Journal of Agricultural Science and Technology B 7 (2017) 147-157
doi: 10.17265/2161-6264/2017.03.002

Association between Agricultural Production Value and the Use of Rural Area within the Municipalities in the State of São Paulo, Brazil

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Abstract: Rural economic development can differ intensely among municipalities within the same region. The economic activity disparity among them makes public policy actions difficult. It is possible to find highly efficient and globally competitive producers, as well as those producing for subsistence, in the same area. This disparity stands out the total productivity importance of the factors of production in the agricultural sector, especially the productivity of the land. The way the land is occupied in the rural area, namely crops, pastures, reforestation and other areas, can be indicative of the productivity of the land factor and the value of agricultural production. The products that compose the value of the agricultural production present different land occupation through their own productive characteristic. The main objective of this work was to measure the association between the production value of groups of agricultural products and the diversified uses of the rural area in the production of the municipalities in the state of São Paulo. In this research, 52 agricultural products produced in 2008 were used, grouped in five production value variables and other nine variables of the land use in production of the municipalities in São Paulo. The multivariate statistical technique of canonical correlation was used to measure the association between the product variables group of the production value with the land use group in agricultural activities. It was concluded that there is a strong correlation (94.3%) in the first pair of canonical variables, representing the production value and the land use, allowing groups of municipalities to be formed at different stages of development in agricultural production. It can be verified that 61.8% of the municipalities in the state were below the average in the production group and land use and that only 4.8% were above average for the production variables group and with values below the average in land use. The stages of agricultural development in the municipalities of São Paulo and the association between the production and use of the area can contribute to identify the direction of public policies to increase the productivity of the agricultural sector.

Key words: Agricultural production value, rural area, canonical correlation, heterogeneity.

1. Introduction

Economic development is a very comprehensive concept. This is a complex subject [1], since there is no universally accepted definition of development within the academic world. In addition, there are also two distinct currents in the literature: one formed by classical economists who consider growth as synonymous with development, and the other who perceives growth as an inseparable condition for development, but not unique [2, 3].

Inequalities, in terms of area size, technological contribution, management and use of the workforce, are enormous when different regions and countries are compared [4]. Even among family farmers, the differences are significant. In this context, producers

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who are fully inserted in the market up to units that produce practically for subsistence, and in some cases, even suffering from food insecurity, are found [5].

The heterogeneity is also present in countries, such as India, which is characterized by a large mass of micro producers and large monoculture farms. In a country, like China, where property rights belong to the state, there could be greater symmetry in production. However, with the end of the collective production system, the increase in inequality occurred in a pronounced way. There is a difference in incomes between the provinces of Southeast China, where economic reforms began [6].

Economic growth is driven by gains in agricultural productivity [7]. Because of this, it relies on resources, such as natural, human and agricultural technology. Rapid agricultural growth raises the efficiency of transfer resources among non-agricultural sectors, resulting in increased overall productivity of agriculture, capital and labor [8]. The heterogeneity of agricultural regions highlights the importance of productivity in the agricultural sector. The determinants of land and labor productivity in Brazilian agriculture in 2006, allowed us to infer that there is a high probability that the best productivity results of these factors are in the same geographic spaces [9]. Most municipalities in the South and Southeast of Brazil had a low productivity index, while few had very high values [9].

The effects of increased productivity in Brazil can be seen in the negative rates of total input use in the last decade. The areas of pastures had significant reductions, while the number of animals had great increase. Another relevant aspect concerns the reduction of labor in agriculture and the index of capital, which has presented a continuous and intense pattern of growth, resulting in the implementation of agricultural modernization [10]. Labor productivity was the main component associated with the increase in total factor productivity (TFP) [11]; between 1975 and 2011, the estimate of the annual growth rate of labor productivity was higher than that of land productivity—4.46% against 3.81%. The effect of land productivity on TFP was also significant in this period, being 284.21%, higher than the productivity of the capital, which was 207.22%.

The need to understand the causes of changes in land use has been emphasized in literature [12]. The causes of changes in land use and land cover are dominated by development and environmental policies [13].

The different forms of land occupation in rural areas, such as crops, pastures, reforestation and other areas, may be indicative of the productivity of the land factor and the value of agricultural production, considering all the production patterns, that is, small, medium and large farms. The products that compose the value of the agricultural production present different land occupation through their own productive characteristic, influencing differently the value of the total production and the productivity of the land. In this way, the result of agricultural economic activity may present significant discrepancies within the same region.

The study of productive variables and land occupation in an isolated way does not consider the possible associations between them, and therefore, makes any deepening of the variation structure ineffective. The use of multivariate statistical techniques, in which there is a structure of simultaneous relationship between variables, constitutes an appropriate alternative for the exploratory and inferential analysis. In this sense, the multivariate statistics for the joint analysis of indicators that evaluate the association of agricultural production and land use in the rural area of a municipality can be an important tool to help consistently the policy manager. Thus, the main objective of this work was to measure the association between the production value of groups of agricultural products and the diversified uses of the rural area in the production of the municipalities in the state of São

Paulo. It was also intended to form groups of municipalities with similar characteristics as the value of agricultural production and the use of the area.

2. Materials and Methods

2.1 Materials

Information about the municipalities in São Paulo was used with agricultural production in 2008, due to the official availability of coincident information for the two groups of variables in this year.

The first group of variables calculated the value of production in reais (R$) by product groups, following the division used by the Agricultural Economy Institute of the state of São Paulo [14], which were described in Table 1.

The second group, designated as variables of the rural area use, employed information on the use of rural areas, in hectares (ha), according to Census Survey of Agricultural Production Units (LUPA project) of the state of São Paulo for 2007/2008, which were described in Table 2 [15].

The official data sources used were from the Brazilian Institute of Geography and Statistics Foundation (IBGE), the State System of Data Analysis Foundation (SEADE), the Institute of Agricultural Economics (IEA), the Integral Technical Assistance Office of the Department of Agriculture and Supply of the State of São Paulo (CATI).

Table 1 Description of agricultural production variables.

Variables	Description
FRF	Value of municipal agricultural production of fresh fruits. It consists of avocado, pineapple, banana, persimmon, fig, guava, orange, lemon, mango, passion fruit, watermelon, strawberry, peach, tangerine and table grapes.
OLE	Value of municipal agricultural production of oleraceous. It consists of pumpkin, zucchini, lettuce, potato, sweet potato, beet, onion, carrot, cassava, red peppers, cabbage and tomato.
VPI	Value of municipal agricultural production of vegetable products for industry. It consists of rubber, benefited coffee, cane sugar, guava for industry, orange for industry, cassava for industry and tomato for industry.
ANP	Value of municipal agricultural production of animal products. It consists of beef, chicken, pork, silkworm cocoon, grade B milk, grade C milk, honey and eggs.
GRF	Value of municipal agricultural production of grains and fibers. It consists of cotton, peanuts, rice, beans, corn, soybeans, sorghum, wheat and triticale.

FRF: fresh fruits; OLE: oleraceous; VPI: vegetable products for industry; ANP: animal products; GRF: grains and fibers.

Table 2 Description of the variables of the rural area use.

Variables	Description
APC	Area with perennial crop. It includes the land occupied with perennial crops (also known as permanent), that is, those that grow for several years until they have become productive, remaining this way for several years, without perishing after harvest.
TCA	Temporary crop area. It includes land occupied with temporary crops (also known as annual), that is, those that last a single season, perishing after harvest.
APA	Area with pasture. It includes land occupied with grasses and similar, which are effectively used in cattle raising, including those intended for weeding, as well as those intended for the supply of vegetative material for silage or haymaking.
ARF	Area with reforestation. It comprises the lands occupied with the cultivation of exotic or native forest essences.
ANV	Area of natural vegetation comprises lands occupied with various types of natural vegetation, including natural forest, Capoeira[1], Cerrado[2], Cerradão[3], fields and similar. The natural forest refers to any area of vegetation untouched by humans, as well as to those in an advanced degree of regeneration.
FAA	Fallow area. It comprises commonly arable lands, but for some reason, are not currently being cultivated. The area used for annual crops, which is not in use during the off-season, should not be considered as fallow area.
AMM	Area of marsh and meadow vegetation. It comprises the lands occupied with marsh, meadow or another form of flooded or drenched land, without agricultural use.
COA	Complementary area. It includes the other lands with units of agricultural production (UAP), such as those occupied with improvements/facilities (house, barn, stable), dam, pond, road, tracks, fence, as well as unusable areas for agricultural activities.
APU	Average production unit. It corresponds to UAP average size of the municipality.

[1] Capoeira is the area whose vegetation has been mowed and/or burned for cultivation or other purposes, and which is being renewed; [2] Cerrado is a field of low-growing trees, thorny bushes, especially cacti; [3] Cerradão is a xerophilous forest of the plateaus, denser and more varied than the Cerrado.

2.2 Methods

The multivariate statistical technique of canonical correlation analysis was used to evaluate the association between groups of value variables of agricultural production (called "production") and use of the rural area (called "area use"), which simultaneously considers all variables and the entire structure of variation in the data [16].

This technique measures the existence and the intensity of the association between two sets of random variables, summarizing them by means of linear combinations, in new variables called canonical variables. The correlations between the canonical variables of the first set with those of the second one are called canonical correlations. The coefficients of these linear combinations are determined to obtain the maximum association between the canonical variables, in the set of linear combinations that present variances equal to one and that are not correlated with the previous combinations [16, 17].

Considering the 14 variables of this study, the random X vector of dimension 14, was fractionated into two sets of random vectors of form $X' = \left[X'^{(1)} \quad X'^{(2)}\right]$, where $X'^{(1)}_{1 \times p} = (X_1 \quad \dots \quad X_p)$, a random vector representing the set of p = 5 characteristics of agricultural production value and $X'^{(2)}_{1 \times q} = (X_{(p+1)} \quad \dots \quad X_{(p+q)})$, a vector representing the set of $q = 9$ characteristics of the rural agricultural area, with the general structure of S variability $S = \begin{bmatrix} S^{(1,\ 1)}_{p \times p} & S^{(1,\ 2)}_{p \times q} \\ S^{(2,\ 1)}_{q \times p} & S^{(2,\ 2)}_{q \times q} \end{bmatrix}$ similar to X vector partition.

As the variables were not measured in the same unit, standard variables were used, and consequently, the canonical functions were obtained from the eigenvalues (λ_t) and the respective eigenvectors (a_t, b_t) associated with the determinant equations: $\left|R^{(1,\ 2)}\left[R^{(2,\ 2)}\right]^{-1}R^{(2,\ 1)} - \lambda_t R^{(1,\ 1)}\right| = 0$ or $\left|R^{(2,\ 1)}\left[R^{(1,\ 1)}\right]^{-1}R^{(1,\ 2)} - \lambda_t R^{(2,\ 2)}\right| = 0$, where $R^{(1,\ 1)}$ and $R^{(2,\ 2)}$ are the matrices of estimated correlations of the first original variables $\left(X'^{(1)}\right)$ and the second set $\left(X'^{(2)}\right)$ of variables respectively, while $R^{(1,\ 2)}$ and its transposed matrix $R^{(2,\ 1)}$; the correlation matrix between the $X'^{(1)}$ vector variables and those presented on $X'^{(2)}$ vector.

Thus, it was possible to establish five pairs of canonical variables given by linear Eqs. (1) and (2):

$$u_t = a'_t X^{(1)} \tag{1}$$

$$v_t = b'_t X^{(2)} \tag{2}$$

where, t = 1, …, min(p, q), i.e., t = 5, and consequently, five coefficients of canonical correlations (r_{u_t, v_t}) between the two sets of variables that were determined in descending order of magnitude.

The coefficients of canonical correlations were obtained by Eq. (3):

$$r_{u_t, v_t} = \sqrt{\lambda_t} \tag{3}$$

where, t = 1, …, min(p, q).

The canonical variables allowed the construction of a two-dimensional scatter plot between the set of variables of production and area use. The positioning of each municipality in this Cartesian plane determines its location in quadrants and represents its characteristic, regarding the association between the area use and the agricultural production value. A map of the state of São Paulo was also constructed to identify groupings of municipalities in relation to the quadrant that each one was located.

For a better understanding and interpretation of the canonical variables, the correlations of each original variable with the respective canonical variable (canonical charges) were evaluated. Subsequently, by means of descriptive statistics, the product groups were quantified in relation to each quadrant and to the state of São Paulo, and the productivity of the area was determined, considering only permanent, temporary, pasture, reforestation and complementary areas. All analytical results were discussed at 5% level of significance.

3. Results and Discussion

3.1 Canonical Correlation between the Use of the Area and Agricultural Production

In this study, 633 municipalities were used with area and agricultural production in the state of São Paulo. Table 3 presented the five canonical correlations found. The first four group was significant ($P < 0.001$), with values equal to 0.943, 0.655, 0.557 and 0.439, respectively.

With these significant results ($P < 0.001$), it is possible to affirm that there are four canonical variables expressing distinct characteristics regarding the agricultural production (u_1, u_2, u_3 and u_4) associated with canonical variables expressing certain situations of use of the rural area (v_1, v_2, v_3 and v_4) However, in this study, the association between the pair of canonical variables (u_1, v_1), which presented a significant correlation of 0.943 and represented 84.72% of the variability contained in the data, was used to deepen the discussion of the results. This association points out interesting aspects of the influence of agricultural production and the use of the rural area of the municipalities in São Paulo.

The canonical functions of the first pair of variables can be described in relation to the variables searched by Eqs. (4) and (5):

$$u_1 = 0.121 \times \text{FRF} + 0.219 \times \text{GRF} + 0.007 \times \text{OLE} + 0.075 \times \text{ANP} + 0.895 \times \text{VPI} \quad (4)$$

$$v_1 = 0.319 \times \text{APC} + 0.865 \times \text{TCA} - 0.005 \times \text{APA} - 0.020 \times \text{ARF} - 0.00 \times \text{ANV} - 0.065 \times \text{AMM} - 0.020 \times \text{FAA} + 0.065 \times \text{COA} - 0.096 \times \text{APU} \quad (5)$$

It can be seen that the variable u_1 associates the production variables in a total of all production variables of fresh fruit (FRF), grains and fibers (GRF), oleraceous (OLE), animal products (ANP) and vegetable products for industry (VPI). The highest weights of this association are expressed in the coefficients of canonical functions for VPI (0.895) and GRF (0.219) groups.

Table 3 Coefficients of canonical functions, eigenvalue, canonical correlation between production variables (u_t) and area use (v_t) and the results of this statistics test.

Group	Variables	Coefficients of canonical functions				
		1st	2nd	3rd	4th	5th
		(u_1, v_1)	(u_2, v_2)	(u_3, v_3)	(u_4, v_4)	(u_5, v_5)
Production (u_t)	FRF	0.121	-0.887	-0.195	0.244	-0.423
	GRF	0.219	0.254	0.451	-0.858	-0.858
	OLE	0.007	-0.341	0.319	0.683	0.683
	ANP	0.075	-0.044	0.689	0.722	0.205
	VPI	0.895	0.239	-0.323	-0.058	0.336
Area use (v_t)	APC	0.319	-0.494	-0.329	0.267	0.062
	TCA	0.865	0.720	0.119	-0.531	-0.159
	APA	-0.005	0.184	0.807	0.636	0.106
	ARF	-0.020	0.016	0.431	-0.755	-0.117
	ANV	-0.003	-0.317	-0.183	-0.024	-0.889
	AMM	-0.065	-0.186	-0.277	0.185	0.256
	FAA	-0.020	-0.251	0.205	-0.515	0.738
	COA	0.065	-0.465	0.012	0.520	0.042
	APU	-0.096	0.080	-0.153	0.101	0.136
Eigenvalue		0.889	0.429	0.310	0.192	0.012
% retained		84.717	7.915	4.733	2.504	0.131
r_{u_t, v_t}		0.943	0.655	0.557	0.439	0.111
P value		< 0.001	< 0.001	< 0.001	< 0.001	0.173

3.2 Division of Municipalities in Quadrants according to Canonical Variables

Fig. 1 showed the dispersion for the first pair of canonical variables (u_1 and v_1) relative to the values that these variables assumed in each municipality. Note the positive linear association between the canonical variable v_1 (representing a situation for the use of the rural area) and the variable u_1 (representing jointly the variables of agricultural production).

The municipalities in the first (Q_1) and third (Q_3) quadrants illustrate the behavior of the correlation. In Q_1, above the average values (positive) are observed for values of u_1 (agricultural production) associated with above the average values (positive) for v_1 (rural area use). In Q_3, the inverse is seen, that is, in this quadrant, the municipalities with below-average values (negative) of u_1 (agricultural production) associated with below-average values (negative) for v_1 (rural area use) are observed. This characteristic demonstrates the direct association of the land production factor as indicative of high values of agricultural production in most of the municipalities in São Paulo.

In the second quadrant (Q_2), below-average values are observed for the value of u_1, with the occurrence of values above the average of v_1, that is, even with greater land use, the agricultural production was low. In this way, considering the land production factor, the municipalities in this quadrant perceive lower productivity in their use.

The fourth quadrant (Q_4) presents values above the average for u_1 and below the average for v_1, so these results occurred with less use of rural area, indicating a higher productivity per unit area in these municipalities. The growth of production, generated by the agricultural sector, was due to the incorporation of the other factors of production into the productive process, as capital and technology. The stages of development of agricultural activity [18] in the northwestern part of Rio Grande do Sul, a Brazilian state, initially demonstrated the growth of production by the intensive use of the land factor, as a result of the incorporation of new areas into the productive process. With the exhaustion of the agricultural frontier,

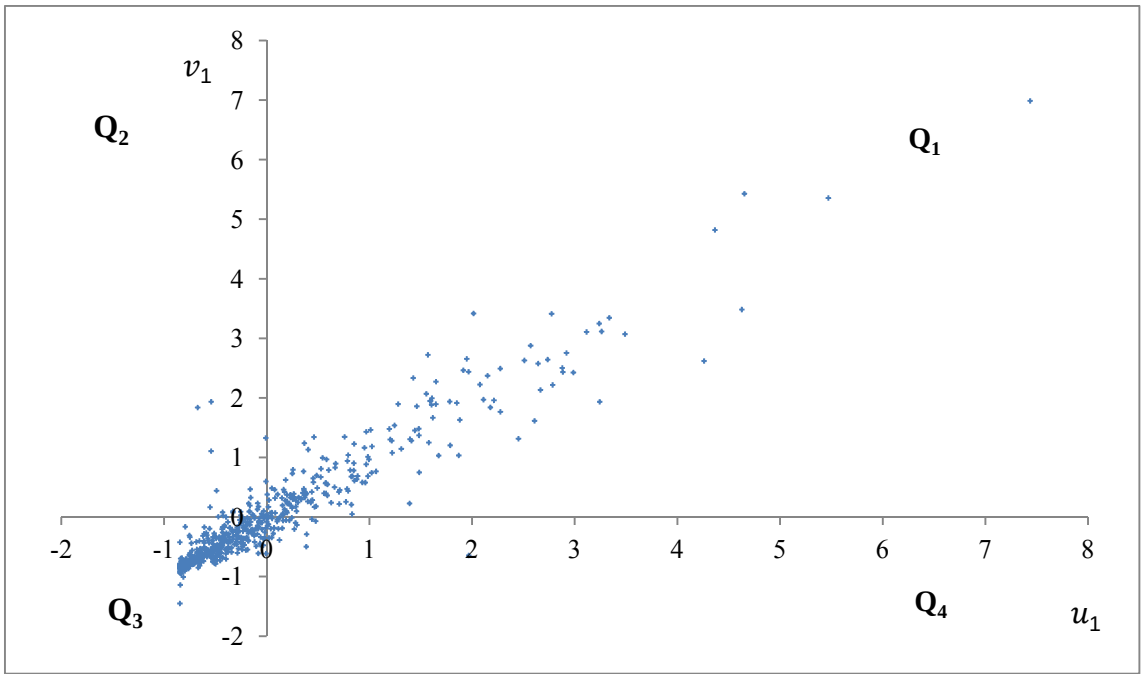

Fig. 1 Scatter plot of the first pair of standardized canonical variables.

the use of other factors of production (capital, mainly) is intensified to maintain the upward trend of production.

3.3 Assessment of Canonical Charges

In Fig. 2, there were positive correlations between the original variables and the canonical variable u_1 (agricultural production), with emphasis on vegetable products for industry (0.96), with 46.73% of the state production. In this way, the production of vegetables for industry becomes a driver of the behavior of agricultural production, being an interesting economic indicator of the expected performance for agribusiness. The values of the correlations between production with other groups of products, such as grains and fibers (0.38) and animal products (0.24), fresh fruits (0.31) and oleraceous (0.12), indicate that these variables are an indicator of low trend expression of the municipalities' productive activity.

The canonical variable v_1 (area use) has a positive correlation with the variables of temporary area (0.87) and permanent area (0.32), being practically null for the other variables (some express positive and others negative values; all of them close to 0). It should be noted that most of the state's area is occupied by pastures (39.4%), with an association of only 0.004, that is, it does not represent the behavior of the canonical variable related to the area use. The main area indicator is the temporary area variable (32.3% of the state), i.e., higher values of v_1 occur in municipalities with larger areas of temporary crops. Researches on farmers' decision-making [19] attempt to explore which variables lead farmers to innovate, to choose crop or breed. Yet, land use is still an acceptable indicator for the outcome of such decisions.

The positive correlation between the canonical variables u_1 (agricultural production) and v_1 (area use) makes it possible to associate higher values of u_1 when there is greater use of temporary areas and higher values of v_1 in the presence of the group of vegetable products for industry.

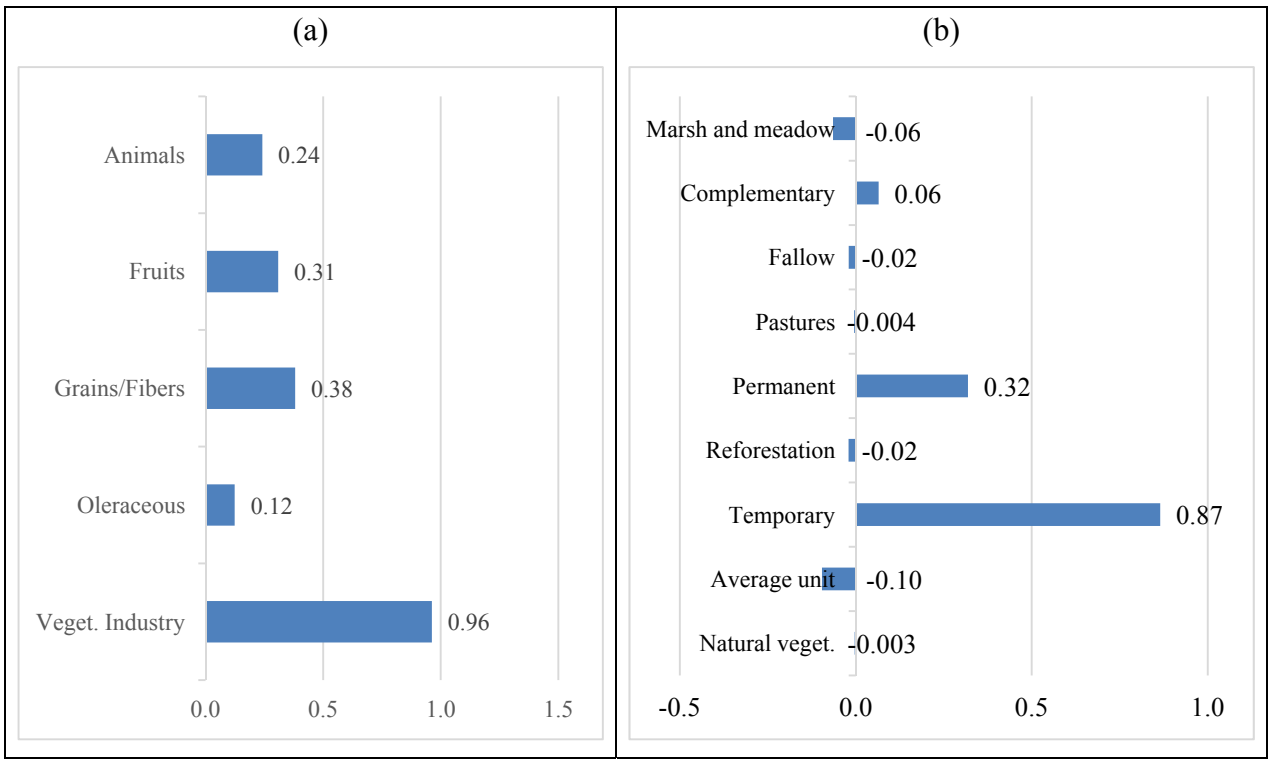

Fig. 2 Correlation between the original production variables with the canonical variable u_1 (a) and the original variables of the area use with the canonical variable v_1 (b).

3.4 Geographical Distribution of Municipalities according to the Association of Canonical Variables

The map of the state of São Paulo, represented in Fig. 3, showed the colored municipalities, according to the quadrant to which they belong. It can be seen the formation of groups of municipalities from the same quadrant in adjacent areas. In the white area, there are municipalities without agricultural and/or livestock production concentrated in the metropolitan region of São Paulo (the municipality of São Paulo is in Q_3, in green), and in the center of the state, the municipality of Águas de São Pedro, also in white.

The municipalities in Q_1, represented by the color blue, are in the interior of the state, mainly in the North, characterized by the direct relation between production and use of the agricultural area, with productivity of R$2,564.56/ha.

In Q_2, isolated municipalities are seen, or at most in two, scattered throughout the state, in orange color, characterized by the use of above average area and below average production, with a relation of R$1,253.58/ha. Groups of adjacent municipalities were not observed; a specific study would be considered to verify the factors that justify the low productivity of the land use.

In Q_3, represented by the green color, the formation of groups has a direct relation between production and area, with a productivity of R$1,760.25/ha, but with values below the average in the state, located predominantly to the south and throughout the coastal region. It should be noted that Q_3 is the quadrant opposite to Q_1, but it would be possible that Q_3 would have similar productivity per hectare, with less production and area use, proportionally to Q_1. However, lower productivity of the area was observed.

The municipalities that form Q_4, in red color, are dispersed throughout the interior of the state, except in the Southern and Coastal region, where only the municipality of Miracatu represents this quadrant. Q_4 has the highest productivity of the land factor with R$3,287.13/ha. There is no formation of clusters of

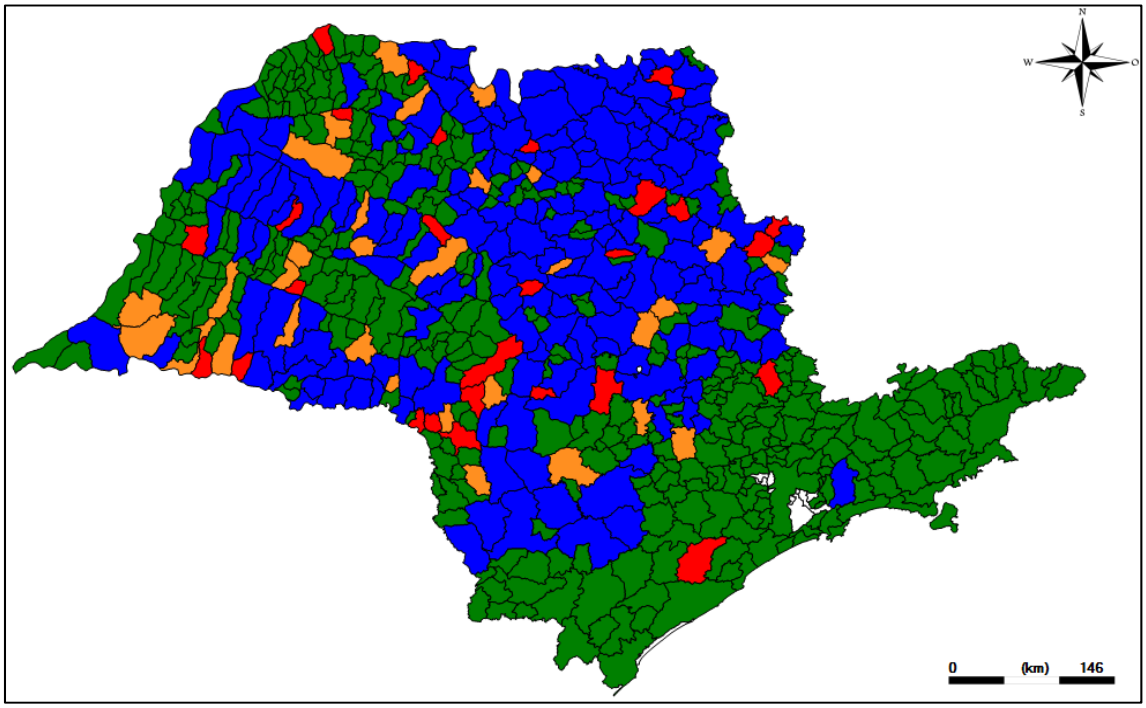

Fig. 3 Map of the state of São Paulo, in colors per quadrant of the first pair of standardized canonical variables.
Q_1: represented by blue color; Q_2: represented by blue color; Q_3: represented by green color; Q_4: represented by red color.

adjacent areas (maximum of two municipalities), presenting as the opposite of Q_2.

Table 4 showed the distribution of the area, production value and quantity of municipalities, as well as the productivity of each quadrant and state of São Paulo (total). The largest quadrant of the state is represented by Q_1 with 59.42% of the production, 48.86% of the area and 183 (28.91%) municipalities. The largest number of municipalities is in Q_3 (391), however with 40.14% of the area and 30.35% of the production, that is, smaller municipalities. The quadrants Q_2 and Q_4 are smaller in area (7.06% and 3.94%, respectively) and production (4.28% and 5.95%). It can be seen in Q_1 and Q_4 quadrants that the percentage of the occupied area is lower than the production and productivity is above the state average (R$2,564.56 in Q_1 and R$3,287.13 in Q_4), notably where u_1 is positive. The inverse occurs in Q_2 and Q_3, which has negative u_1 with below-average production and productivity (R$1,253.58 in Q_2 and R$1,760.25 in Q_3).

Q_1 and Q_4 quadrants presented positive values for the canonical variable u_1 (agricultural production). It can be observed in Table 5 that the main group of products of these quadrants was formed by vegetable products for industry, with 56.87% and 45.03%, respectively. On the other hand, Q_2 and Q_3 quadrants with negative values for u_1 presented animal products as the main group with 43.99% and 39.95% of the total produced in the quadrant.

As for the area use, 45.67% of the area is in temporary crops in Q_1. In Q_4, 41.01% is used for pastures, while in Q_2 and Q_3 the pasture was characterized by 48.53% and 50.80%, respectively. It

Table 4 Percentage of total area, value of production, quantity, percentage of municipalities and productivity per quadrant in the state of São Paulo (SP).

Description	Q1	Q2	Q3	Q4	Total SP
Total area (%)	48.86	7.06	40.14	3.94	100.00
Production value (%)	59.42	4.28	30.35	5.95	100.00
Municipalities number	183 (28.91%)	31 (4.90%)	391 (61.77%)	28 (4.42%)	633 (100%)
Productivity (R$/ha)	2,564.56	1,253.58	1,760.25	3,287.13	2,191.27

Table 5 Percentage (%) per quadrant of product groups and areas uses (São Paulo state/quadrant).

Variables	SP	Q_1	Q_2	Q_3	Q_4	Total
Product groups						
Fresh fruit	10.73	48.61*/8.78**	2.67/ 6.69	44.71/15.81	4.02/7.25	100/-
Grain and fibers	11.04	70.27/13.06	4.06/10.46	22.50/8.19	3.18/5.90	100/-
Oleraceous	4.49	40.23/3.04	2.88/3.02	49.42/7.31	7.46/5.63	100/-
Animal products	27.00	40.16/18.25	6.98/43.99	44.89/39.95	7.97/36.18	100/-
Vegetable for industry	46.73	72.32/56.87	3.28/35.84	18.66/28.74	5.73/45.03	100/-
Total	100.00	-/100.00	-/100.00	-/100.00	-/100.00	
Area use						
Permanent	5.95	62.39/7.59	6.36/5.36	27.72/4.11	3.52/5.31	100/-
Temporary	32.87	67.88/45.67	6.86/31.95	21.56/17.66	3.70/30.83	100/-
Pastures	39.39	35.43/28.57	8.70/48.53	51.77/50.80	4.11/41.01	100/-
Reforestation	5.00	43.76/4.47	4.32/3.06	46.58/5.80	5.34/6.76	100/-
Natural vegetation	11.86	36.17/8.78	4.46/7.49	55.48/16.39	3.88/11.67	100/-
Marsh and meadow	1.43	51.58/1.51	5.81/1.18	38.81/1.39	3.80/1.38	100/-
Fallow	1.09	32.62/0.73	3.56/0.55	60.56/1.64	3.25/0.90	100/-
Complementary	2.42	54.15/2.68	5.48/1.88	36.89/2.22	3.48/2.13	100/-
Total	100.00	-/100.00	-/100.00	-/100.00	-/100.00	

* The first value refers to the percentage of the quadrant in the total of the quadrants; ** The second refers to the percentage of the quadrant in the total of the product groups or area use.

is worth noting the strong correlation between the canonical variable of area v_1 (0.87) with the use of the temporary crops area and the practically null correlation (0.004) with the pasture area.

Pastures occupy 39.39% of São Paulo state area, higher than the sum of permanent crops and temporary crops (38.82%). However, the production value of animal products (beef, poultry, pork, silkworm cocoon, milk, honey and eggs) represents 27% of the total compared to 46.73% for vegetable products for industry. This finding can be verified in the productivity per hectare of Q_2 and Q_3, with the lowest of the four quadrants (R$1,253.58 and R$1,760.25, respectively), whose main group is animal products (43.99% and 39.95%).

4. Conclusions

The correlation result from the first pair of canonical variables showed that there was a positive association between the value of agricultural production and the use of rural area.

The group of vegetable products for industry is indicative of the behavior of the production value with a strong association with the group of production variables, as a whole. The use of temporary areas had a strong association with the group of area variables. Therefore, the positive association between the production value and the area allows relating the agricultural production with temporary areas and the area use with vegetable products for industry, i.e., it can be highlighted that municipalities with greater production of vegetables for industry also presented a larger area of temporary crops.

The division of the state in quadrants allowed to identify groups of municipalities in different stages of development of area use. The municipalities in Q_1 formed a geographical cluster of predominantly adjacent municipalities in the interior of the state, especially in the North. On the other hand, the few municipalities in Q_4 quadrant were dispersed throughout the interior of the state. Both showed the highest productivity (above the state average), however, in Q_1 a high productivity and the highest percentage of the rural area of the state were observed, while Q_4 showed high productivity and the smallest portion of area utilization.

Isolated and dispersed municipalities in the interior of the state were observed in Q_2 quadrant, presenting the lowest productivity. No groups of adjacent municipalities were observed, and a specific study is necessary to verify the factors that justify the low productivity of land use. Also showing low productivity (below the state average), Q_3 quadrant presented the formation of the largest group of adjacent municipalities, predominantly to the south and the entire coastal region, with some adjacent clusters in the interior.

Although the pasture area occupies the highest percentage of the state area, corresponding to the sum of the temporary and permanent crop areas, the production of animal products represents approximately half of the value of the production of vegetal products for industry. The municipalities of the quadrants Q_2 and Q_3 were characterized with a greater percentage of pasture area with animal products as the main group, resulting in the lower productivities.

The stages of agricultural development of the municipalities in São Paulo and the association of the production and area use can contribute to identify the direction of public policies to increase the productivity of the agricultural sector.

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