

For the other variables, we note that the signs of the coefficients are all positive, with the effect of the productive factors being similar in *production*, except in the case of *land*. In addition, the results of the coefficients of the DN, DNE, and DMW dummies are underestimated, whereas the DSE dummy is overestimated if the model is estimated using the OLS approach.

Note that one of the advantages of using the Cobb–Douglas functional form is the possibility of identifying the returns to scale of the production function using the direct sum of the elasticities of the

¹⁴ First, we estimated the SAR model using the GMM, seeking to control potential endogeneities. However, the result did not eliminate the problem of spatial autocorrelation.

productive factors (Chambers, 1988). Here, the estimated function has a sum of elasticities of 1.04. That is, the return on the technology used approaches constant returns to scale (Table 4). This result is similar to that found by Alves et al. (2012), who, using microdata of the 2006 Census of Agriculture, identified a return to scale near unity (0.924). In addition, Helfand et al. (2015), using data from the 2006 Census of Agriculture, obtained a return to the scale of 1.02¹⁵.

4.3.1. *Effects in the Southeast, Central–West, and South Regions*

The partitioned effects of the dummies are arranged in the last three columns of Table 4, and all are statistically significant for all variables. In general, the association by a farmer with a cooperative has a positive and direct influence on the growth of agricultural production in his municipality. It also indirectly influences the agricultural production of contiguous municipalities in the Central–West Region and Southeast Region in 2006, in comparison with the South Region of Brazil (base region).

Thus, a 10% increase in the cooperative association rate, *ceteris paribus*, would increase the GVP of the municipalities of the Central–West Region by 1.65%, with an effect on neighboring municipalities of around 0.09%. This would culminate in a total effect of increasing the GVP by about 1.74%. For the Southeast Region, this increase would lead to an effect of 0.42% on the GVP of the municipalities of the region, with a result of 0.02% in the neighboring municipalities, leading to a total effect of 0.44%. In turn, the base category, the South Region, would show an average increase in GVP, *ceteris paribus*, of 0.8%.

Based on the values in Table 1 and Table 2, we can say that a 10% increase in the contingent of cooperative members would have a positive impact of USD 275 million, or 0.61%, of the GVP of the three regions.

To explain these results, note that the cooperative system has a significant relevance among grain producers, mainly in the Central–West Region and South Region. In this sense, according to Zanon and Saes (2010), a significant portion of soybean production (57%) is delivered in cooperatives. Still, according to the authors, the smallest soy producing properties are concentrated in the southern region of the country. This reinforces the importance of the participation of soy producers in cooperatives in the region. Similar to soybeans, 43% of corn production uses a cooperative as a marketing channel (IBGE, 2016).

Some of the largest agricultural cooperatives in the country are located in the South and Midwest of Brazil. The main products grown by their members are rice and cotton, as well as wheat, in Rio Grande do Sul (OCB, 2013). With regard to livestock, important cooperatives in the South and Southeast are responsible for receiving and processing milk and meat, the latter being mainly chicken and pork. According to Chaddad (2007), Brazil is one of the largest producers in the world, with up to 40% of all milk collected being delivered through cooperatives.

Farmers who grow sugarcane in the state of São Paulo and coffee in Minas Gerais and Espírito Santo are among those who most seek cooperatives to obtain inputs and to dispose of their production. According to the IBGE (2016), 48% of coffee produced in Brazil is delivered in cooperatives. According to Oñate and Lima (2012), independent producers account for some 30% of São Paulo's sugarcane production. However, this does not diminish the relevance of cooperatives to independent producers, because, according to Oñate and Lima (2012), credit unions are an important source of financing for sugarcane producers.

Another relevant point in this regard concerns the local impact of these cooperatives. In general, they obtain most inputs locally. Because cooperative associates are usually members of the community, they can support the purchase of these inputs locally (even if they are more expensive). After all, in the long run, it is expected that social and economic benefits will be generated for the community. Using the same logic, consumers can buy more from their local cooperatives, especially if they are members (Fulton and Ketilson, 1992; Merrett and Walzer, 2001).

In addition to the economic and productive issues, we mention the high level of social capital existing predominantly in the South Region (Silva et al., 2003). This capital is tied to joint projects that promote

¹⁵ In contrast to this article, Alves et al. (2012) use three production factors to represent the production frontier of Brazil: labor expenses, land expenses, and expenditure on technological inputs. Helfand et al. (2015) use land, family labor, intermediate inputs purchased, and stock of capital (machinery, animals, and trees). Thus, the small difference in the returns on productive factors may be due to differences in the model specifications in each study.

collaboration for the mutual benefit of society as a whole. This characteristic drives the cooperative movement and should be developed and stimulated through education for cooperation in all regions of the country.

4.3.2. Effects in the North and Northeast Regions

The opposite effect to the Southeast and Central–West Regions is found in the North and Northeast Regions. In these regions, an association of more 10% of farms to cooperatives in the municipalities directly affects the agricultural GVP by -0.51% in the North Region and 0.65% in Northeast Region, *ceteris paribus*. At the same time, it indirectly affects the neighboring municipalities, generating a decrease of 0.03% in the first region, and 0.04% in the second. Thus, a 10% increase in associates in these regions would decrease GVP by USD 87 million, or 0.65%. Even so, the combined result, considering the effect of the variation in the number of cooperatives in the five Brazilian regions (North, Northeast, Southeast, Central–West, and South) would be positive, at USD 188 million.

The negative effect of cooperativism in the North and Northeast Regions of Brazil, when compared to the South Region, can be explained by the history of mutual organizations in these regions. Traditionally, deep contrasts marked Northeastern cooperativism. Cooperatives were created by local power groups (i.e., large landowners) aiming to occupy managerial positions and exert influence over small producers, who formed the vast majority of members (Rios, 1973).

In addition, both the North and the Northeast Regions resent the absence of effective development policies. This culminates in difficulties for many cooperatives in accessing resources and infrastructure enabling them to improve their management and production practices. This is accompanied by a lack of planning and investment capacity, yielding cooperatives with a low level of competitiveness and capitalization, especially in the case of smaller ones (Silva et al., 2003).

However, the search for the revitalization of cooperativism in these regions is under way. It is an effort that involves universities, representative entities, and public and private agencies in the construction of channels to discuss the model most appropriate to local realities. Furthermore, it focuses on economic and social sustainability, focusing on the training of members and managers of cooperatives and associations (Silva et al., 2003).

Specifically, note that despite its negative results, the Northeast Region is endowed with an associative wealth and collective actions that supplant the legal form. The act of cooperating through various organizational forms (formal and informal associations) enables mutual solidarity. These are not part of the official statistics but are no less important. On the contrary, supporting these enterprises can allow the development of their financial and management capacities. This is necessary so that these enterprises can make a greater difference to the production and the quality of life in the agricultural areas. They are treated as organizational forms that, according to Rios (1973), are part of the “pre-cooperative stage.” They aim at learning by coordinating efforts and strengthening the social capital of its members.

5. Conclusions

Support for actions aimed at publicizing and strengthening cooperativism in Brazil should be based on studies that measure their real impact on their members and on the regional and national economies. In this sense, it is important that we have precise measures of the return of the association with cooperatives. We seek to clarify whether the association with cooperatives has the capacity to raise the economic income of the agricultural establishment. Such estimates are useful for government and representative bodies of the cooperative sector. This may justify political support for investment aimed at the propagation of cooperative education and the incentive of these organizations for local economic development and for the supply of goods and services.

Thus, the methodology proposed in this work allowed us to shed light on a topic that has not yet been explored in the literature, namely, the influence of cooperatives on agricultural production in Brazilian regions. Using a parsimonious model and including spatial corrections, we found that being associated with a cooperative is a positive factor for farmers in the Southeast and Central–West Regions in terms of

production. In turn, belonging to a cooperative in the North and Northeast Regions has a negative impact on farmers' production, as compared with farmers in the South Region (base region).

The results also show that the diffusion of the cooperative model throughout the country may not be sufficient proof of its viability as an organization or of its positive influence on the communities in which it is inserted. Recent unsuccessful experiences and crises experienced by cooperatives demonstrate that there is a long way to go before Brazil's cooperative rates in rural areas are as high as those in other countries. In addition, the ineffective impact of cooperatives in regions where the movement is not as widespread shows that the national cooperatives may not yet be compatible with the benefits they potentially generate.

Finally, note that in many places in the Northeast and North Regions, cooperativism may not yet be the most appropriate organizational form. Informal groups, associations, rural unions, and other formats of collective enterprises may be more suitable for farmers. Such organizations offer possibilities for collective action to farmers without the complexities of managing cooperative enterprises. They often act as true pre-cooperative trials, preparing members for more complex organizations, such as cooperatives.

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