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IMPORTÂNCIA DA ATIVIDADE LEITEIRA NO ESTADO DE SÃO PAULO: UMA ANÁLISE ESPACIAL

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ABSTRACT

Dairy farming is one of the most relevant Brazilian agribusiness sectors, given its oustanding socioeconomic importance to food and nutritional security. Brazil is ranked as the sixth largest milk producer in 2019 worldwide. The state of São Paulo alone has been showing a gradual decline in Brazil's representativeness regarding milk production in recent decades. In this context, the general objective of this research is to analyze the dynamics of dairy activity in the state of São Paulo. For such a purpose, this work was developed through an exploratory and quantitative study. 645 municipalities of the state of São Paulo were analyzed and their relevance to the state's dairy activity has been found through an indicator composed of the following variables: milk production, production worth, and milked cows. Its method was based on the Common Factor Analysis and Hierarchical Clusters to allow categorizing and mapping municipalities into high, medium and low levels of importance in terms of their dairy activity. Results revealed that the state of São Paulo suffered a significant reduction in its cattle herd and number of cows milked during the period under analysis, consequently leading to a reduction in milk production. Despite managing to increase its milk productivity rates, the state was unable to follow the nation's growth trend for this sector.

Keywords: Milk, Dairy Farming, Agribusiness, Spatial Distribution.

RESUMO

A pecuária leiteira é um dos setores mais relevantes do agronegócio brasileiro, apresentando elevada importância socioeconômica e para a segurança alimentar e nutricional. No cenário mundial, o Brasil posicionou-se como o sexto maior produtor de leite do mundo em 2019. O estado de São Paulo, especificamente, vem apresentando gradativa queda na representatividade brasileira na produção de leite nas últimas décadas. Nesse contexto, o objetivo geral da pesquisa foi analisar a dinâmica da atividade leiteira no estado de São Paulo. Para consecução do objetivo proposto, o presente trabalho se desenvolveu por meio de um estudo exploratório de caráter quantitativo. Foram analisados os 645 municípios do estado de São Paulo, identificando a relevância de cada município para a atividade leiteira estadual, por meio de um indicador composto pelas variáveis: produção de leite, valor da produção e vacas ordenhadas. O método de análise se baseou na Análise Fatorial Comum e Clusters Hierárquicos, permitindo que os municípios fossem categorizados e mapeados em alta, média e baixa importância em termos de sua atividade leiteira. Os resultados revelaram que o estado paulista apresentou redução significativa do seu rebanho bovino e de vacas ordenhadas durante o período de análise, levando, consequentemente, a uma redução da produção leiteira. Apesar de conseguir aumentar seus índices de produtividade leiteira, o estado não seguiu a tendência nacional de crescimento para o setor.

Palavras-chaves: Leite, Pecuária Leiteira, Agronegócio, Distribuição Geográfica.

INTRODUCTION

Agribusiness plays a prominent role in the Brazilian economy, given its relevance to the Gross Domestic Product (GDP) and balance of trade. In addition to its economic importance, the social relevance and development capacity of this sector for the country must also be evidenced.

The Milk Agroindustrial System stands out in Brazilian agribusiness. This production system plays an important role in supplying food and generating employment and income for the Brazilian population (Perobelli et al., 2018). In 2019, Brazil was responsible for producing 34.8 billion liters of milk, representing an increase of 2.7% compared to the previous year (IBGE, 2021). This result places the country as the sixth largest producer worldwide, after the European Union, the United States, India, China and Russia (USDA, 2019). There was reduction in the total number of cows milked compared to previous years, however, milk production reached the second largest volume of milk production countrywide in 2019, revealing higher productivity of 2,141 liters of milk/cow per year (IBGE, 2021).

Although it is spread throughout the Brazilian territory, it was found that milk production was mainly concentrated in the southeastern region of the country in the 1990s, and the states of Minas Gerais and São Paulo are the main producers, i.e. representing 43% of the country's total production (IBGE, 2021). Nonetheless, there was an increase in milk production in the southern states from the 2000s onwards (Paraná, Santa Catarina and Rio Grande do Sul), thus indicating a change in production activities in the country (Bánkuti et al., 2017).

In this context, it is observed that the state of São Paulo, which once held a prominent position on the national scenario, has been gradually losing its standing. According to data from IBGE (2021), São Paulo was accountable for 13.54% of Brazil's milk production in 1990 and was the 2nd largest milk producer countrywide, i.e. only after Minas Gerais. However, São Paulo was ranked as the 6th largest Brazilian milk producer in 2019, but it was only accountable for 4.74% of the country's total production.

Given that it is a typical activity of small properties and/or family farming, dairy production has great socioeconomic relevance to Brazilian producing regions (Bánkuti et al., 2020; Perobelli et al., 2018), once it is capable of promoting and sustaining rural and regional development.

Therefore, from a scientific point of view, it is it is worth comprehending the changes in dairy farming activities in the state of São Paulo and identifying the regions where this activity was more or less intense, as well as allowing to observe the phenomenon spatially. In this sense, the general objective of the research is to analyze the dairy farming activity dynamics in the state of São Paulo between 1990 and 2019.

LITERATURE REVIEW

Milk is one of the most important agricultural commodities in the world and was ranked one of the five most often traded products in terms of volume and price. It is regarded as a vital source of nutrition owing to its macro proteins of great biological value, in addition to having essential vitamins and minerals to the development of the human body at different stages of life (Muniz; Madruga; Araujo, 2013; Siqueira, 2019).

According to the FAO, the Food and Agriculture Organization of the United Nations, milk has physical and chemical characteristics allowing it to be very versatile in its use, which is the reason billions of people around the world consume it daily in its most diverse forms. In addition to being consumed in its natural form as a main meal (UHT milk), it is also used as base for producing derivatives and processed foods, such as cheese, butter, yogurt and dairy drinks, in addition to being widely used in the food industry (Siqueira, 2019).

In addition to its nutritional importance, milk has strong socioeconomic relevance, since it is the livelihood of numerous rural producers worldwide, in addition to playing an essential role in the economic development of countries having already reached development, mainly those consisting of family farming systems (CONAB, 2016; Matte Júnior; Jung, 2017). According to Neto and Basso (2005), this activity brings about positive effects to municipalities, either directly or indirectly, fostering rural and regional development.

Global milk production is 816 million tons per year, and an average of 116.5 kg of long-life milk is consumed per inhabitant, which is expected to reach a yearly increase of 1.2% (GDP, 2019). According to data from the International Monetary Fund (IMF), around 1 billion people depend on milk to survive and 600 million live on 133 million dairy farms around the world (Siqueira, 2019).

In the 20th century, the Brazilian political scenario started favoring agricultural activities, making it possible, albeit somewhat slowly, to modernize farms and develop dairy farming. During this period, there was greater government regulation concerning the quality of milk production and marketing. Meanwhile, there was a transformation in dairy farming through successive legal, technological and logistical changes providing ways to create a dairy supply chain supported by improvements in transportation and studies aimed to reduce the perishability of these products (Vilela et al., 2017; Milinski; Ventura, 2010).

Martins et al. (2004) pointed out that, from the 1990s onwards, there were profound changes in dairy agribusinesses. Among the main drivers of such transformations were the end of milk price controls, increased consumption boosted by the Real Plan, greater milk production in the Central-West region, the market opening and a consequent increase in imports, in addition to mergers and acquisitions of bulk collection companies compelling companies to become more

competitive and efficient in adapting to the new demands of the national market.

In 1994, the Brazilian economy stability strongly stimulated the sector due to a generalized drop in inflation, since an increase in consumer income also led to greater demand for dairy products. On the other hand, from a production engineering perspective, economic stability together with trade liberalization reduced the price of milk and producers' profit margins, placing the dairy sector at risk and exerting even more pressure on less efficient production systems (Gomes, 2001).

Given the need to reformulate and update government measures adopted for the milk chain, the Ministry of Agriculture, Livestock and Food Supply (MAPA) established Normative Instruction No. 51/2002. The regulation launched the National Milk Quality Improvement Program (PNMQL), a strategic public policy for Brazilian agribusiness implemented to boost the country's competitiveness (Milinski; Ventura, 2010). Normative Instruction 62, of 2012, brought changes in the dairy production system by regulating management systems and infrastructure standards, whose main objective was to establish minimum hygiene and health standards (BRASIL, 2011).

Legal and normative regulations initially laid out in 1990 have been intensified over the years. Furthermore, milk transportation and distribution logistics have also undergone significant changes. Bulk milk collection using trucks with insulated tanks has led to profound and major transformations in the dairy production logistics system. As a result, Brazil has one of the fastest milk collection logistics chains worldwide (Martins et al., 2016).

In addition to logistics system modernization, introducing the concept of transport logistics in the dairy production system has enabled significant cost savings and quality gains, since it allowed the closure of cooling stations, reduction of collection routes (without necessarily prioritizing large producers) and larger quantities transported by trucks (Martins et al., 2004; Martins et al., 2016)

However, such changes triggered a series of imbalances, reactions and adaptations to the institutional environment of the milk production chain, thus affecting the commercial, structural and organizational context of the Brazilian dairy sector (Oliveira; Silva, 2012; Moutinho, 2018).

MATERIALS AND METHODS

To analyze the importance of dairy production in the state of São Paulo, this study was developed through an exploratory and quantitative study. Its adopted time frame was the period ranging between 1990 and 2019, and its analyzed data specifically refer to the years 1990, 2001, 2011 and 2019. These periods were selected due to their importance to the Brazilian dairy chain development. In the 1990s, institutional and market changes brought about important modifications to most food systems in Brazil (Saes; Silveira, 2014). In 2002, Normative Instruction No. 51 (BRASIL, 2002) significantly affected this production chain. Furthermore, Normative Instruction No. 62 (BRASIL, 2011) was introduced in 2012 and effected changes to this production system. Finally, the year 2019 represents the current status of dairy activity in the state of São Paulo.

The geographic scope adopted in this work is the state of São Paulo. However, 645 municipalities constituting the state of São Paulo were selected as units of analysis.

To achieve the proposed objectives, secondary data on dairy farming were used. The Municipal Agricultural Survey carried out by the IBGE Automatic Recovery System (PAM/SIDRA) was adopted as data source. The geospatial data for generating the analysis maps were obtained in shapefile format (".shp") through the cartographic databases from the Brazilian Institute of Geography and Statistics (IBGE) and the geographic grid of the Institute of Applied Economic Research (IPEAGeo) using the open-source software Quantum GIS, version 3.4.13 (QGIS).

It is evident that these methods have been used frequently while observing current works as Bánkuti and Caldas (2018), Rivas et al. (2015), Gelasakis et al. (2012), among others. This is justified by the fact that these techniques can be used to analyze the impact of institutional changes in agricultural production systems (Bánkuti; Caldas, 2018).

To analyze the spatial dynamics of milk production in São Paulo, three different variables were analyzed: milk production (liters of milk/municipality), production worth (R$/liter of milk/municipality) and cows milked (number of cows milked/municipality). These variables represent the importance of dairy activity and are suitable for studies as such according to Bánkuti and Caldas (2018).

From this set consisting of the three variables mentioned above, indicators of the dairy activity of each municipality were generated for different periods of analysis. According to Palácio et al. (2020), an

indicator can be considered as a tool to support decision-making, as it is capable of numerically translating the behavior of phenomena, thus revealing broader meanings.

The factor analysis was adopted using the SPSS (Statistical Package for Social Sciences) Statistical Software, version 18, to analyze regional differences and established indicators. Factor analysis, by definition, is a statistical Multivariate Analysis tool used to group a large set of variables by synthesizing the original data matrix into a smaller number of factors without compromising the amount of information, which favors an exploratory data analysis. In this sense, a factor represents a set of variables presenting high correlation between them, and low correlation with other factors (Fávero et al., 2009; Hair et al., 2009; Melo; Parré, 2007).

It is worth selecting the factor analysis method due to the fact that it eases understanding of original data matrix by synthesizing it into a reduced number of factors with minimum loss of information, thus allowing to join distinct regions into a geographic space having similarities, grouping such similarities and highlighting the common patterns of regions under analysis (Hair et al., 2009; Melo; Parré, 2007; Ferreira Junior et al. 2004). The following assumptions are adopted while using this technique (Hair et al., 2009; Bánkuti et al., 2020):

a) Common factors (Fk) are independent and equally distributed factors whose mean is 0 and variance equals 1 (k = 1,..., m);

b) Errors (Ɛi) are independent and equally distributed variables whose mean equals 0 and variance is ψi (i = 1,..., p);

c) Fk and Ɛii are independent variables.

These factors are defined by combining linear variables, as in equation 1:

$$Fm = dm1 + X1 + dm2 + X2 + \cdots + dmi + Xi \quad (1)$$

Where:

Fm = common factors

dmi = factor score coefficient, and

Xi = original variables

The factor analysis model herein is represented by equation 2.

$Xp = \mu p + ap1F1 + ap2F2 + \cdots + apmFm + \varepsilon p$ (2)

Where:

μp = Mean vector

aij = Loading

Xi = Variable

Fm = Common factor

εi = Error

In this sense, considering a standardization of X (mean = 0 and standard deviation = 1), the generic model of the present factor analysis can be presented generically as in equation 3:

$X1 = ai1F1 + ai2F2 + \cdots + ai\text{m}Fm + \varepsilon i$ (i= 1, $\cdots$, p) (3)

The Varimax rotation technique using standardized Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests were selected to extract the principal components of the factor analysis (Lebart, 2000; Barroso; Artes, 2003). Variables presenting low factor loadings (less than |0.05|) were disregarded. To determine the number of factors to be considered in the analysis, the minimum criteria of a cumulative variance of 60% and an eigenvalue greater than 1.0 in each factor were used (Fávero et al., 2009; Hair et al., 2009). Eigenvalues represent how much each factor explains the total variation. Considering that variables are standardized, given a mean of 0 and variance of 1, selecting factors whose eigenvalues are greater than 1 indicates that the factor explains the variation of at least one model variable. Thus, only factors whose eigenvalues are greater than 1.0 are significant (P <0.05) (Fávero et al., 2009).

The factor score –the factor analysis result – was generated using the regression model. It allows analyzing factor scores differently, including through means tests. In this technique, each of the municipalities in São Paulo had a contribution score for the factors generated.

Then, the factor scores derived from the factor analysis were used as input to define the homogeneous groups of municipalities for the years 1990, 2001, 2011 and 2019. For such a purpose,

the cluster analysis was used (Rivas et al., 2015). Cluster analysis (also known as clustering, segmentation or taxonomy analysis) is a multivariate analysis technique aimed to group objects with respect to the similarity of their main characteristics regarding distance or proximity (Hair et al., 2009).

The number of groups was decided based on a dendrogram analysis considering the quadratic Euclidean distance (Fávero et al., 2009; Hair et al., 2009). The greatest internal consistency between municipalities in each group and the greatest centroid distance between groups were considered. Ultimately, using the average score found through factor analysis scores, clusters were classified as low, medium, high or very high level of importance in terms of their dairy activity (Bánkuti et al., 2017).

RESULT AND DISCUSSION

Using the Factor Analysis technique and considering the 4 time periods adopted in this research (1990, 2001, 2011 and 2019), 3 factors were generated for each period under analysis, F1, F2 and F3. Table 1 shows the calculation of the variance for each generated factor.

Table 1 | Variance of generated factors by time

Factor	Factor Loading	Variance (%)	Total Variance (%)
F1_1990	2.749	91.638	91.638
F2_1990	0.221	7.351	98.989
F3_1990	0.030	1.011	100.00
F1_2001	2.671	89.026	89.026
F2_2001	0.285	9.512	98.538
F3_2001	0.440	1.462	100.00
F1_2011	2.673	89.095	89.095
F2_2011	0.312	10.387	99.482
F3_2011	0.016	0.518	100.00
F1_2019	2.675	89.158	89.158
F2_2019	0.315	10.506	99.664
F3_2019	0.010	0.336	100.00

Source: the authors

It is possible to observe that F1 is the factor that best demonstrates the standings of data analyzed in each period due to the high percentage of variance (F1_1990 [91.6%]; F1_2001 [89.0%]; F1_2011 [89.1%]; F1_2019 [89.2%]) and high factor loading values (F1_1990 [2.75]; F1_2001 [2.67]; F1_2011 [2.67]; F1_2019 [2.67]). Thus, factors F2 and F3 should be excluded from the analysis process accordingly (Hair et al., 2009).

In addition to the previous analysis, the factor loading of each variable under analysis was found based on generated factors, as well as the results from the Bartlett sphericity test and Varimax rotation based on the Kaiser-Meyer-Olkin (KMO) test. These pieces of information are shown in Tables 2 and 3, respectively.

Table 2 | Variable loadings in the definition of factors

Variable	Factor Loading			
	F1_1990	F1_2001	F1_2011	F1_2019
Milk production (*liters/municipality*)	0.963	0.953	0.976	0.981
Milk production worth *(R$/liters/municipality)*	0.936	0.914	0.970	0.966
Milked Cows (*cattle heads/municipality*)	0.850	0.805	0.883	0.882

Source: the authors

Table 3 | KMO and Bartlett tests by analyzed period

Year	Test	
	KMO	Bartlett
1990	0.691	0.00
2001	0.675	0.00
2011	0.682	0.00
2019	0.610	0.00

Source: the authors

From the factor scores found through the factor analysis, it can be stated that the variables 'Milk Production, Milk Production Worth and Milked Cows' statistically explain factors F1_1990, F1_2001, F1_2011 and F1_2019. Thus, for each of the municipalities in São Paulo, a contribution score was found for generated factors, which were used to define homogeneous groups of municipalities for 1990, 2001, 2011 and 2019.

Table 4 shows three groups of municipalities for each analyzed period classified according to their level of importance for dairy farming: low, medium or high. This classification was based on factor loadings (F1) of each municipality. It should be noted that F1 is an indicator that cannot be considered the absolute value of any factors under analysis (milk production, production worth or cows milked). It consists of the three factors under analysis, thus generating a dimensionless coefficient of variation.

Table 4 | Group of municipalities and their level of importance for dairy farming

Groups	1990			2001			2011			2019			Importance
	N	%	Average F1	N	%	Average F1	N	%	Average F1	N	%	Average F1	
1	499	88.5	-0.286	527	86.7	-0.320	477	78.6	-0.421	507	84.1	-0.342	B
2	58	10.3	1.751	64	10.5	1.446	117	19.3	1.229	79	13.1	1.149	M
3	7	1.2	4.644	17	2.8	3.692	13	2.1	4.188	17	2.8	3.538	A
Total	**564**	**100**	-	**608**	**100**	-	**607**	**100**	-	**603**	**100**	-	-

B = Low level of Importance,
M =Medium level of Importance,
A =High level of Importance

Source: the authors

It is worth mentioning that, for the period of analysis, the standings of the group of municipalities having low level of importance for dairy farming activity decreased from 88.5% to 84.1%. The remaining groups showed an increase in their standings, given that the group of medium level of importance rose from 10.3% to 13.1% and the group of high level of importance from 1.2% to 2.8% (Table 9).

It is observed that the number of municipalities (N) under analysis differs between the selected periods – 1990, 2001, 2011 and 2019. This is since, in certain periods, data related to milk production and/or production worth and/or number of cows milked were absent in the IBGE reports, especially in 1990, therefore that a few municipalities were excluded from the analysis. In addition, it should be considered that some municipalities were regarded as outliers (outside the standard) due to reaching results well above (or well below) the averages found for groups of municipalities. Therefore, such municipalities were excluded from the analysis in accordance with the factor analysis.

Table 5 was compiled to facilitate observation of data extracted through the performed analyses. It shows milk production (column A), the number of cows milked (column B) and production worth (column C) classified by level of importance of dairy activity (low, medium and high) for each analysis period.

Table 5 | Milk production, number of cows milked and production worth by level of importance in dairy farming for the state of São Paulo in 1990, 2001, 2011 and 2019

	Level of Importance	N	A	B	C
1990	Low	499	2,201.99[a]	2,588.42[a]	0.0148[a] *
	Medium	58	11,245.90[b]	11,328.28[b]	0.7783[b] *
	High	7	23,430.43[c]	24,383.14[c]	0.16757[c] *
	Total	**564**	**3,395.51**	**3,757.70**	**0.02321** *
2001	Low	527	1,810.56[a]	1,946.72[a]	534.53[a]
	Medium	64	8,229,72[b]	6,937.84[b]	2,481.11[b]
	High	17	15,151.12[c]	13,499.24[c]	5,377.24[c]
	Total	**608**	**2,859.27**	**2,795.11**	**874.84**
2011	Low	477	1,304.69[a]	1,255.09[a]	1,103.47[a]
	Medium	117	6,514.53[b]	5,963.31[b]	5,347.82[b]
	High	13	16,668.69[c]	12,029.69[c]	14,643.69[c]
	Total	**607**	**2,637.94**	**2,393.36**	**2,211.56**
2019	Low	507	1,369.08[a]	910.73[a]	1,885.96[a]
	Medium	79	7,287.37[b]	4,382.63[b]	10,233.53[b]
	High	17	17,248.76[c]	9,465.71[c]	24,375.88[c]
	Total	**603**	**2,592.13**	**1,606.78**	**3,613.64**

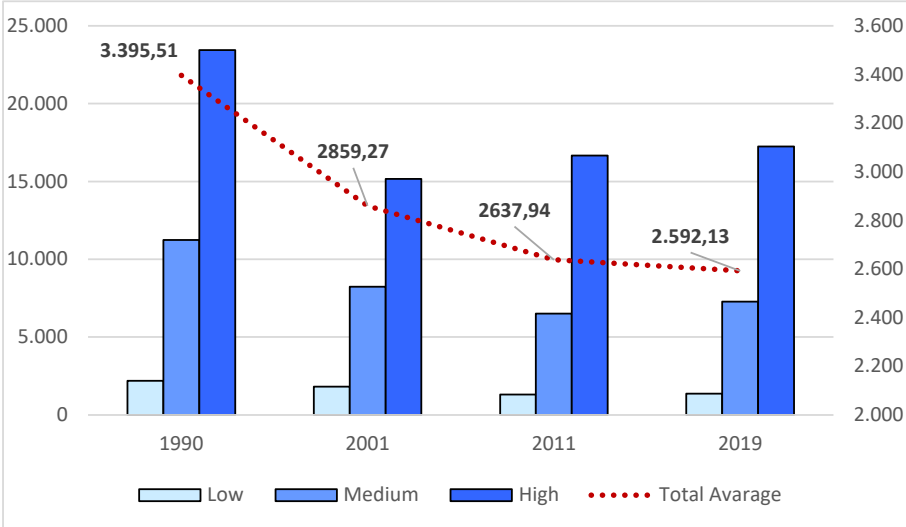
A= Milk production (Thousand liters of milk/group of municipalities)
B= Number of cows milked (Thousand Cattle Heads/group of municipalities)
C = Production Worth (Reais/group of municipalities)

** Real rates exchanged from the Cruzeiro currency into the Real currency*
Average values in columns followed by different letters are statistically different ($p < 0.05$) according to Student's T-test

Source: the authors

The average level of milk production (Column A) showed a statistical difference ($p < 0.05$) between the groups (low, medium and high) in all four periods analyzed (1990, 2001, 2011 and 2019). Overall, the total average milk production (thousand liters/group of municipalities) in the state of São Paulo showed a gradual reduction over the period analyzed (Graph 1), from around 3,4 million in 1990 to approximately 2,6 million liters of milk in 2019.

Chart 1 | Total average milk production (thousand liters/group of municipalities) by level of importance groups concerning dairy activity in the state of São Paulo during 1990, 2001, 2011 and 2019

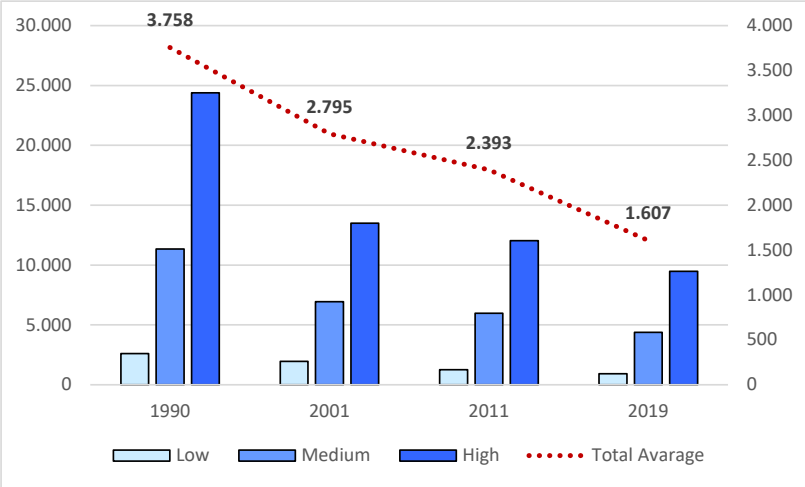


Source: the authors

It is worth mentioning, however, that for municipalities belonging to the group having high level of importance, there was an increase in average milk production between 2001/2011 and 2011/2019. For the municipalities belonging to the groups having medium and low levels of importance, there was a slight increase in average milk production between 2011/2019.

Moreover, it was found that the average number of cows milked (Column B/Table 5) showed a statistical difference ($p < 0.05$) between the periods and level of importance groups regarding the dairy activity. Chart 2 illustrates the behavior of variables, evidencing a continuous reduction in the average number of cows milked in state of São Paulo.

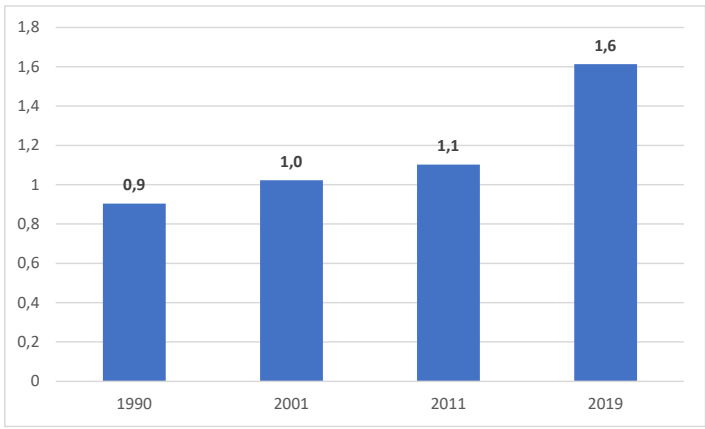
Chart 2 | Total average number of cows (thousand cattle heads/group of municipalities) by level of importance groups regarding dairy farming in the state of São Paulo during 1990, 2001, 2011 and 2019



Source: the authors

Considering the total average milk production and the total average number of cows milked in the state of São Paulo during 1990, 2001, 2011 and 2019, it is possible to evaluate the average productivity index of dairy activity. It can be observed in Chart 3 that productivity is increasing, although production and the number of cows milked have decreased over time.

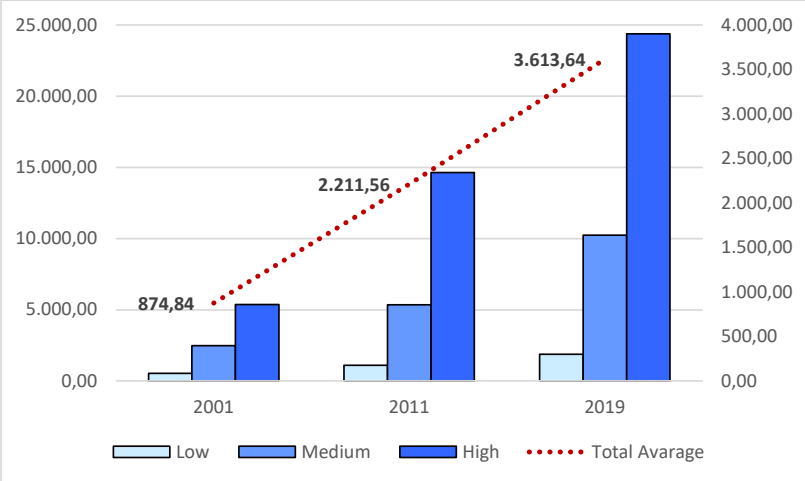
Chart 3 | Average productivity index (thousand liters/heads of cattle) of dairy farming in the state of São Paulo during 1990, 2001, 2011 and 2019



Source: the authors

According to the data presented in Table 5, it can be observed that the average level of production worth (Column C) of dairy farming in the state of São Paulo showed a statistical difference ($p < 0.05$) between the groups according to their level of importance and periods under analysis. Once Brazil had a different currency in 1990 and that the exchange rate to its current currency significantly modifies its worth, data from this specific period were not used in the analysis. Chart 4 allows verifying an increase in the average production worth of dairy farming in the state of São Paulo along the analyzed period.

Chart 4 | Average production worth (Reais) of dairy farming in the state of São Paulo according to groups classified based on their level of importance in dairy farming by analyzed period



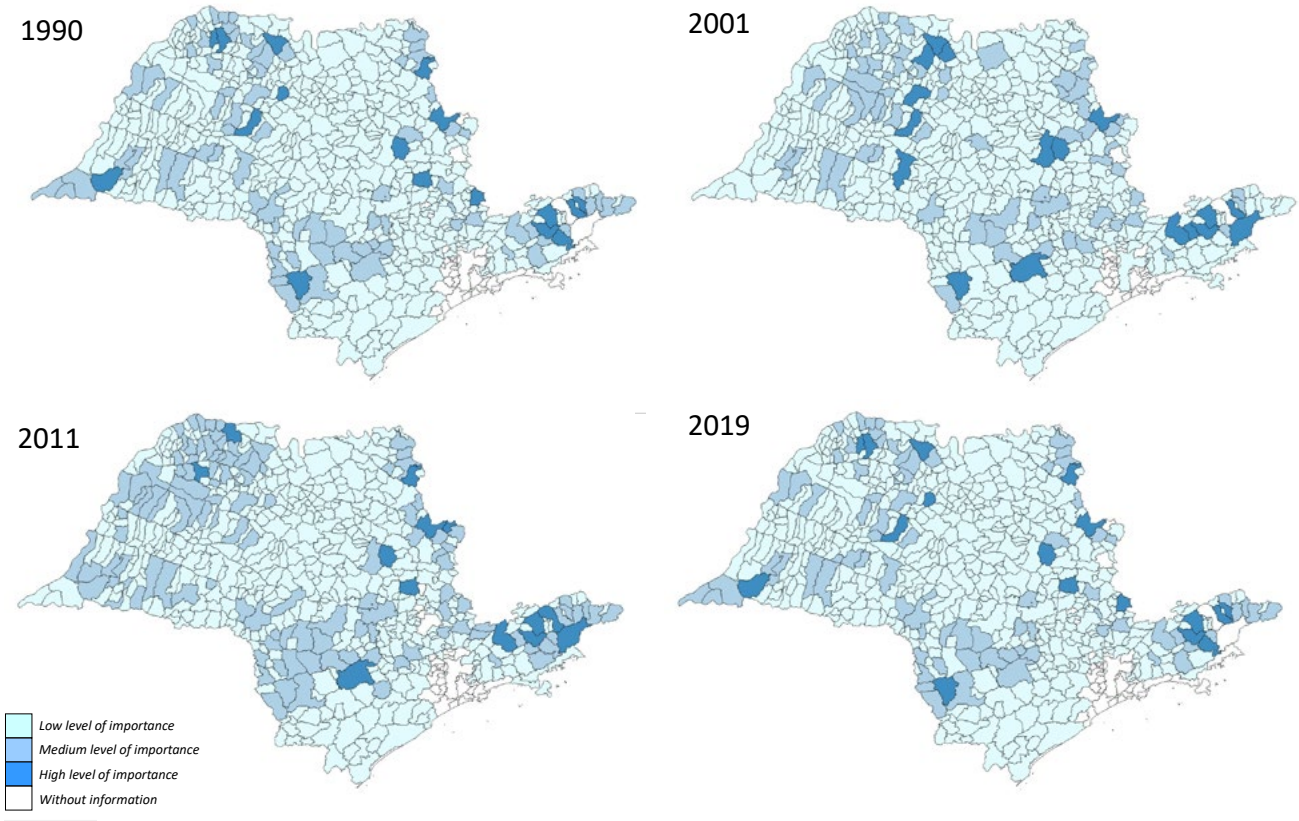
Source: the authors

The geographic distribution of different levels of importance of dairy farming across all municipalities in the state of São Paulo considering the different periods of analysis allows observing the dynamics of this process. Figure 3 shows the set of maps generated from the municipal indices for the years 1990, 2001, 2011 and 2019.

An analysis of maps allows observing that dairy farming is quite geographically dispersed in the state of São Paulo. There is dairy farming in practically all municipalities statewide, except for those in its metropolitan region.

However, despite the initial expectations of this work, no spatial dynamics of dairy activity in the state of São Paulo is observed by analyzing the four maps shown in Figure 3. Instead, there is a pattern of stability of dairy activity in municipalities of São Paulo along the periods under analysis.

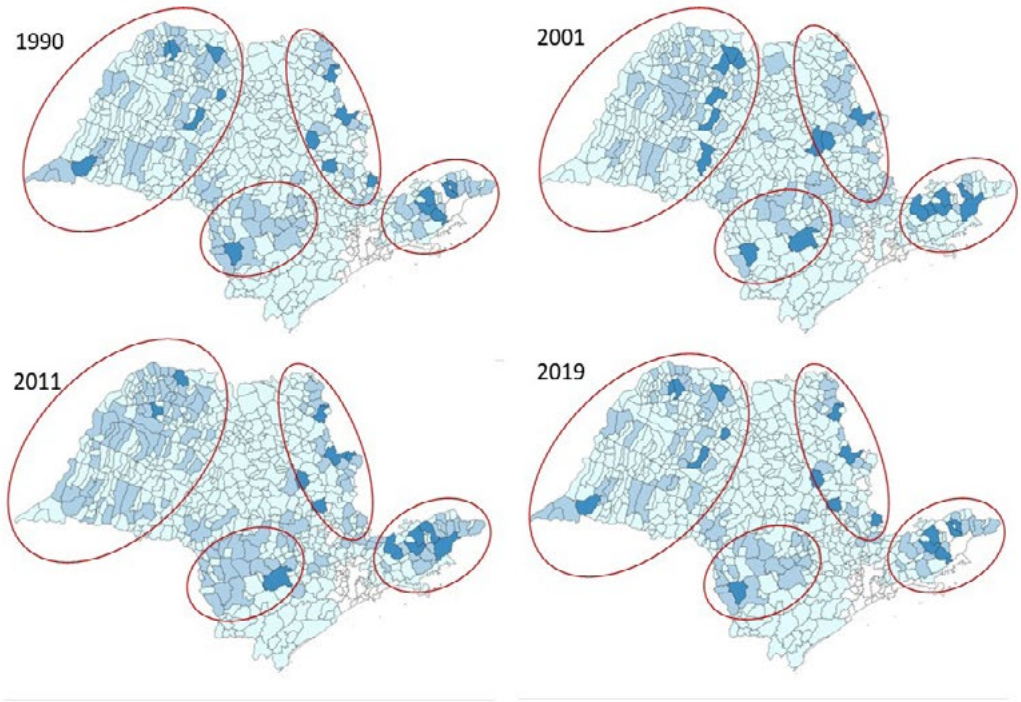
Figure 3 | Spatial distribution of dairy farming activity in municipalities of the state of São Paulo during 1990, 2001, 2011 and 2019



Source: the authors

Figure 4 presents a grouping of municipalities by similarity in terms of dairy activity, demonstrating a certain regularity during the years of analysis, constituting certain regions of dairy activity in São Paulo. The groups were circled by a red line to better understand the phenomenon identified through the analysis method.

Figure 4 | Regions similarity in dairy activity in the state of São Paulo during 1990, 2001, 2011 and 2019



Source: the authors

It is worth mentioning the regions in the Northeast and East of the state of São Paulo regarding dairy farming, as they border the state of Minas Gerais, i.e. the largest Brazilian dairy producer. In the Northwest and Southern Center of the state, there are regions having a considerably high standard of quality during the years analyzed, with special emphasis on the one close to the state of Paraná, given that it has similar features to that found in Minas Gerais which also stands out in the Brazilian scenario in terms of dairy production.

The Central and Metropolitan Regions of the state São Paulo are also those bearing no relevance to dairy activity, since typical results were found for the years of 1990, 2001, 2011 and 2019. In all analyzed years, most municipalities located in these regions are classified as of low milk production.

FINAL CONSIDERATIONS

Given the importance of dairy farming in Brazilian agribusiness, it is scientifically worth understanding the changes occurring over time. In 2019, Brazil was ranked sixth in terms of milk production worldwide. While particularly analyzing the state of São Paulo, official data reveals lower standings in this activity countrywide, as it dropped from the second largest Brazilian milk producer in 1990 to the sixth place in 2019.

In this context, this work aimed to understand the levels of importance of dairy farming in the state of São Paulo based on an analysis of milk production indices, number of cows milked and production worth of each of the 645 municipalities of the state of São Paulo adopting four distinct time periods as time frame: 1990, 2001, 2011 and 2019.

Exploratory quantitative research, the Common Factor Analysis and Hierarchical Clusters were used as analysis methods and allowed identifying the level of importance of dairy farming in each municipality of the state of São Paulo. Data analysis allowed clustering the municipalities in São Paulo into three levels of importance: Low, Medium and High.

The method used allowed finding that the three importance levels (low, medium and high) of municipalities had statistical differences between them during all analysis periods (1990, 2001, 2011 and 2019) concerning all study variables.

Furthermore, it can be observed that the spatial dynamics of dairy farming in São Paulo contradict the pattern presented by other states in the nation. E.g. Bánkuti et al. (2017) states that the state of Paraná presented a sort of dairy corridor by employing the same analysis tool and method as those used in the present study, and the state of São Paulo demonstrated no relevant changes or formation of clusters, but it maintained a pattern of regional behavior of dairy farming activity – especially in regions bordering the states of Mato Grosso do Sul, Minas Gerais and Paraná.

Contrary to initial expectations, the dynamics of São Paulo remained basically unchanged over the analyzed years. This fact, coupled with initial results, allows finding that the state of São Paulo diminished its standings of cattle herds and milked cows during the period analyzed countrywide (1990-2019), consequently leading to reduced milk production. Despite managing to increase

its milk productivity rates, the state has not followed the national growth trend for this sector. A combination of these factors explains such lower standings of the state of São Paulo regarding dairy activity nationwide. Its production structure does not seem to be a factor influencing this dynamic, since the production characteristics on small properties and the features of Family Farming resemble those of the main producing states and the country as a whole.

Revela-se, assim, o potencial de melhoria produtiva que o estado apresenta, bem como a necessidade dos agentes envolvidos buscarem ações estratégicas, técnicas e operacionais para dirimir esse "gap" técnico/tecnológico. Por fim, argumenta-se que os resultados desse trabalho contribuem para o debate e formulação de políticas públicas e privadas que visam à melhoria da importância da atividade leiteira no estado de São Paulo, contribuindo, consequentemente, para o desenvolvimento rural e regional. This reveals the potential for production improvement in the state, as well as the need for agents involved to seek strategic, technical and operational actions aimed to eliminate this technical/technological gap. Ultimately, it is suggested that the results of this work contribute to discuss and frame public and private policies aiming to improve the importance of dairy farming in the state of São Paulo, thus contributing to rural and regional development.

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