IRIBA Working Paper: 14

Spatial differences between family and non-family farming in Brazilian agriculture

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September 2014

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ISBN 978-1-910502-13-6

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Abstract

Brazilian agriculture has grown enormously during the past three decades. An interesting aspect of this growth is the respective roles of family and non-family farming, and the seeming importance of this distinction to Brazilian agricultural policy, reflected in the existence of separate agencies in Federal Government with responsibility for each sector. The paper presents multivariate and spatial analyses examining the family and non-family farming sectors to try to quantify how different they actually are. It employs factor analysis to compare both sectors (family and non-family farming) by homogeneous micro-region in terms of productivity, degree of mechanization, intensity of labour use, and investment. The results show that both sectors are not structurally different to each other; both have been administrated according to the same broad agricultural policies, both are overwhelmingly market-oriented, and both tend to cleave to regional differences rather than being importantly different to each other.

Keywords: Brazil, agriculture, agricultural policy, farming, family farming, non-family farming.

Acknowledgement

This document is an output from a project funded by the UK Aid from the Department for International Development (DFID) for the benefit of developing countries. However, the views expressed and information contained in it are not necessarily those of or endorsed by DFID, which can accept no responsibility for such views or information or for any reliance placed on them.

1. Introduction

Brazil´s agricultural sector has grown enormously during the past three decades. Considering the main 63 crops (including sugarcane), agricultural production totalled 384 million tons in 1990, 485 million tons in 2000 and reached 966 million tons in 2012, amounting to a 3.2% annual geometric rate of growth for crop quantity during the 1990s and 6.7% from 2000 to 2012. Meat production also grew considerably, rising from 5.17 million tons in 1990 to 10.33 million tons in 2000 and reaching 22.35 million tons in 2012, a 7.04% annual geometric rate of growth during the 1990s and 6.4% from 2000 to 2012. Simultaneously, agricultural and agro-processed product exports grew, rising from US$ 8.76 billion in 1990 to US$ 15.96 billion in 2000 and reaching US$ 87.58 billion by 2011.

An interesting aspect of this period of agricultural growth is the role of both 'family' and 'non-family' farming. The distinction between family and non-family seems on the face of it to be of central importance in Brazilian agricultural policy, and is the main subject of this paper.

The definition of 'family farming' in Brazil is given by the country's Law 11,326, issued on July 24th 2006. A family farming property fulfils all of the following criteria: (1) the total farming area is at most four fiscal modes[1]; (2) the farm preferentially employs family members; (3) the farmer's income is derived entirely from farming. It is worth noting that nothing in these conditions imply that the designation of 'family farmer' necessarily means low-income or producing for self-consumption; those covered by it range from poor peasants to highly capitalized and market-oriented farmers. According to Brazil´s 2006 Agricultural Census, family farming accounted for 33.2% of Brazilian agriculture´s gross production value (with the other 66.8% coming from non-family farming). The family farming sector frequently achieves high values for specific products; in 2006 it was responsible for 87% of manioc production, 46% of corn production, 38% of coffee production, 58% of milk, and held 59%, 50%, and 30% respectively of swine, chicken and cattle herds.

Figures such as these have justified a split in the Federal Government structure for administrating and policymaking for agriculture. At the end of 1999, the Ministry of Agrarian Development (MDA) was created to support family farming, while the Ministry of Agriculture, Livestock and Food Supply (MAPA), created more than 100 years earlier, continues to support

[1] As defined by Law 6,746, issued on December 10th 1979, a fiscal mode represents the minimum area for a farm to be considered economically viable and ranges from 5 to 110 hectares, depending on the municipality.

non-family farming despite family farmers are also eligible for MAPA´s programmes. Since the beginning of 2000´s, MDA and MAPA have shared responsibility for supporting Brazilian agriculture, using largely the same broad agricultural policies (rural credit, minimum agriculture prices, rural extension and subsidized insurance), but with programs tailored for their respective sectors (family and non-family). For example, in 2003 MAPA created a new insurance program, the Subsidy for Rural Insurance, because the existing Guarantee Program for Agricultural Activity (PROAGRO), created in 1974, was only allocated to family farming. In the same year, MDA created the Food Acquisition Program (PAA), a new version of Federal Government Acquisition (AGF). The PAA is open only to family farmers, whereas both family and non-family farmers can apply to AGF. In 2006, as above, the Family Farming Law was issued, defining the category of family farmer, and since 2012 Brazil has had two annual agricultural plans, issued independently by MDA and MAPA. These plans tend to be in line with the same established agricultural policies overall but contain more specific measures appropriate for family and non-family farmers respectively. Family farmers can apply for both MDA's and MAPA´s programs, but non-family farmers can only apply to MAPA´s programs.

Brazil's vast size suggests that there could well be differences between family and non-family farming in some regions, something that, if it were the case, would need to be taken into account by economic policy. This paper **aims** to quantify, using a dataset from Brazil's 2006 Agricultural Census, how different family and non-family farming actually are in Brazil's homogeneous micro-regions.

Brazil is comprised of 27 states (including the Federal District) and they are organized into five macro-regions, whose are: North, Northeast, Southeast, South and Centre-West. Each state is also desegregated into homogeneous micro-regions what have similar economic features and edafo-climatic conditions. At the total, Brazil has 558 homogeneous micro-regions (HMR).

Literature dealing with family farming has tended to focus on one or some of the following five issues: (1) the definition of family farming (e.g. Navarro 2010); (2) the importance of family farming for Brazilian agriculture (e.g. Guanziroli et al 2001; 2012); (3) economic policy for family farming (e.g. Anjos et al 2004; Silva 2008; Santos 2010), particularly rural credit programs for family farming (e.g. Kageyama 2003; Magalhães and Filizzola 2005; Magalhães et al 2006); (4) differences within the category of family farming (e.g. Buainain 2006); and (5) the trading of agricultural production (e.g. Contenaro 2004; Perondi 2007). However, there has not yet been a study comparing family and non-family farmers regarding productivity level, degree of mechanization, intensity of labour use, and use of funding and investment. Understanding the differences between family and non-family farming with respect to these variables is important for the planning of market-oriented policies to keep Brazilian agriculture growing.

2. Methodology

In this paper, both multivariate and spatial analysis are used to compare family and non-family farming, drawing on Brazil´s 2006 Agricultural Census, aggregated by homogeneous micro-regions.

An important part of the methodology is the factor analysis, which refers to a variety of multivariate statistical techniques that try to reduce a large set of variables into a smaller number of hypothetical variables called common factors (Kim and Mueller, 1978a). The new hypothetical variables will be related to the original variables through a linear model (Kim and Mueller, 1978b). According to Johnson and Wichern (2007, 481) "… the essential purpose of factor analysis is to describe, if possible, the covariance relationships among many variables in terms of a few underlying, but unobservable, random quantities called factors". Factor analysis attempts to determine how the original variables are quantitatively linked amongst themselves by revealing similar patterns across variables.

Using the factor analysis procedure, we intend to find out common factors for both family and non-family farming, in order to compare:

I. Productivity level;
II. Degree of mechanization;
III. Intensity of labour use;
IV. Use of funding and investment.

This procedure permits to investigate possible differences between family and non-family farms in terms of their technological level. Once some differences have been unveiled, the duality in Brazilian agriculture would be taken for the planning of market-oriented policies to keep Brazilian agriculture growing.

As soon as the common factors are identified, the factor scores are then calculated. These are the numbers for each observation sample (which in this article are Brazil's homogeneous micro-regions). The factor scores are variables that can assume positive or negative values, but with mean zero and standard deviation equal to one. They can be used to indicate the rank of each observation (each micro-region) in relation to the concept expressed by the factor. A higher real value of the factor score indicates a better rank of the micro-region concerning the factor in question.

Once the common factors and their factor scores for each Brazilian micro-region have been calculated, an exploratory spatial data analysis (ESDA) is carried out. ESDA is a collection of techniques that describe and visualize spatial distributions, identify atypical locations (spatial outliers), and unveil patterns of spatial association (spatial clusters). ESDA is able to point out different realities in the analysed space (Anselin 1995). According to Anselin (1996, p. 113) "…ESDA should focus explicitly on the spatial aspects of the data, in the sense of spatial dependence (spacial association) and spatial heterogeneity".

The first step in using ESDA is to define a spatial weight matrix. According to Anselin (1988), spatial weight matrix is defined as the formal expression of spatial dependence among observations. The literature suggests a range of spatial weight matrices, such as spatially contiguous neighbours, matrices with inverse distance, *n* nearest neighbours, and so on (Getis and Aldstadt, 2004).

The second step is to verify whether the spatial data is randomly distributed. Randomness would mean that the value of an attribute in a particular region does not depend on the value of this attribute in neighbouring regions (Mayhew, 2009). To verify the randomness of spatial data, the hypothesis of an univariated global spatial association is tested by using Global Moran's I. The value of this statistic measures the degree of spatial correlation, i.e., the extent to which there are similarity values of a given variable associated with its position. Mathematically, Global Moran's I is provided by:

$$I = \frac{n}{S_0} \frac{z^{'}Wz}{z^{'}z}$$

where: n is the number of regions (number of Brazil´s homogeneous micro-regions); z is the value of a standard variable of interest (in this case, z is the factor scores); Wz is the average of neighbours' standard values of the variable in question, adopting a specific weighting matrix W ; S_0 is the sum of all elements in the spatial weight matrix.

As the name suggests, Global Moran's I is a global measure, and as such does not reveal the structure of a local spatial autocorrelation. For that, local autocorrelation detection techniques were developed to examine the existence of spatial clusters with high or low values; these identify the regions featuring most of the spatial autocorrelation. Among these techniques, Moran scatter plot and LISA (Local Indicator of Spatial Association) have mainly been used, and can usefully complement the Global Moran's I statistic.

A Moran scatter plot shows the spatial lag of the variable of interest on the vertical axis and its value on the horizontal axis (Anselin, 1996). The Moran scatter plot also shows clusters representing four types of spatial linear association between regions and their neighbours, namely: High-High (HH), Low-Low (LL), High-Low (HL) and Low-High (LH). Consequently, the Moran scatter plot is divided into four quadrants (Anselin, 1996), as can be seen in the diagram below.

The high-high linear spatial association means that a homogeneous micro-region with a high factor score for a specific feature (a specific factor) has neighbours with high factor scores for the same feature. A low-low linear spatial association means that a homogeneous micro-region with a low factor score for a specific factor (a feature) has neighbours with low factor scores for the same factor. In the same way, high-low linear spatial association means that a homogeneous micro-region with a high factor score has neighbours with low factor scores for the same feature. Finally, the low-high linear spatial association means that a micro-region with a low factor score for a given factor has neighbours with high values for this factor.

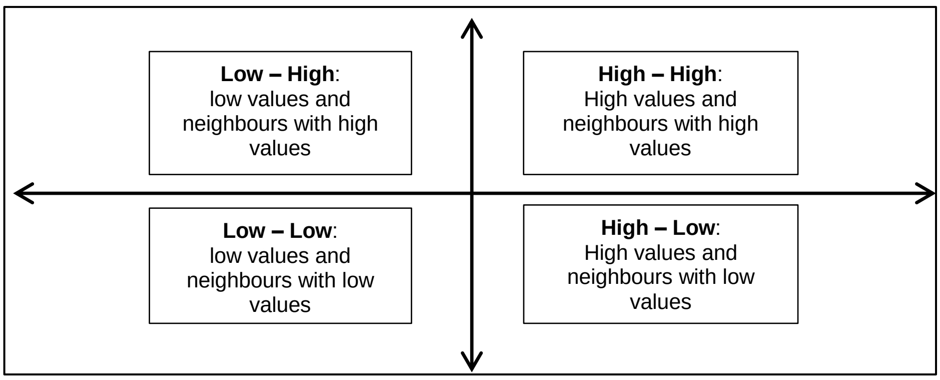

Figure 1 – Moran scatter plot

The LISA statistic, also called the Local Moran's I, measures the individual contribution of each observation into the Global Moran's I statistic. LISA captures simultaneously the associations and heterogeneous spatial correlations (Miller, 2004). Mathematically, the LISA statistic for the i^th observation is provided by:

$$I_i = z_i \sum_j w_{ij} z_j$$

where: z_i is the value of a standardized feature at the i^th observation; $\mathbf{z}_j$ is the value of the standardized feature at the j^th observation; and w_{ij} are the average values of a standardized feature in the neighbours, using a specific weighting matrix. The sum of the LISA statistics is proportional to the global Moran's statistic, and the former can be interpreted as an indicator of local spatial clusters (Anselin, 1995).

The most efficient way to present a LISA statistic is to map its values and analyse these in the same way as the Global Moran's I, i.e., using high-high (HH), low-low (LL), high-low (HL) and low-high (LH) quadrants.

Both a bivariate Global Moran's I and a bivariate Local Moran's I statistic can be calculated. They allow investigation of whether the values of a feature in a particular micro-region hold a relationship with the values of another feature observed in neighbouring micro-regions. In our case, for example, we might want to find out if the factor score for a variable for family farming in a micro-region is associated with the factor score for a different variable for non-family farming in neighbouring micro-regions.

The overall statistic for two different features is given by:

$$I^{z_1 z_2} = \frac{n}{S_0} \frac{z_1' W z_2}{z_1' z_2}$$

where: z_1 and z_2 are features and Wz_2 is z_2´s spatial lag.

The global statistic value for two separate factors (which can be the same feature, but for different groups like family and non-family farming) can be positive or negative. A positive value of I^{z1z2} means micro-regions with a high (low) factor score for a specific factor/feature for family farms tend to be surrounded by neighbouring micro-regions with high (low) factor scores for the same factor/feature for non-family farming. A negative value of I^{z1z2} means that micro-regions with a low (high) factor score for a certain factor/feature for family farms are surrounded by micro-regions with high (low) factor scores for the same factor/feature in non-family farming.

The local statistic for two distinct features (or two separate factors) is given by:

$$I_i^{z_1 z_2} = z_{1i} W z_{2j}$$

where z_{1i} and z_{2j} are standardized variables; Wz_{2j} is z_{2j}´s spatial lag. Results from the above equation have the same interpretation given to I^{z1z2}.

Chart 1, below, presents the variables used in this study, which are separately measured for family and non-family farming for each of Brazil´s homogeneous micro-regions in 2006. A dataset from Brazil's 2006 Agricultural Census is used.

Chart 1: variables used in the multifactorial analysis

Variables	Definition
X1	Share of explored area with planted pasture (%)
X2	Share of farms that use mechanical force (%)
X3	Number of tractors/EA
X4	Number of tractors/EM
X5	Number of mechanical plows/EA
X6	Number of mechanical plows/EM
X7	Number of harvesting machines/EA
X8	Number of harvesting machines/EM
X9	Total amount of investments/EA
X10	Total amount of investments/EM
X11	Total amount of borrowings/EA
X12	Total amount of borrowings/EM
X13	Ratio of borrowings/production value
X14	Gross value of agricultural production/EA
X15	Gross value of agricultural production/EM
X16	Total expenditure/EA
X17	Total expenditure/EM
X18	Share of farms that use electrical energy
X19	Occupied workforce/total area of farms
X20	Number of salaried employees/total area of farms
X21	Gross value of agricultural production/number of farms
X22	Gross value of agricultural production/occupied workforce
X23	Gross value of agricultural production/number of salaried employees

The choice of these variables was based on three criteria:

(1^{st}) variables used in earlier work (Hoffmann and Kageyama 1985; Hoffman 1992; Souza and Lima 2003) were firstly taken into consideration. These papers measure the variables in terms of explored area (EA) and equivalent men (EM). 'Explored area' in cludes temporary and permanent croplands, planted and natural pastures, planted and native forestlands (Hoffmann 1992). ‘Equivalent man’ is a reference point; because agriculture involves both full and part time, salaried and non-salaried, family and non-family workers, as well as male, female and child workers, and these groups do not all have the same labour productivity and workday length, Silva and Kageyama (1983) consider a male, salaried worker as a reference and measure the other workers in relation to him. Chart 2, below, shows the conversions used.

(2nd) information available in the 2006 Agricultural Census was used to redefine or exclude (in the case of lack of data) some of these variables;

(3rd) other variables were selected to measure productivity level, degree of mechanization, investment and intensity of labour use for both family and non-family farming.

Chart 2 - Conversions of agricultural workers into ‘equivalent man’

	Salaried worker	Family worker	Non-salaried and non-family worker (such as business associate, household resident, for example)
Male	1 EM	1 EM	1 EM
Female	1 EM	0.6 EM	0.66 EM
Child	0.5 EM	0.4 EM	0.5 EM

Source: Silva and Kageyama (1983).

3. The importance of family and non-family farming in Brazilian agriculture

Family farming was introduced as a category into Brazil’s agricultural administration and policy in the 1990s in order to reflect the importance of smaller-sized farms using family labour. Earlier, in the 1970s, some of this group were designated as ‘minifundiários’ (smallholders), ‘pequenos produtores’ (small producers), or ‘agricultores de subsistência’ (subsistence farmers). For farmers in the North-East region and settlers in the South the most common term used was ‘peasant’. However, as noted earlier, family farmers as defined by law are not necessarily poor or low-income, even though family farms are typically smaller in size.

Family farming holds the larger number of farms and the smaller share of farming total area. However, according to 2006 Brazil´s Agricultural Census, both family and non-family farming are unequally distributed among the Brazilian macro-regions with different dimensions and productivities.

Family farming answered for 84.4% of the total number of farms in Brazil, holding 24% of the total farming area and 33.2% of the agricultural gross production value (see Table 1). Northeast, South and North held the majority of family farming. In 2006, Northeast held 50% of family farms but just 35% of family farming area and 25% of its agricultural gross product in 2006. The same percentages for Southern region were 19.5%, 16.3% and 38.7%, respectively. And the percentages for North were 9.5%, 20.7% and 9.3%, respectively. On average, Northeastern family farm produced US$ 370.92 per hectare of total area in 2006, while Southern family farm had an average of US$ 743.10 per hectare and Northern family farms produced US$ 140.52. These figures reflect different mix of products, productivity and market-orientation.

Table 1: dimensions of family and non-family farming in Brazil – year of 2006

Brazil and regions	Number of agricultural establishments		
	Total	Non-family farming	Family farming
Brazil	5,175,636	809,369	4,366,267
North	475,778	63,112	412,666
Northeast	2,454,060	266,929	2,187,131
Southeast	922,097	222,342	699,755
South	1,006,203	156,510	849,693
Centre-West	317,498	100,476	217,022
Brazil and regions	Total area of farms (ha)		
	Total	Non-family farming	Family farming
Brazil	333,680,037	253,577,343	80,102,694
North	55,535,764	38,924,487	16,611,277
Northeast	76,074,411	47,759,359	28,315,052
Southeast	54,937,773	42,166,474	12,771,299
South	41,781,003	28,726,492	13,054,511
Centre-West	105,351,087	96,000,530	9,350,556
Brazil and regions	Permanent cropland (ha)		
	Total	Non-family farming	Family farming
Brazil	11,679,152	7,387,618	4,291,534
North	1,863,160	831,510	1,031,651
Northeast	3,520,901	2,067,768	1,453,133
Southeast	4,068,888	2,912,305	1,156,583
South	1,498,203	1,017,768	480,435
Centre-West	727,999	558,268	169,732
Brazil and regions	Temporary cropland (ha)		
	Total	Non-family farming	Family farming
Brazil	44,609,043	32,592,327	12,016,716
North	1,987,682	1,085,513	902,168
Northeast	10,102,756	5,814,162	4,288,594
Southeast	8,219,243	7,017,138	1,202,105
South	13,261,744	8,185,112	5,076,632
Centre-West	11,037,619	10,490,402	547,217
Brazil and regions	Agricultural Production Gross Value (2006 US$ thousand)		
	Total	Non-family farming	Family farming
Brazil	75,384,733	50,333,710	25,051,023

North	4,202,470	1,868,264	2,334,205
Northeast	13,431,855	7,270,402	6,161,453
Southeast	24,308,740	18,895,743	5,412,997
South	20,192,910	10,491,614	9,701,295
Centre-West	13,248,758	11,807,686	1,441,072

Source: 2006 Brazil´s Agricultural Census.
Note: In 2006, the exchange rate average was R$ 2.175325 for each US$ 1.00.

Also non-family farming is unequally spread over Brazil´s territory with different dimension and productivity. Only in the North, family farming produces more than non-family farming. The difference is narrow in the Northeast and South, but it is very large in the other two Brazilian macro-regions. Southeastern non-family farming´s gross agricultural production value was 3.5 times larger than the family farming value. This number was 8.2 times larger for Centre-Western non-family farming in comparison with family farming. Southeastern non-family farms generated US$ 448.12 per hectare of total area, while family farms produced US$ 423.84. The last figures do not permit us to conclude that family farming is more land-use efficient than non-family farming.

Despite its smaller size, the family farming sector contains highly-successful farmers with high income per year (see Table 2, below). In 2006, almost 60% of family farmers earned R$ 50 thousand (almost US$ 23 thousand, 148 times the Brazilian monthly minimum wage) or more in total annual revenue. Almost a quarter of family farmers were in the highest rank of agricultural income (R$ 500 thousand, or US$ 300 thousand, per year). However, the family farming sector continues also to contain poor farmers: 3.1% of family farming´s gross production came from farmers earning less than R$ 2.5 thousand (US$ 1,149, 7.4 times the minimum wage) per year, in contrast to 0.2% of non-family farmers at the same income level.

Table 2: Distribution of family versus non-family farmers across ranks of agricultural gross production

Annual agricultural production revenue	Share of family farming agricultural revenue	Share of non-family farming agricultural revenue
More than zero less than R$ 2.5 thousand per year	3.1	0.2
From R$ 2.5 thousand to less than R$ 10 thousand per year	9.1	0.7
From R$ 10 thousand to less than R$ 25 thousand per year	13.9	1.6
From R$ 25 thousand to less than R$ 50 thousand per year	14.2	2.5
From R$ 50 thousand to less than R$ 100 thousand per year	13.2	4.2
From R$ 100 thousand to less than R$ 500 thousand per year	23.1	18.7
R$ 500 thousand or more per year	23.5	72.1

Source: Brazil´s 2006 Agricultural Census
Note: In 2006, the exchange rate average was R$ 2.175325 for each US$ 1.00 and the minimum wage averaged R$ 337.50 per month.

Family farming accounts for most of the beans and milk production in Brazil (Table 3, below), but the majority of this production goes to the market. For products such as rice and beans, central components of the Brazilian staple diet, half of family farming's production goes to the market. More than 90% of cotton, orange, milk, soybeans and wheat produced by family farming are traded on the market. Non-family farming produces a larger amount of cotton, orange, soybeans, rice and wheat, and this too is predominantly allocated to the market.

Table 3: Importance of family and non-family farming to the main agricultural products, and shares of produce sold to the market (values in percentages)

Product	Share of overall quantity produced		Share of the produce sold to the market	
	Family farming	Non-family farming	Family farming	Non-family farming
Beans	70.8	29.2	50.3	87.0
Coffee	38	62	91.2	89.1
Corn	45.6	54.4	49.0	88.9
Cotton	2.3	97.7	98.3	76.4
Orange	16.4	83.6	99.8	99.9
Milk	57.6	42.4	90.2	92.2
Soybeans	14	86.	96.3	98.9
Rice	33.1	66.9	51.2	92.2
Wheat	21.2	78.8	94.8	94.5

Source: Brazil´s 2006 Agricultural Census.

4. Multivariate analysis of family versus non-family farmers

We began by running the factor analysis, using the variables listed in Chart 1, for family farming alone and then for non-family farming alone. In both cases, the data was aggregated by homogeneous micro-regions as defined by the Brazilian Institute of Geography and Statistics (IBGE). The principal component method generated five factors with characteristic roots larger than one for each group (family and non-family farming). After using the Varimax orthogonal rotation method, we obtained the factors shown in Table 4, below.

Table 4: Factors generated by principal component method for family and non-family farming

	Family farming			Non-family farming		
Factor	**Characteristic roots**	**Variance explained by factor (%)**	**Accumulated variance explained by factor (%)**	**Characteristic roots**	**Variance explained by factor (%)**	**Accumulated variance explained by factor (%)**
Factor 1	4.64	20.20	20.20	4.65	20.24%	20.24%
Factor 2	4.56	19.82	40.02	3.79	16.46%	36.69%
Factor 3	4.48	19.47	59.49	3.14	13.66%	50.35%
Factor 4	2.36	10.26	69.75	2.89	12.58%	62.94%
Factor 5	2.33	10.11	79.86	2.61	11.34%	74.27%

Source: dataset generated by the research.

Table 5, below, shows the factor loadings and communalities for each factor for family farming and non-farming family after the orthogonal rotation. Only factor loadings greater than 0.600 in absolute value (values highlighted in bold in the table) were considered strongly related to each factor, in order to name the factor. The same criterion was used in papers by Hoffmann and Kageyama (1985), Hoffmann (1992) and Souza and Lima (2003).

The communality values reveal that the variability of 20 out of 23 variables is captured by five factors in the family farming model (the three exceptions are X3, X13 and X18), and 19 out 23 variables are captured by factors related to non-family farming (the four exceptions being X3, X5, X8 and X18).

Table 5: Factor loadings and communalities after the orthogonal rotation

Variables	Family farming						Non-family farming					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communality	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	communality
X1	-0.002	0.156	0.071	-0.162	**-0.762**	0.636	0.101	-0.097	-0.220	-0.209	0.322	0.216
X2	**0.806**	0.114	0.267	0.099	0.133	0.761	0.217	**0.669**	0.202	0.065	0.083	0.546
X3	0.494	-0.005	0.323	0.380	0.382	0.639	-0.096	0.347	0.563	-0.006	-0.054	0.449
X4	**0.758**	0.063	0.382	-0.067	0.314	0.827	0.280	**0.844**	-0.122	0.058	0.148	0.831
X5	0.323	0.360	0.132	0.172	**0.698**	0.767	-0.092	0.510	0.494	0.463	-0.066	0.730
X6	0.442	0.411	0.142	-0.191	**0.645**	0.836	0.129	**0.784**	-0.064	0.356	0.058	0.765
X7	**0.765**	0.267	0.171	-0.052	0.222	0.738	0.214	**0.635**	0.091	0.452	-0.017	0.662
X8	**0.789**	0.192	0.194	-0.184	0.104	0.741	0.514	0.558	-0.205	0.209	0.086	0.669
X9	0.154	**0.942**	0.071	-0.108	0.082	0.934	0.087	0.166	-0.036	-0.044	**0.920**	0.884
X10	0.154	**0.942**	0.071	-0.108	0.082	0.934	0.087	0.166	-0.036	-0.044	**0.920**	0.884
X11	**0.658**	0.511	0.229	0.198	0.207	0.828	0.005	0.178	0.167	**0.875**	-0.029	0.825
X12	**0.738**	0.444	0.266	-0.223	-0.027	0.863	0.049	0.356	-0.018	**0.876**	-0.049	0.900
X13	0.474	0.257	-0.344	-0.270	-0.263	0.551	-0.233	-0.092	-0.099	**0.819**	-0.121	0.757
X14	0.003	-0.017	**0.720**	0.477	0.134	0.764	0.364	0.260	**0.780**	0.018	-0.077	0.816
X15	0.281	0.107	**0.935**	-0.034	0.077	0.972	**0.914**	0.282	-0.049	-0.075	0.088	0.930
X16	0.232	**0.917**	0.115	-0.022	0.090	0.917	**0.631**	0.004	0.027	-0.013	0.589	0.746
X17	0.232	**0.917**	0.115	-0.022	0.090	0.917	**0.631**	0.004	0.027	-0.013	0.589	0.746
X18	0.148	0.199	0.132	0.115	0.556	0.402	0.095	0.528	0.349	-0.112	0.086	0.429
X19	-0.125	-0.062	-0.055	**0.879**	0.129	0.811	-0.096	-0.123	**0.883**	0.097	-0.057	0.816
X20	-0.035	-0.101	-0.007	**0.917**	0.130	0.869	-0.037	-0.138	**0.906**	-0.021	-0.005	0.842
X21	0.290	0.160	**0.921**	0.014	0.073	0.962	**0.876**	0.003	0.169	-0.099	0.134	0.824
X22	0.274	0.073	**0.935**	-0.023	0.073	0.960	**0.918**	0.273	-0.032	-0.088	0.098	0.935
X23	0.194	0.187	**0.796**	-0.172	-0.007	0.735	**0.842**	0.387	-0.134	0.036	0.032	0.879

Source: data generated in this research.

4.1 Concerning family farming

Factor 1 is strongly correlated with the following variables: share of farms that use mechanical force (X2), number of tractors/EM (X4), number of harvesting machines/EA (X7), number of harvesting machines/EM (X8), total amount of borrowings/AE (X11), and total amount of borrowings/EM (X12). We can label Factor 1 as the *degree of mechanization*.

Factor 2 relates to: total amount of investment/EA (X9), total amount of investment/EM (X10), total expenditure/EA (X16), and total expenditure/EM (X17). Factor 2 measures *investments*.

Factor 3 has a strong relationship with: gross value of agricultural production/EA (X14), gross value of agricultural production/EM (X15), gross value of agricultural production/number of farms (X21), gross value of agricultural production/occupied workforce (X22), and gross value of agricultural production/number of salaried employees (X23). Factor 3 concerns *productivity*.

Factor 4 is strongly correlated with the following variables: occupied workforce/total area of farms (X19), and number of salaried employees/total area of farms (X20). Factor 4 is associated with the *intensity of labour use*.

Finally, Factor 5 links strongly with: share of explored area with planted pasture (X1), number of mechanical plows/EA (X5), and number of mechanical plows/EM (X6). Factor 5 measures *crop intensity in agriculture*.

4.2 Concerning non-family farming

Factor 1 is strongly linked with: gross value of agricultural production/EM (X15), total expenditure/EA (X16), total expenditure/EM (X17), gross value of agricultural production/number of farms (X21), gross value of agricultural production/occupied workforce (X22) and gross value of agricultural production/number of salaried employees (X23). Therefore, non-family farming´s Factor 1 measures *productivity*.

Factor 2 is strongly correlated with: share of farms that use mechanical force (X2), number of tractors/EM (X4), number of mechanical plows/EM (X6), and number of harvesting machines/EA (X7). Non-family farming´s factor 2 measures the *degree of agricultural mechanization*.

Factor 3 is related to: gross value of agricultural production/EA (X14), occupied workforce/total area of farms (X19), and number of salaried employees/total area of farms (X20). Therefore, non-family farming´s factor 3 measures the *intensity of labour use*.

Factor 4 is linked to: total amount of borrowing/EA (X11), total amount of borrowing/EM (X12), and ratio of borrowings/production value (X13). Factor 4 measures non-family farming´s *borrowing*.

Finally, Factor 5 strongly relates to: total amount of investment/EA (X9), and total amount of investment/EM (X10). As such, Factor 5 measures *investments*.

Table 6, below, shows the equivalence of factors generated for both family and non-family farming.

Table 6: Equivalence among the factors generated for family and non-family farming

Denomination	Family farming	Non-family farming
Productivity	Factor 3	Factor 1
Degree of mechanization	Factor 1	Factor 2
Intensity of labour use	Factor 4	Factor 3
Investments	Factor 2	Factor 5
Borrowings	-	Factor 4
Crop intensity	Factor 5	-

Source: information generated by the research.

The next step is to reveal the factor scores, i.e., the factor value for each of the analysed micro-regions. The factor scores have mean equal to zero and standard deviation equal to one, and they can be used to rank the relative position of each micro-region in relation to the feature expressed by the factor. Factor scores can assume positive or negative values, and the larger the positive value the higher is the position of a micro-region's ranking for the feature in question. Figures 1-20 (see Figures Appendix) plot factor scores for each of Brazil´s homogeneous micro-regions, separating family and non-family farming. Table 7, below, shows the descriptive statistics for these scores.

Table 7: Descriptive statistics for the factor scores according to the type of factor and organized by Brazil´s macro-regions – year of 2006.

Factor	Macro-region	Number of micro-regions	Mean of factor score		Standard deviation of factor score		Coefficient of variation		F-test of mean differences
			Family farming	Non-family farming	Family farming	Non-family farming	Family farming	Non-family farming	
Productivity	North	64	-0.081556	-0.25882	0.715593	0.264331	-8.774217	-1.021285	2.146E-13
	Northeast	188	-0.412175	-0.26609	1.061751	0.780717	-2.575974	-2.934002	3.093E-05
	Southeast	160	0.387536	0.003696	0.92946	1.069485	2.398384	289.37255	0.077762
	South	94	0.180355	0.203099	0.855594	0.613505	4.743937	3.020711	0.001523
	Centre-West	52	0.072103	0.902065	0.935772	1.730710	12.978295	1.918609	2.201E-05
	Brazil	558	5.376E-09	1.434E-09	0.999104	0.999104	185,833,266	696,874,784	0.999999
Mechanization	North	64	-0.526357	-0.768178	0.521395	0.484829	-0.990574	-0.631142	0.565563
	Northeast	188	-0.464859	-0.720810	0.465770	0.452994	-1.001960	-0.628452	0.704088
	Southeast	160	0.147883	0.306594	0.984435	0.759283	6.656864	2.476510	0.001148
	South	94	0.982384	1.3120818	1.3127808	0.852624	1.336322	0.649825	4.33E-05
	Centre-West	52	0.097597	0.236249	0.742794	0.728376	7.610855	3.083094	0.889222
	Brazil	558	5.556E-09	1.792E-09	0.999104	0.999104	179,838,633	557,499,752	1
Intensity of labour use	North	64	-0.438470	-0.748626	0.374852	0.232952	-0.854909	-0.311172	0.000221
	Northeast	188	0.441256	0.097147	1.157452	1.169847	2.623087	12.042084	0.884342
	Southeast	160	-0.031628	0.467458	1.045445	0.957579	-33.054567	2.048483	0.269358
	South	94	-0.216062	-0.105181	0.559684	0.691711	-2.590387	-6.576384	0.042409
	Centre-West	52	-0.567763	-0.678033	0.644603	0.366940	-1.135338	-0.541184	9.4E-05
	Brazil	558	1.792E-10	5.376E-10	0.999104	0.999104	5,575,001,94	185,832,830	1
Invest-ment	North	64	-0.149631	-0.092379	0.568652	0.537099	-3.800372	-5.814083	0.651852
	Northeast	188	-0.284582	-0.260185	0.327901	0.722957	-1.152222	-2.778631	6.82E-25
	Southeast	160	-0.213357	0.184105	0.743215	1.353525	-3.483439	7.351927	2.16E-13
	South	94	0.991366	-0.103613	1.779996	0.625082	1.795498	-6.03286	1.13E-20
	Centre-West	52	0.063542	0.684097	0.499700	1.1444809	7.864128	1.67298	2.99E-08
	Brazil	558	-0.001411	-0.000397	0.999445	0.999956	-708.5155	-2,521,757	0.990379

Source: information generated by the research.

The following can be concluded:

1) Only in the Centre-West macro-region is there a predominance of micro-regions where the productivity of non-family farming is larger than that of family farming (Figure 5), and the opposite is the case in the Northern macro-region (Figure 1). It is noteworthy that there is close proximity between the factor scores for productivity among the micro-regions of the Northeast (Figure 2), Southeast (Figure 3), and South (Figure 4).
2) Family and non-family farming´s degree of mechanization factor scores display little difference among the homogeneous micro-regions (HMR) (see Figures 6-10), with very close values in the Northeast (Figure 7).
3) Only in the Northern macro-region is there a predominance of HMR where family farming displays higher values than non-family farming for intensity of labour use (factor

3, see Figure 11). In the other macro-regions, family farming´s intensity of labour use factor scores are very close to those for non-family farming (Figures 12-15).

4) The Northern region holds some HMR where family farming´s investment factor scores (Factor 4) are greater than those for non-family farming; the opposite is the case in some other Northern HMR, while in some the investment factor scores for each sector are very close (Figure 16). In the Northeast (Figure 17) and Southeast (Figure 18) there is no significant difference between family and non-family farming´s investment factor scores. However, in the Southern macro-region the investment factor scores for family farming are slightly higher than those for non-family farming (Figure 19), while the opposite is the case in the Centre-West (Figure 20).

Looking at Figures 1-20 overall, although the rows for family and non-family farming display some differences across regions, they generally remain close together (i.e. in terms of factor scores), and F-statistic does not suggest any statistical difference among the factor scores for family and non-family farming (see the last column of Table 6, above).

Additionally, Figures 1-20 show that there are large differences within and among Brazil´s macro-regions regarding factor scores. In order to identify possible spatial relations among these factors, quartile maps were generated to assess spatial distribution (see Figures 21-24). Notably, the following can be concluded:

a) The highest productivity factor scores for family farming are found in the Southeast, South and parts of the Centre-West, particularly in areas that have a high concentration of family farms and are significant areas for the production of coffee, soybean, poultry and swine. The highest productivity factor scores for non-family farming are found in soybean and sugarcane plantation areas. In both the Southeast and South macro-regions there is a coincidence of HMR with high productivity for both family and non-family farming. The lowest productivity factor scores for both family and non-family farming are found in HMR in the Northeast, followed by the next-lowest in the Northern region.

b) The highest mechanization factor scores for both family and non-family farming are found in HMR located inside a strip from Triângulo Mineiro to Rio Grande do Sul, coinciding with coffee, sugarcane, soybeans, poultry and swine production areas (Figure 22). There are also micro-regions with a high degree of mechanization in the Centre-west and Northern regions, but these areas do not feature overlapping high mechanization scores for both family and non-family farming.

c) The most intensive labour use in the family farming sector is found in HMR located along the Northeast coast (Figure 23) and inside the states of Minas Gerais and Espírito Santo. For non-family farming the highest scores for intensity of labour use are found in Minas Gerais and Espírito Santo´s coffee-producing areas.

d) The highest investment factor scores for both family and non-family farming are found at the southern part of the Centre-West and inside the Southeast and South regions (Figure 24).

The coincidence of high factor scores for both types of farming in several regions (particularly the Centre-West, Southeast and South) suggests a need to assess the existence of clusters using the Moran's I statistic.

5. Exploratory analysis of spatial data

Both Global and Local Moran's I statistics were calculated to verify spatial relationships. The first order queen weight matrix was used due to its ability to maximize spatial relationships, as per standard procedure in exploratory analysis of spatial data. Table 8, below, presents univariate Global Moran's I coefficients for the four generated and equivalent factors for both family and non-family farming.

Table 8: Values of univariate Global Moran's I statistics for equivalent factors for family and non-family farming – year of 2006

	Univariate Moran's I	
	family farming	**Non-family farming**
Productivity	0.2297	0.3164
Degree of mechanization	0.5482	0.6974
Intensity of labour use	0.4402	0.4019
Investment	0.5024	0.4018

Source: data generated by the research.

Univariate Global Moran's I statistics for productivity, degree of mechanization, intensity of labour use and investment were positive for both family and non-family farming, with p-value of 0.001 after 9,999 permutations. This means that the micro-regions with high (or low) values for productivity factor (or mechanization, labour use or investments) for both family and non-family farming are surrounded by micro-regions which also have high (or low) values for productivity factor (or mechanization, labour use or investments) for both family and non-family farming. Therefore, we can reject the null hypothesis of spatial randomness; in other words, there is evidence of spatial autocorrelation among Brazil´s homogeneous micro-regions concerning the four factors analysed for both family and non-family farming.

In order to check the existence of clusters, we estimated the Local Moran's I statistic for Brazil´s HMR and mapped them, as shown in Figures 25-28. The following is observed:

1) High-high clusters of productivity are found for both family and non-family farming in coffee-growing areas located in southern Minas Gerais and Triângulo Mineiro, and for non-family farming in the states of Mato Grosso and Mato Grosso do Sul, specifically in soybean growing and livestock rearing areas, as well as inside the Northeast´s sugarcane areas (Figure 25). The low-low clusters of productivity for both family and non-family farming are found in the Northeast´s semi-arid areas and in the north of Minas Gerais, and for non-family farming in the state of Espírito Santo.

2) High-high clusters of mechanization occur in the South Region and in the state of São Paulo for both family and non-family farming (Figure 26). Non-family farming also sees high-high clusters for mechanization in the state of Mato Grosso do Sul. Low-low clusters for mechanization are found in the Northeast and North regions, particularly in non-family farming.

3) High-high clusters for the intensity of labour use in non-family farming are found in coffee-growing regions of Minas Gerais and Espírito Santo, and along the northeast coast for family farming (Figure 27). There are also low-low clusters for labour use in the Centre-West, Northeast and North for non-family farming, and in the Centre-West and North for family farming.

4) High-high clusters for family farming´s investment factor are found in the states of Rio Grande do Sul, Santa Catarina and the south of Mato Grosso do Sul. For non-family farming similar clusters are found in the fast-growing grain areas in Mato Grosso, Mato Grosso do Sul, Goiás and Bahia states (Figure 28).

The above results suggest a number of similarities between the clusters found for both family and non-family farming. Because of this, Bivariate Global and Local Moran's I statistics were also estimated. They provide an indication of linear association (positive or negative) between a feature in the i^{th} HMR and the average of another feature in the neighbouring HMR.

Table 9, below, shows the Bivariate Global Moran's I statistics for productivity, degree of mechanization, intensity of labour use and investment factor scores for both family and non-family farms. They were positive, with p-value of 0.001 after 9,999 permutations.

Table 9: Bivariate Moran's I statistic between family and non-family agricutlure´s same factor

Factor	Bivariate Moran's I
Productivity	0.126
Degree of mechanization	0.443
Intensity of labour use	0.241
Investment	0.040

Source: data generated by the research.

Figures 29-32 map the Bivariate Local Moran's I statistics. A high-high cluster means that a HMR with a high score for productivity factor (or degree of mechanization, intensity of labour use, or investment) for family farming is surrounded by HMR with high scores for the same factor in non-family farming. Low-low means that a HMR with a low score for productivity factor (or mechanization, labour use or investment) for family farming is surrounded by HMR with similarly low scores in the non-family farming sector. High-low means that a HMR with a high score for productivity factor (or mechanization, labour use or investment) for family farming is surrounded by HMR with low scores for the same factors in non-family farming. Finally, low-high means that a HMR with a low score for productivity factor (or mechanization, labour use or investment) for family farming is surrounded by HMR with contrastingly high scores for the same factor in non-family farming.

Clearly, high-high productivity clusters are seen in the Centre-West region and in the states of São Paulo and Minas Gerais, mainly in sugarcane, coffee and soybean areas. Meanwhile, low-low clusters are found in the Northeast (Figure 29). High-high clusters for mechanization (for both family and non-family farming) are seen in the South and the state of Mato Grosso do Sul (Figure 30), while and low-low clusters for mechanization occur in the North and Northeast regions. There are sizeable low-low clusters for intensity of labour use in the North and Centre-West regions (Figure 31), with smaller spots of high-high clusters for labour use in the Northeast and Southeast (Figure 31). High-high clusters for investment are found in the fast-growing agricultural areas of Mato Grosso do Sul, Mato Grosso, Pará and Bahia states (Figure 32).

These results show that there are no major differences between family and non-family farming in Brazil; rather, both sectors tend to cleave to regional differences. Both sectors have low productivity and investment in the North and Northeast of Brazil, and, conversely, both enjoy relatively high productivity, mechanization and investment in the Centre-West, Southeast and South. Farmers in the South-East, South and Centre-West enjoy a high technological level, in contrast to a lower technological level in the North-East.

6. Conclusions

Despite the fact that distinct agencies of the Brazilian Federal Government – MDA and MAPA – have responsibility for family and non-family farming respectively, both have broadly followed the same long-established market-oriented agricultural policies, such as rural credit, minimum prices, agricultural research, agricultural extension and rural insurance. The only difference has come in the design and implementation of specific programmes to carry out these policies, such as in MDA's creation of programmes for family farming (even though family farmers are still eligible for MAPA programmes). Furthermore, the research presented here demonstrates that the family farming sector is not technologically different to non-family farming. Both sectors are market-oriented, and the important differences in the variables analysed here are between geographical regions rather than between the sectors themselves.

In order to minimize the geographical difference among Brazilian farmers, the agricultural policies would differentiate among the Brazil´s regions, paying more attention to their edafo-climatic and economic features.

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FIGURES APPENDIX

Figure 1 - Productivity Factor Scores - Northern Homogeneous Microregions

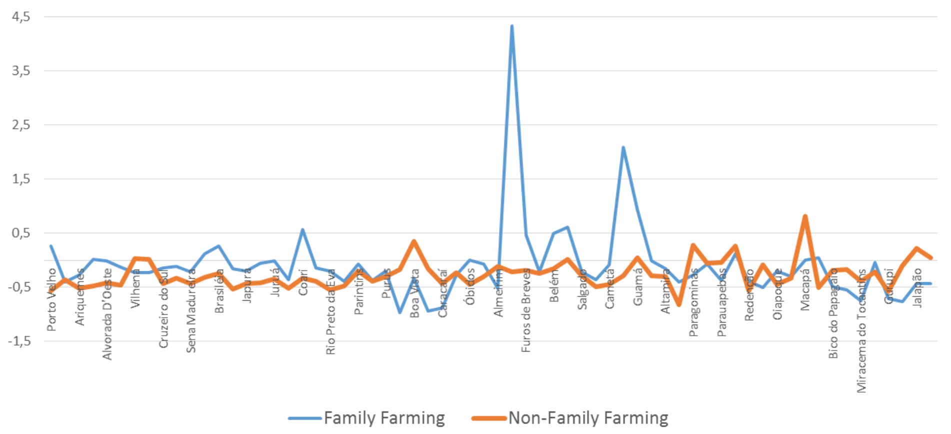


Figure 2 - Productivity Factor Scores - Northeast Homogeneous Microregions

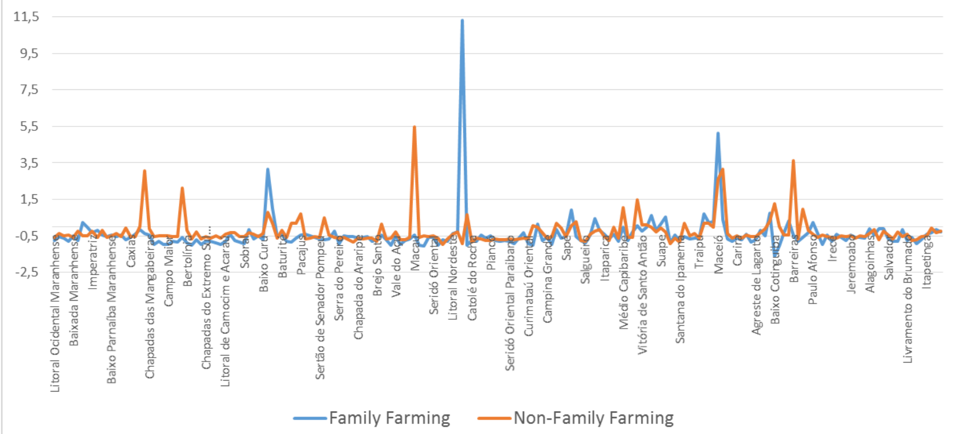


Figure 3 - Productivity Factor Scores - Southeast Homogeneous Microregions

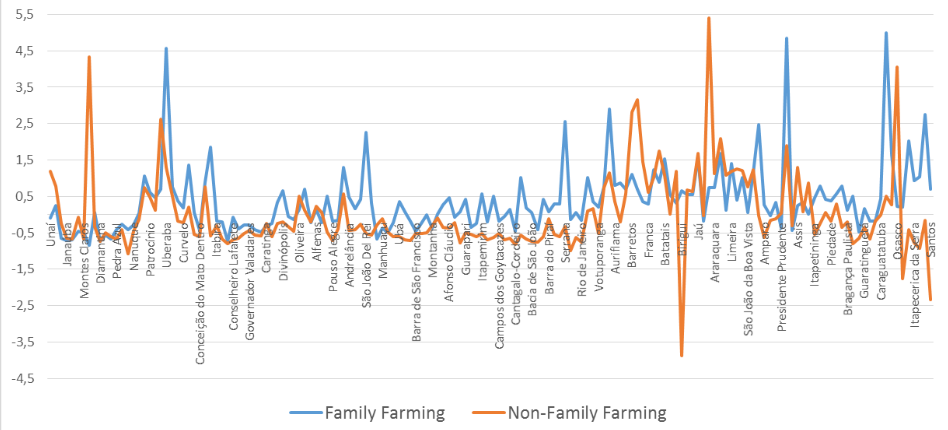


Figure 4 - Productivity Factor Scores - South Homogeneous Microregions

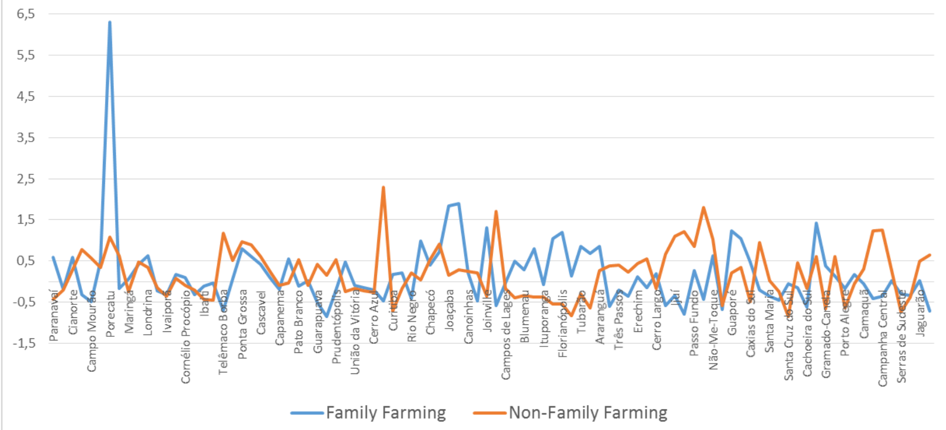


Figure 5 - Productivity Factor Scores - Center-West Homogeneous Microregions

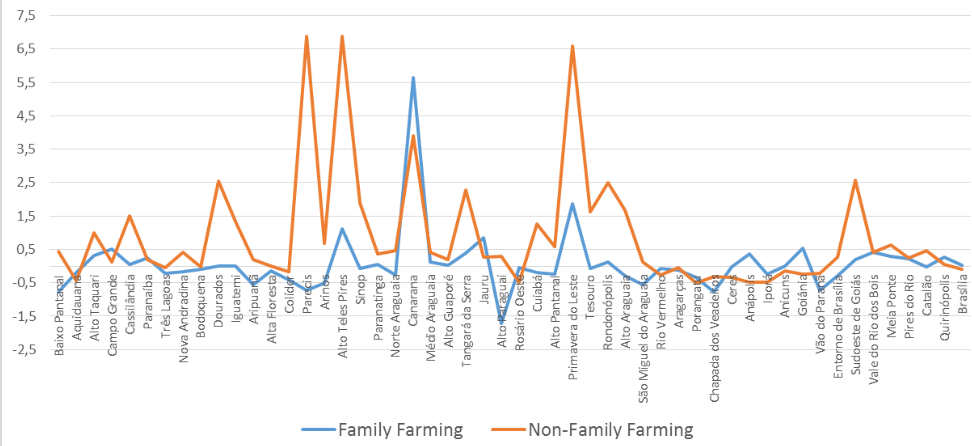


Figure 6 - Mechanization Factor Scores - Northern Homogeneous Microregions

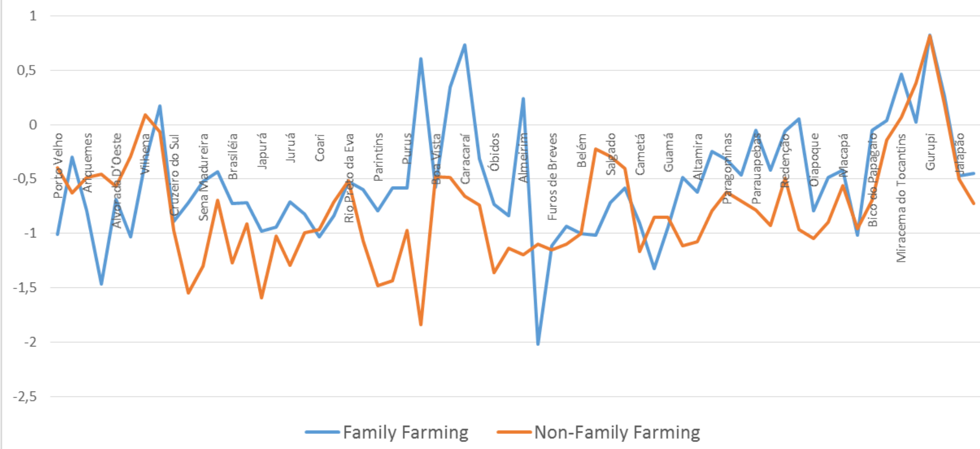


Figure 7 - Mechanization Factor Scores - Northeast Homogeneous Microregions

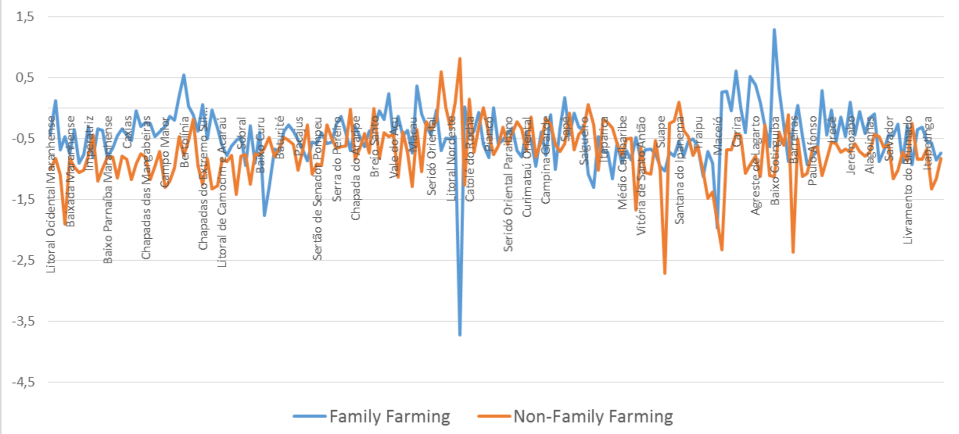


Figure 8 - Mechanization Factor Scores - Southeast Homogeneous Microregions

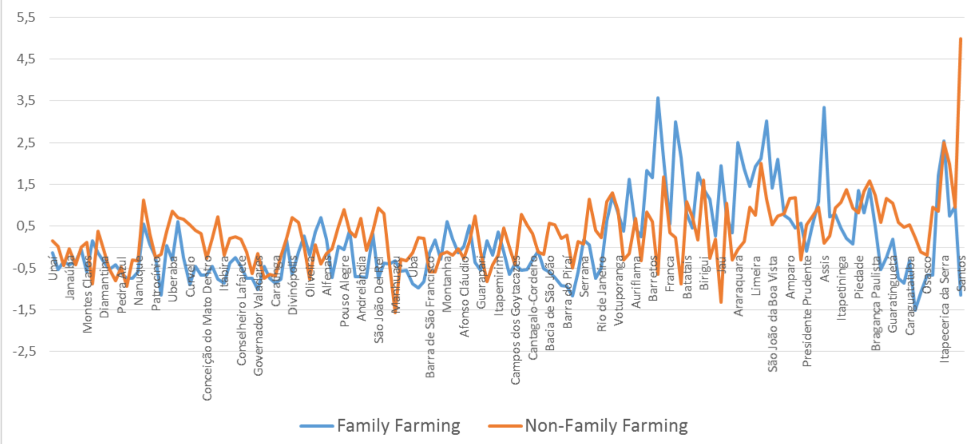


Figure 9 - Mechanization Factor Scores - South Homogeneous Microregions

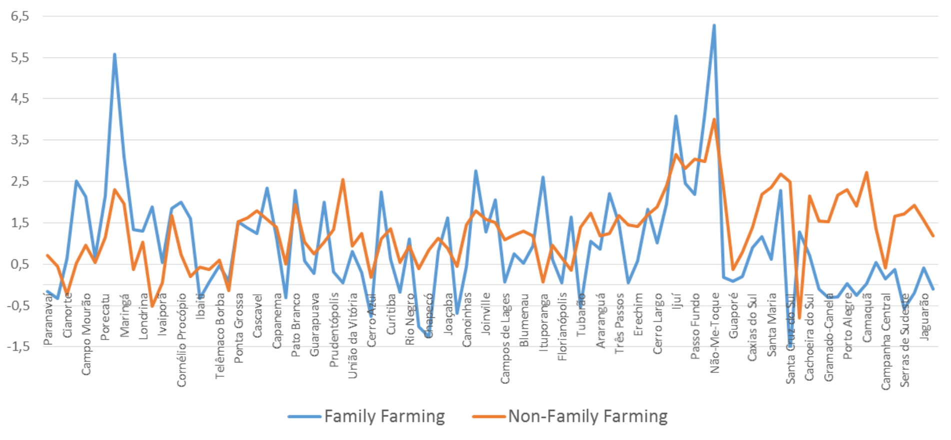


Figure 10 - Mechanization Factor Scores - Center-West Homogeneous Microregions

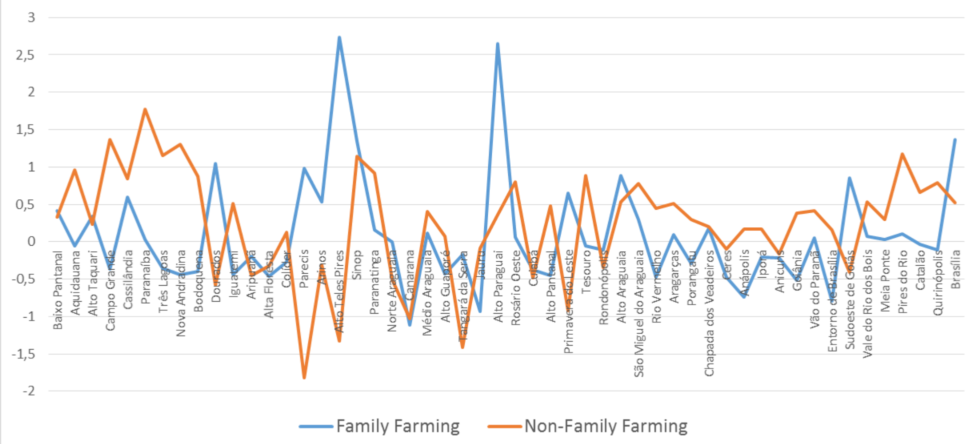


Figure 11 - Labour Use Intensity Factor Scores - Northern Homogeneous Microregions

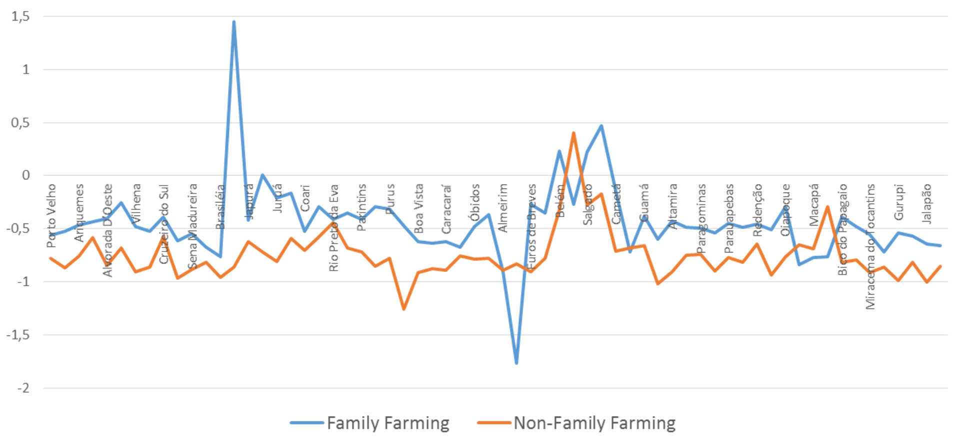


Figure 12 - Labour Use Intensity Factor Scores- Northeast Homogeneous Microregions

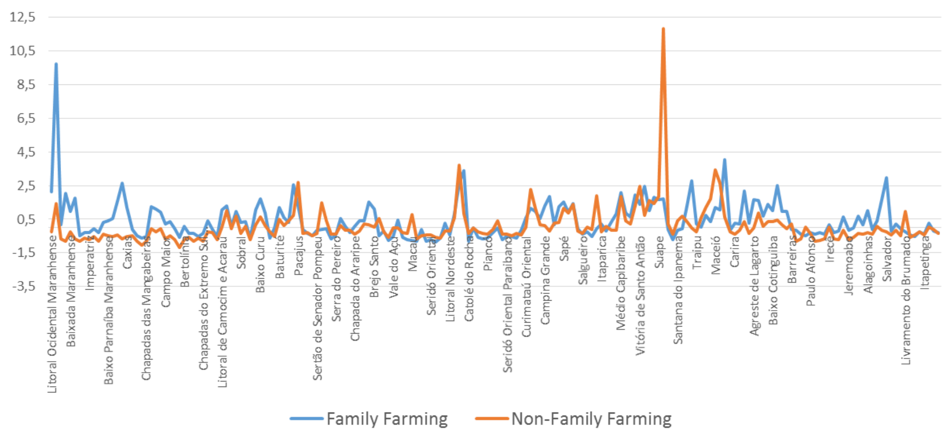


Figure 13 - Labour Use Intensity Factor Scores- Southeast Homogeneous Microregions

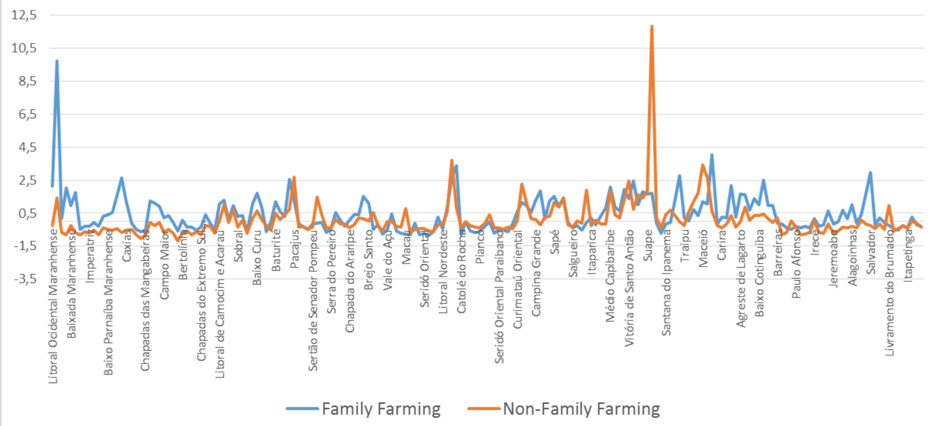


Figure 14 - Labour Use Intensity Factor Scores- South Homogeneous Microregions

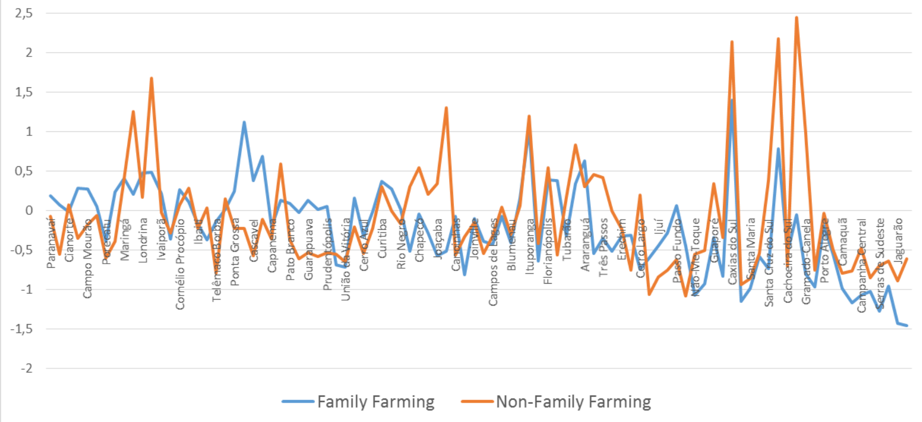


Figure 15 - Labour Use Intensity Factor Scores - Center West Homogeneous Microregions

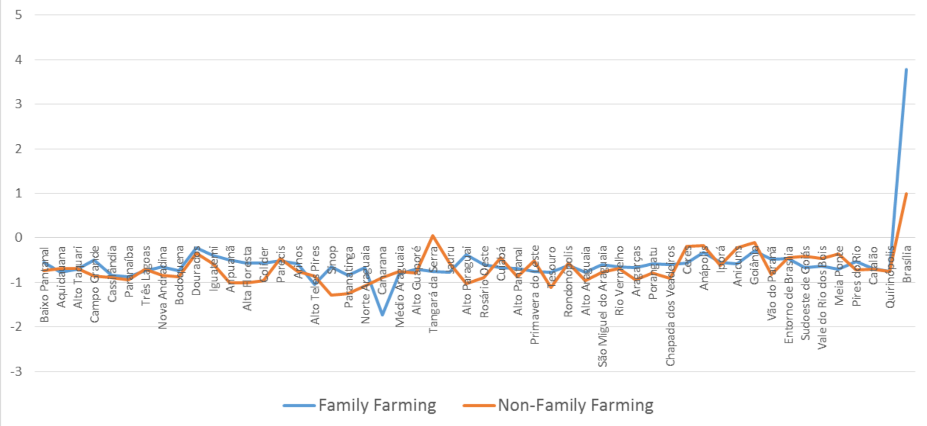
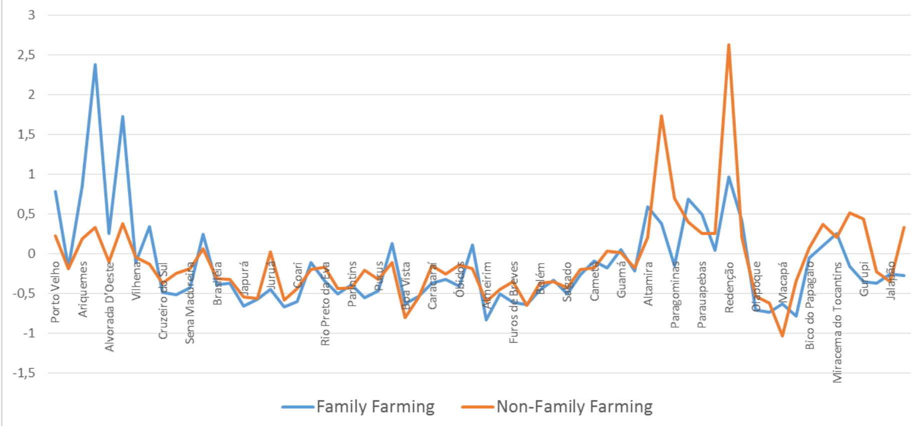


Figure 16 - Investment Factor Scores- Northern Homogeneous Microregions



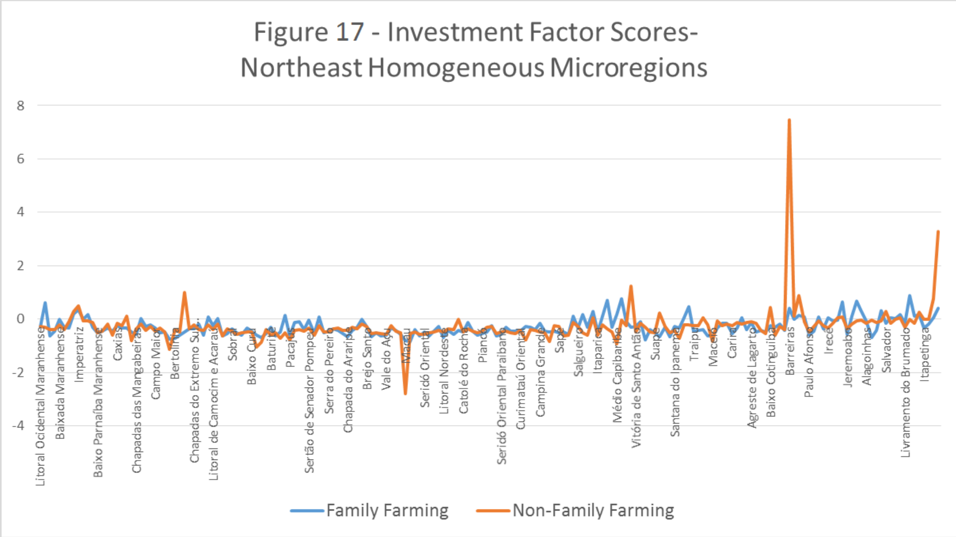


Figure 17 - Investment Factor Scores- Northeast Homogeneous Microregions

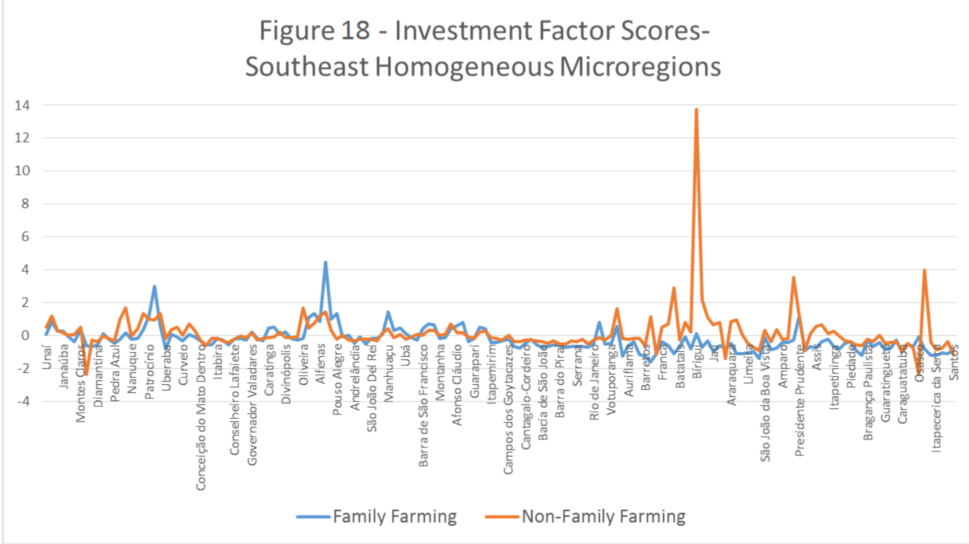


Figure 18 - Investment Factor Scores- Southeast Homogeneous Microregions

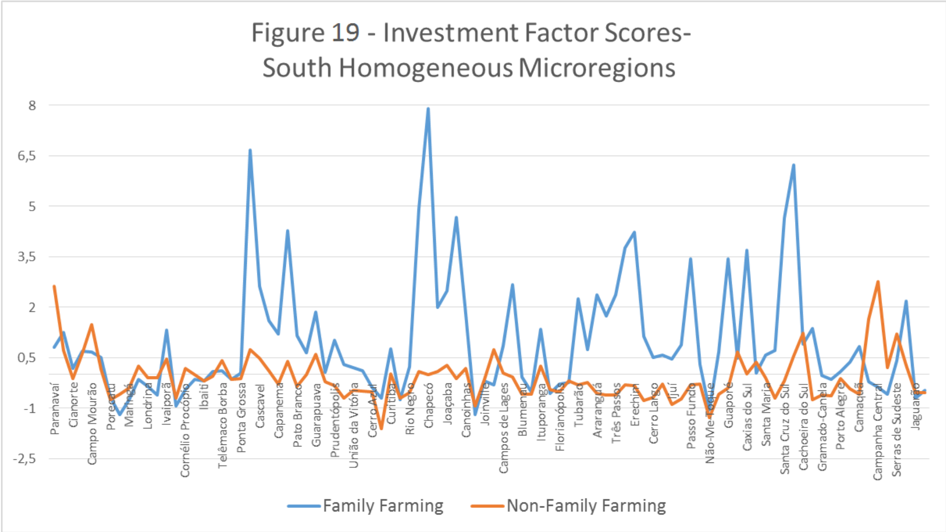


Figure 19 - Investment Factor Scores- South Homogeneous Microregions

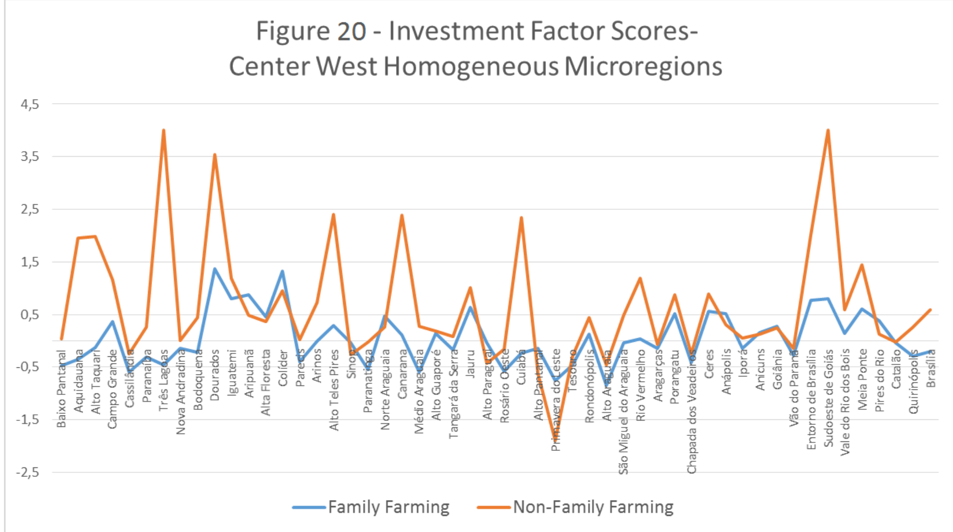
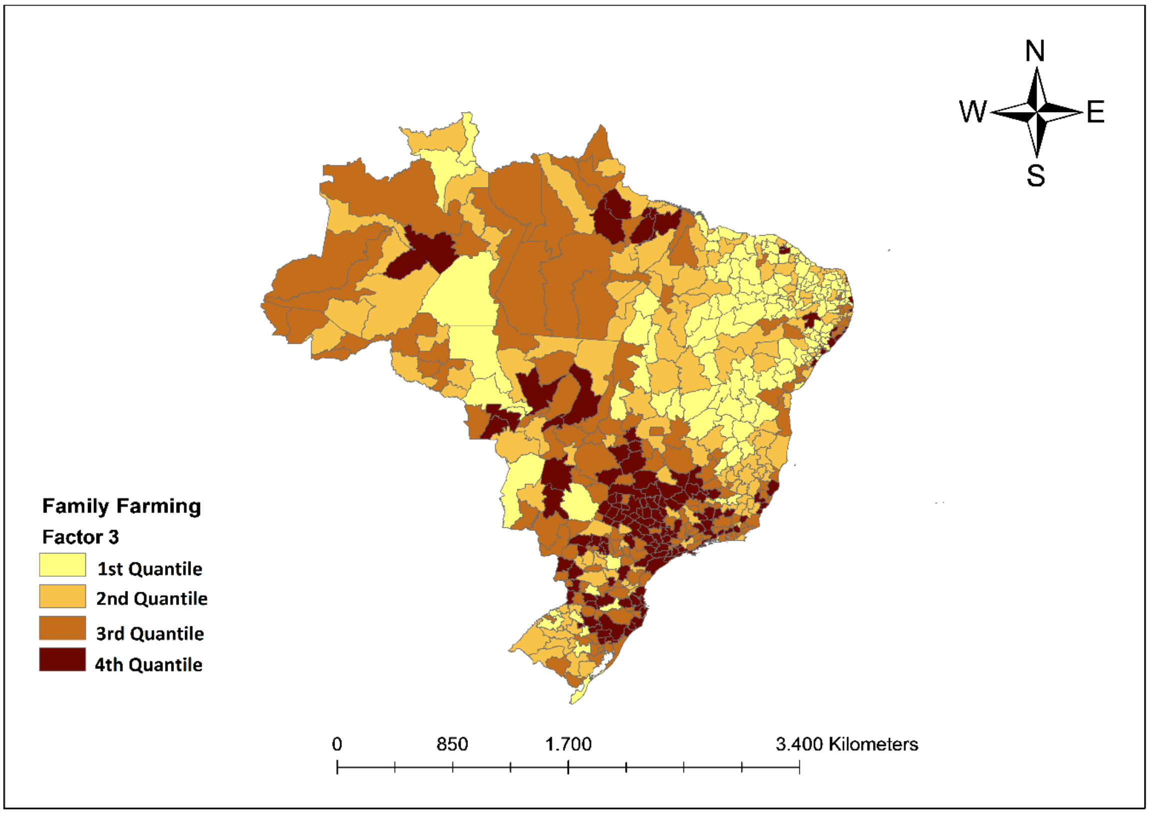


Figure 20 - Investment Factor Scores- Center West Homogeneous Microregions

Fig. 21: Spatial Distribution of productivity factor scores



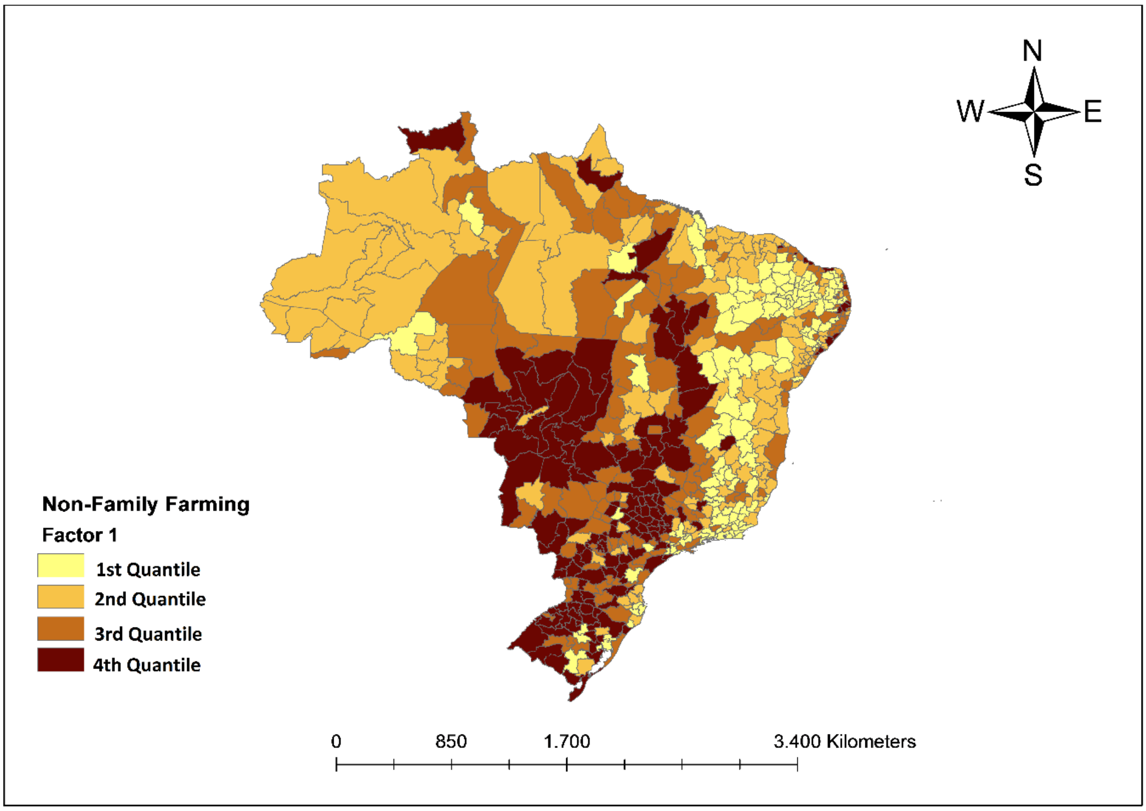
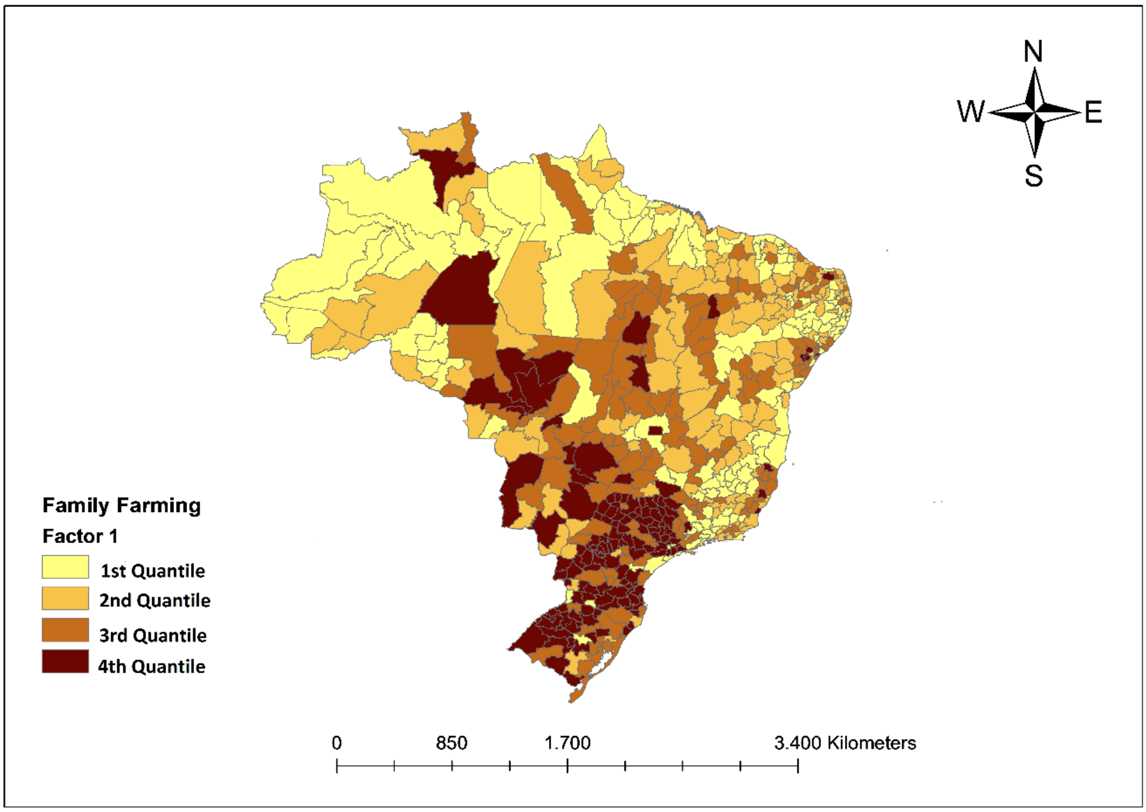


Fig. 22: Spatial Distribution of degree of mechanization factor scores



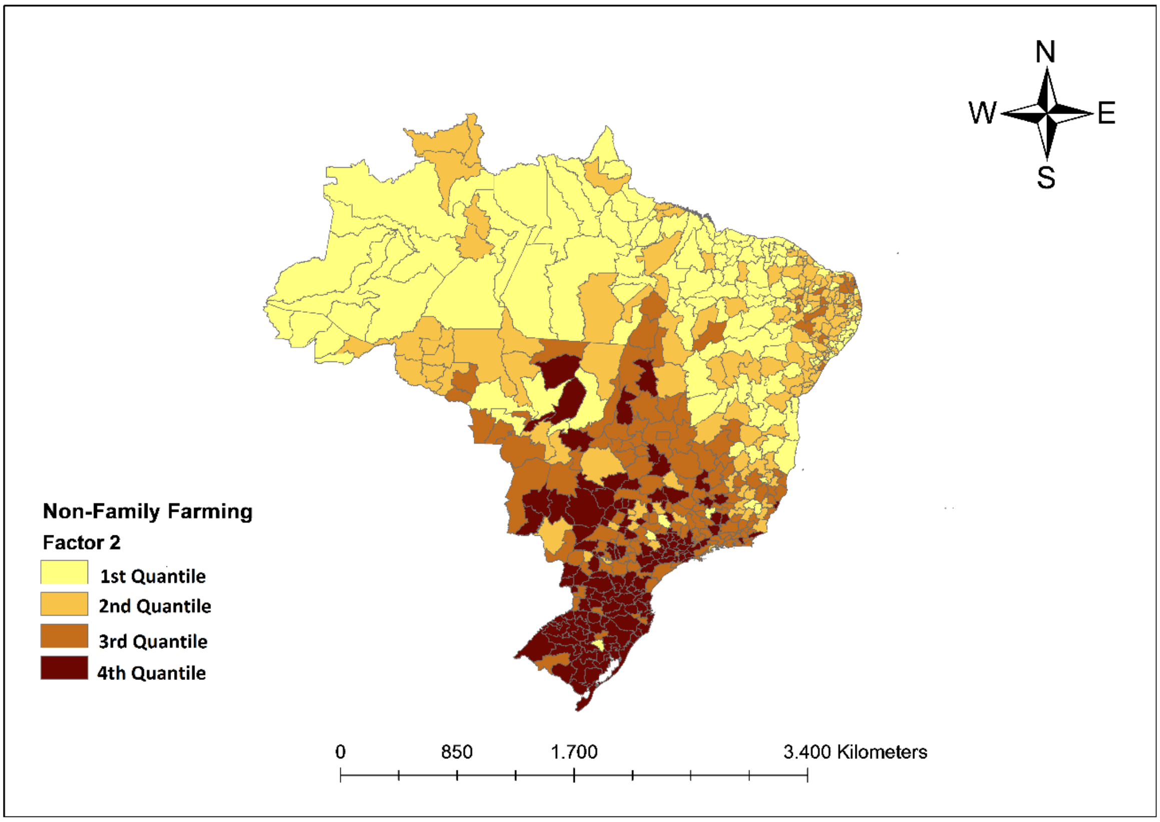
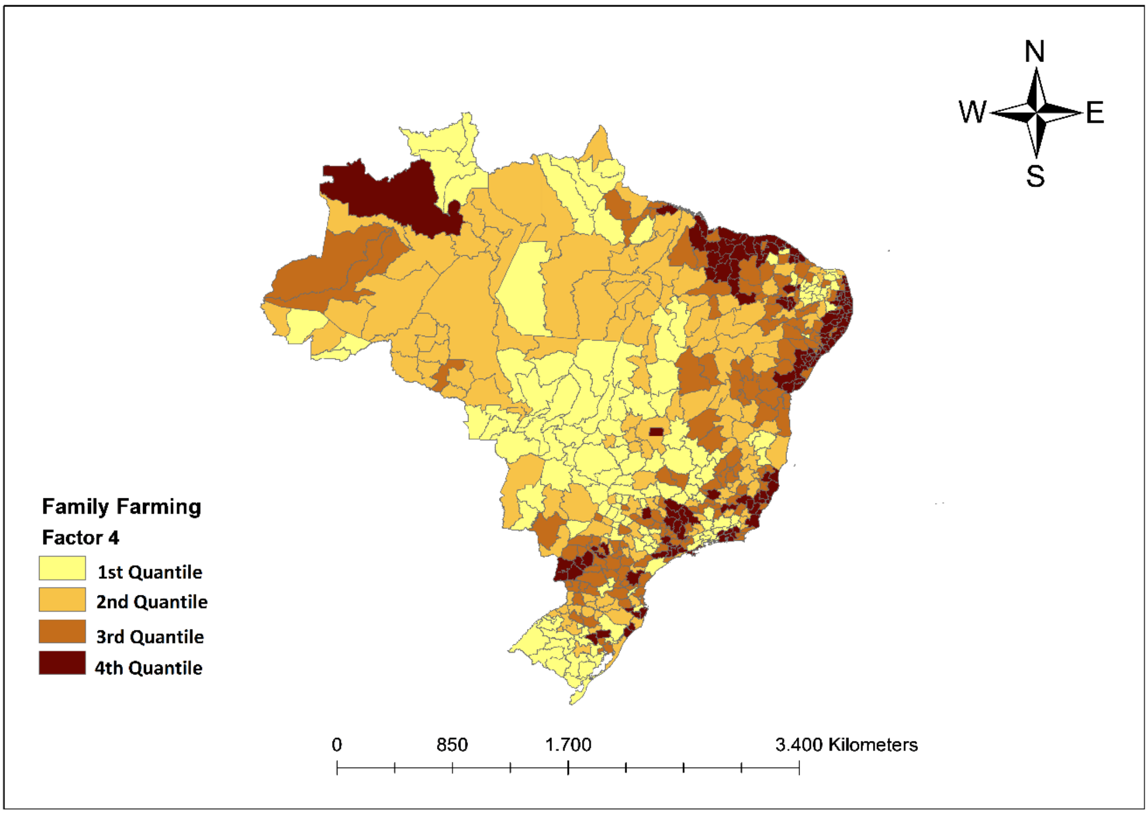


Fig. 23: Spatial Distribution of labour intensity factor scores



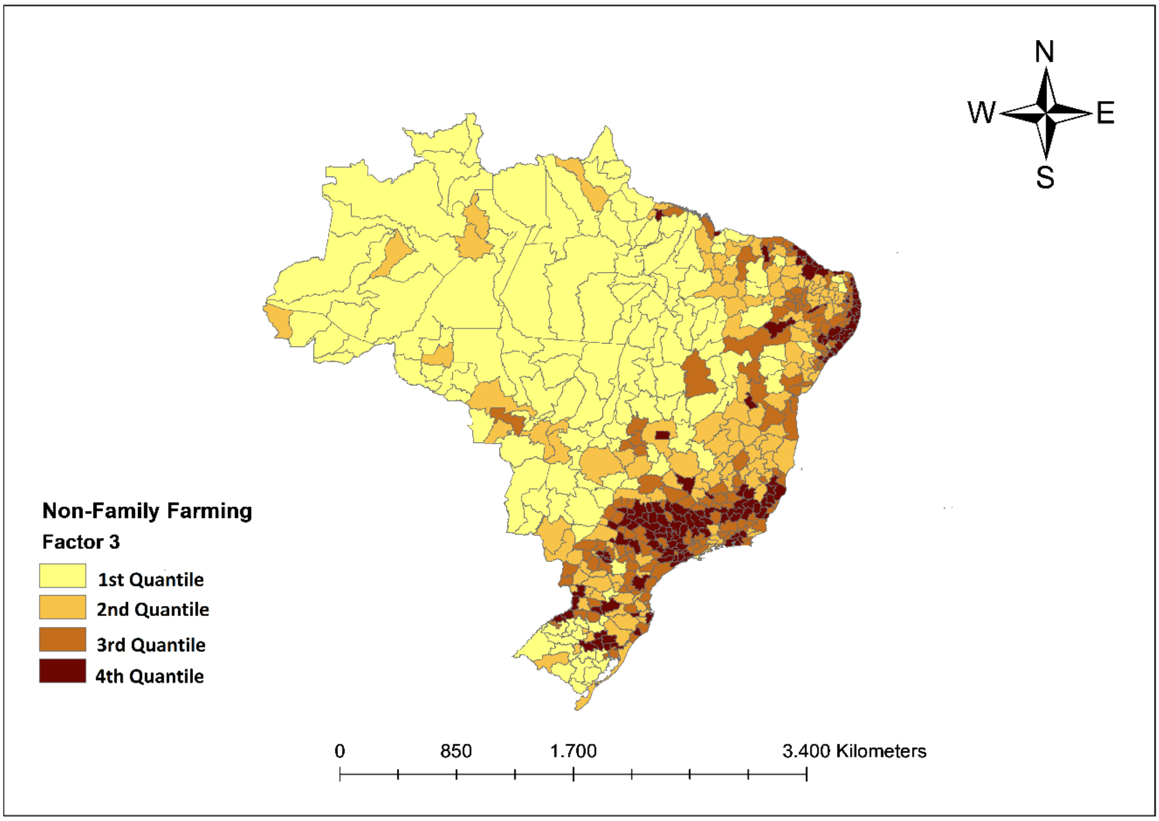


Fig. 24: Spatial distribution of investment factor scores

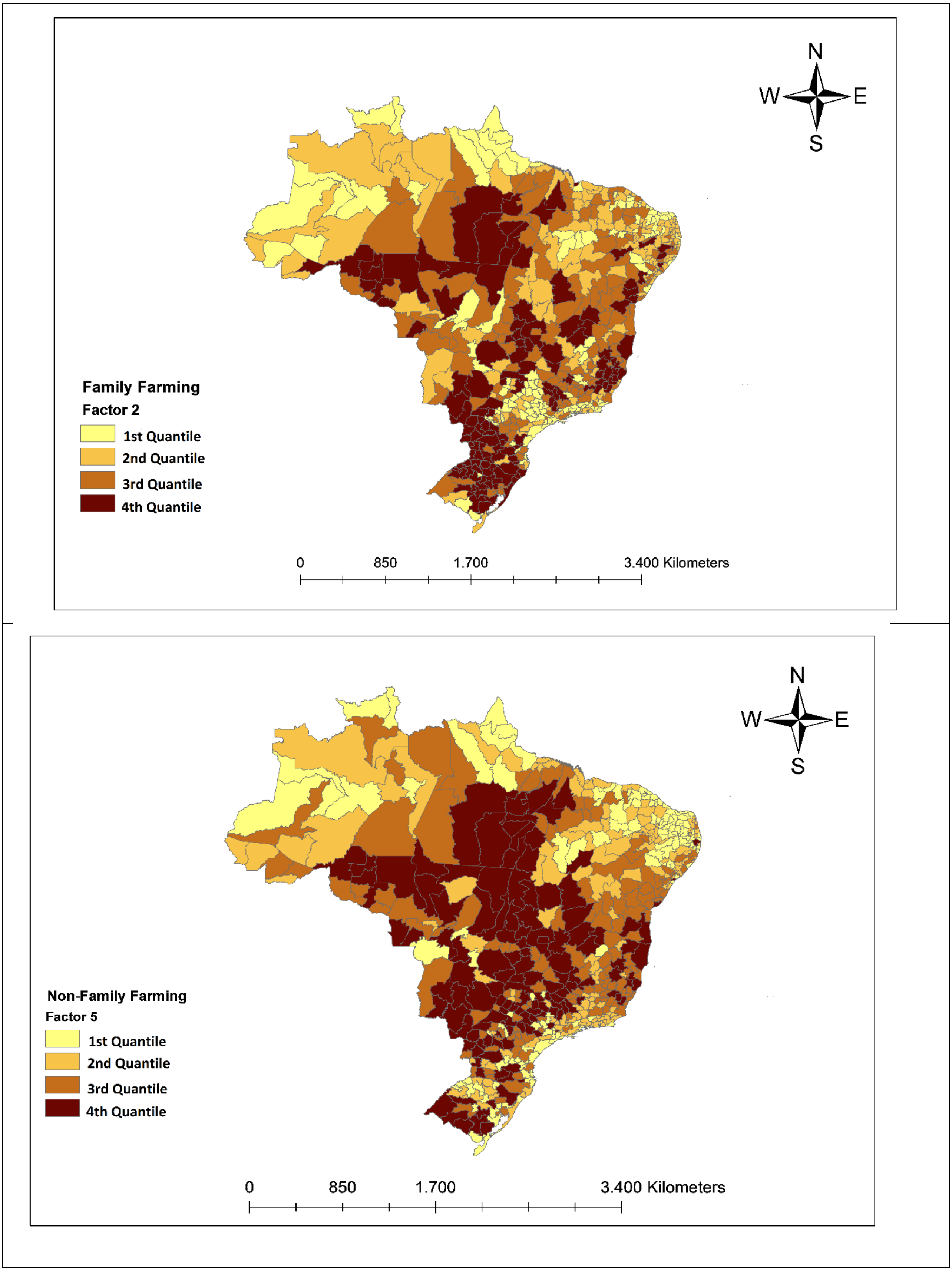


Fig. 25: Spatial clusters for productivity factor

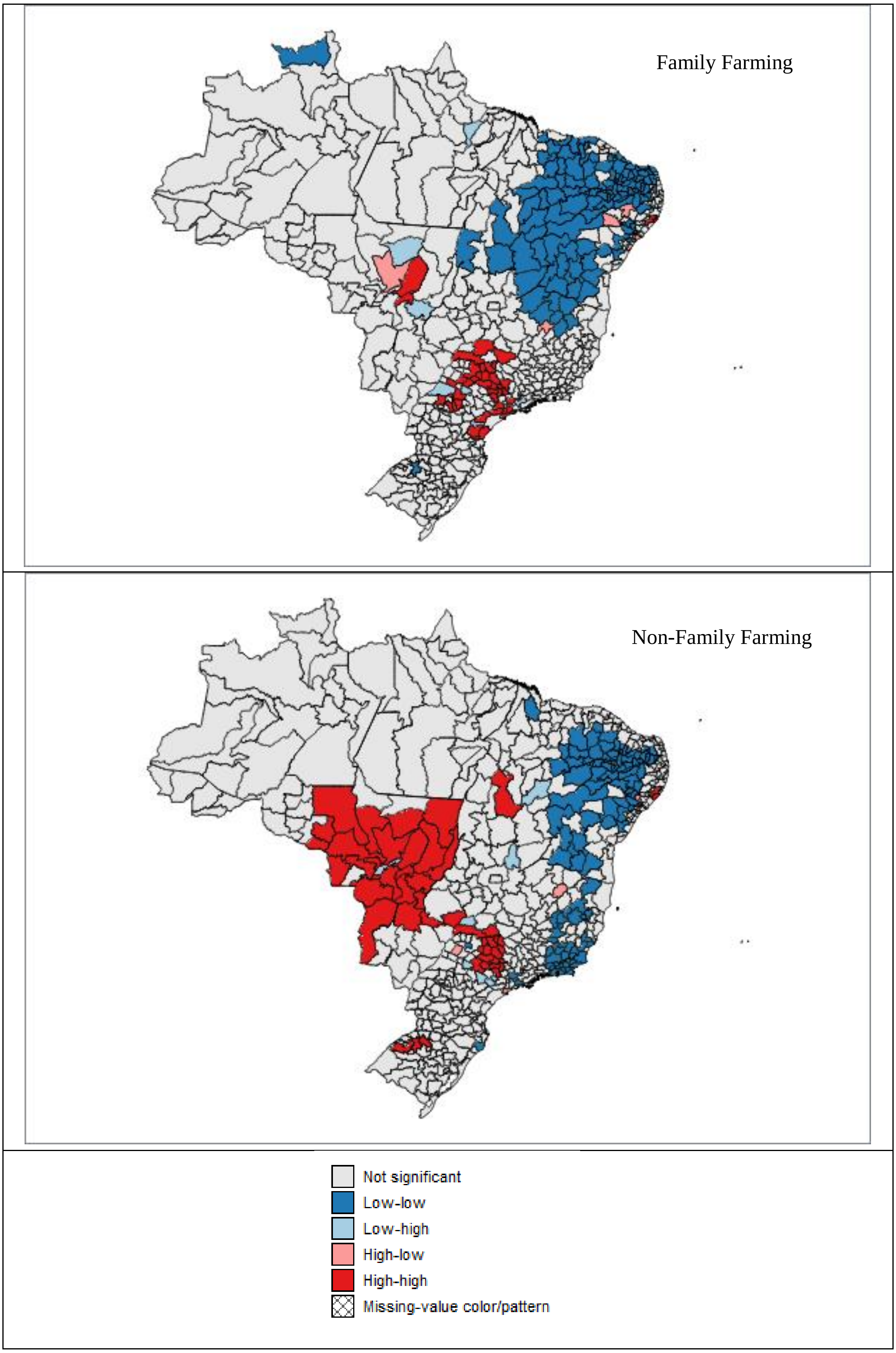


Fig. 26: Spatial clusters for factor of mechanization intensity.

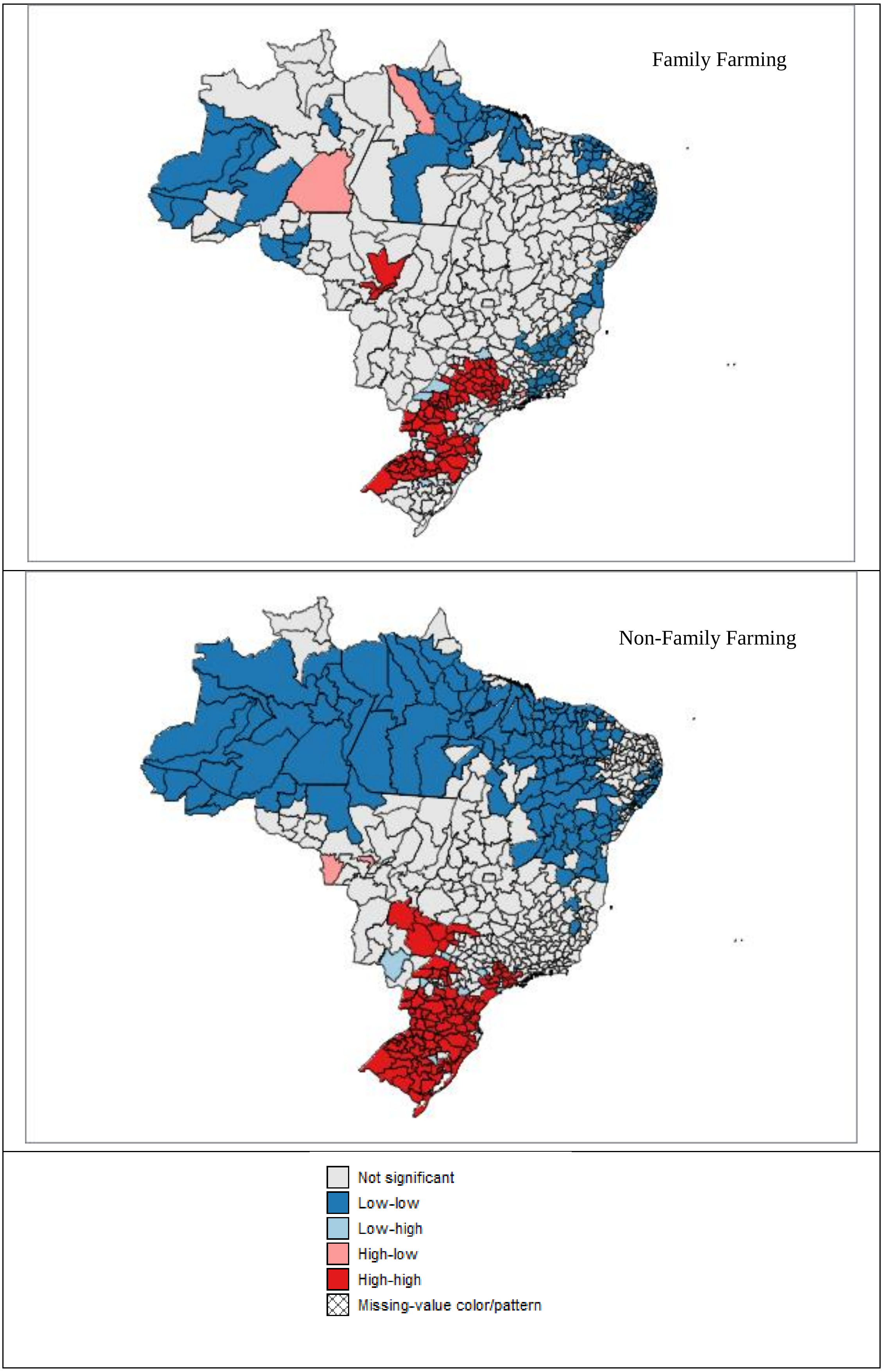


Fig. 27: Spatial clusters for factor of labour intensity use.

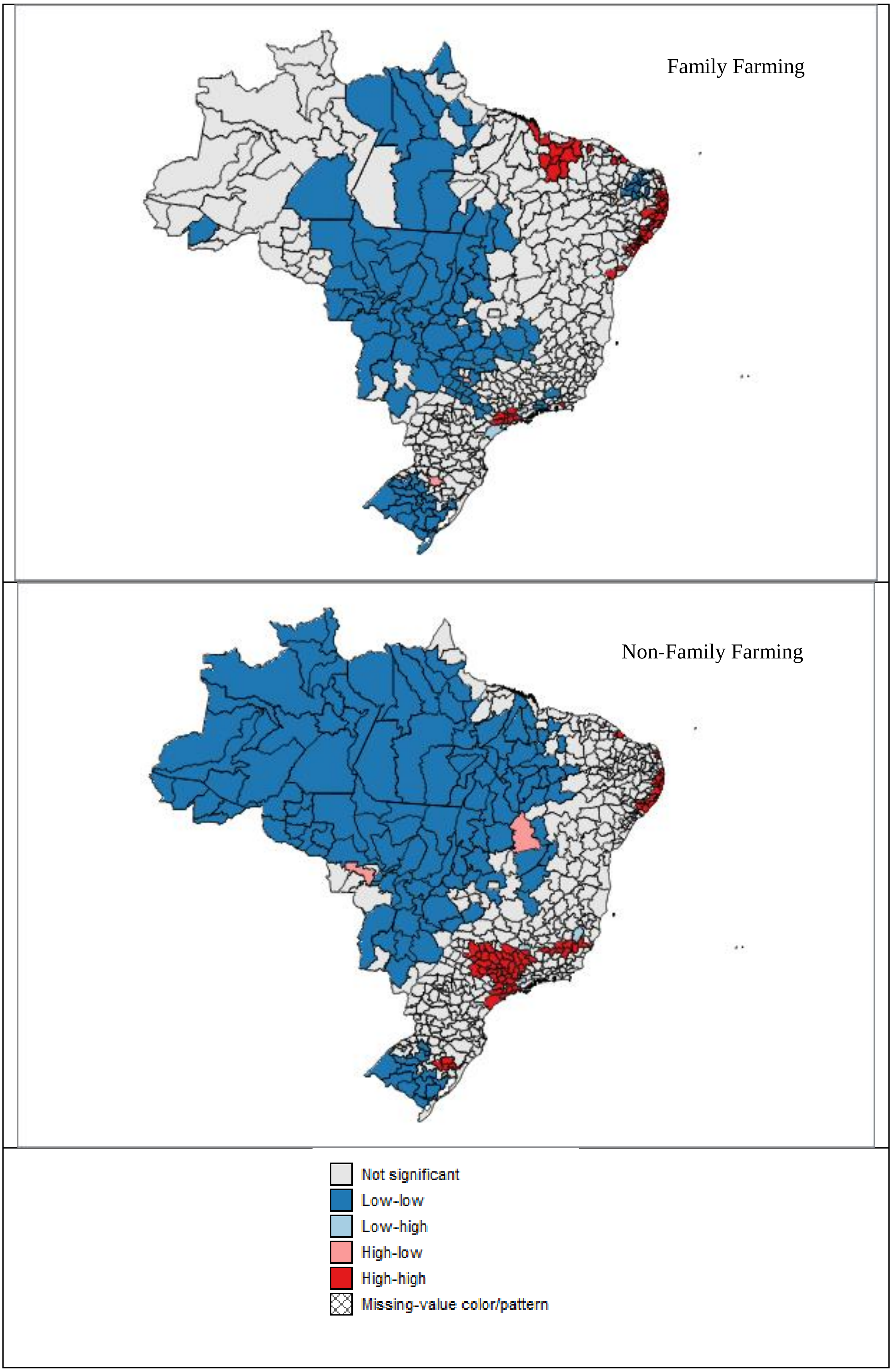


Fig. 28: Spatial clusters for factor of investment.

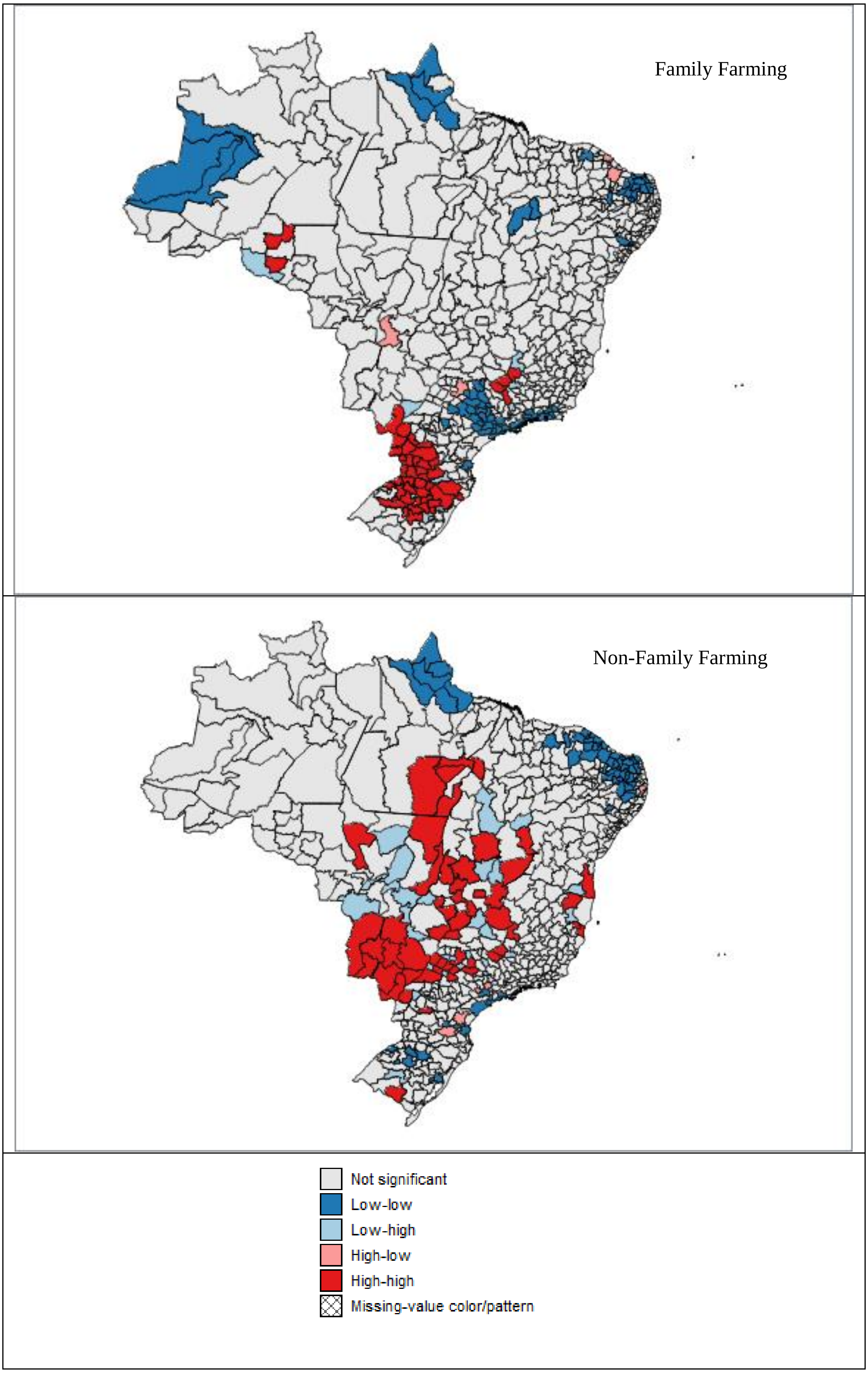


Fig. 29: Bivariate cluster for family and non-family farming´s productivity factor scores

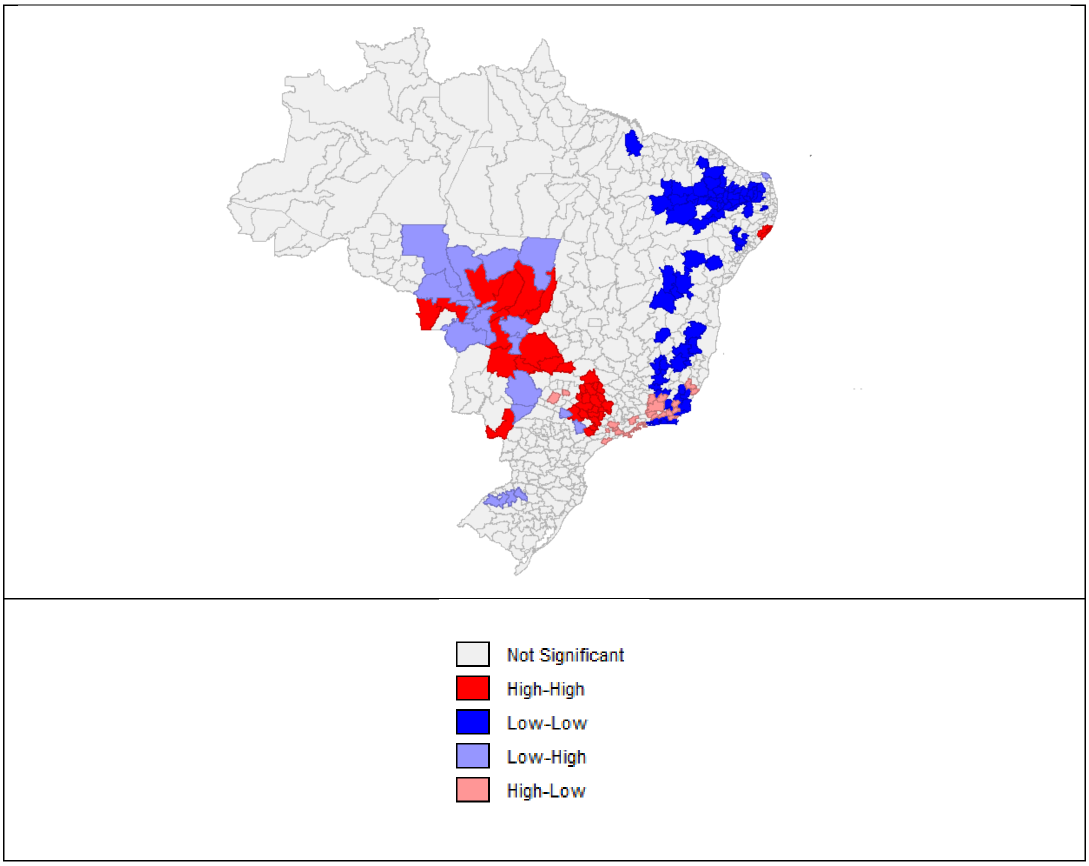


Fig. 30: Bivariate clusters for family and non-family farming´s degree of mechanization factor scores

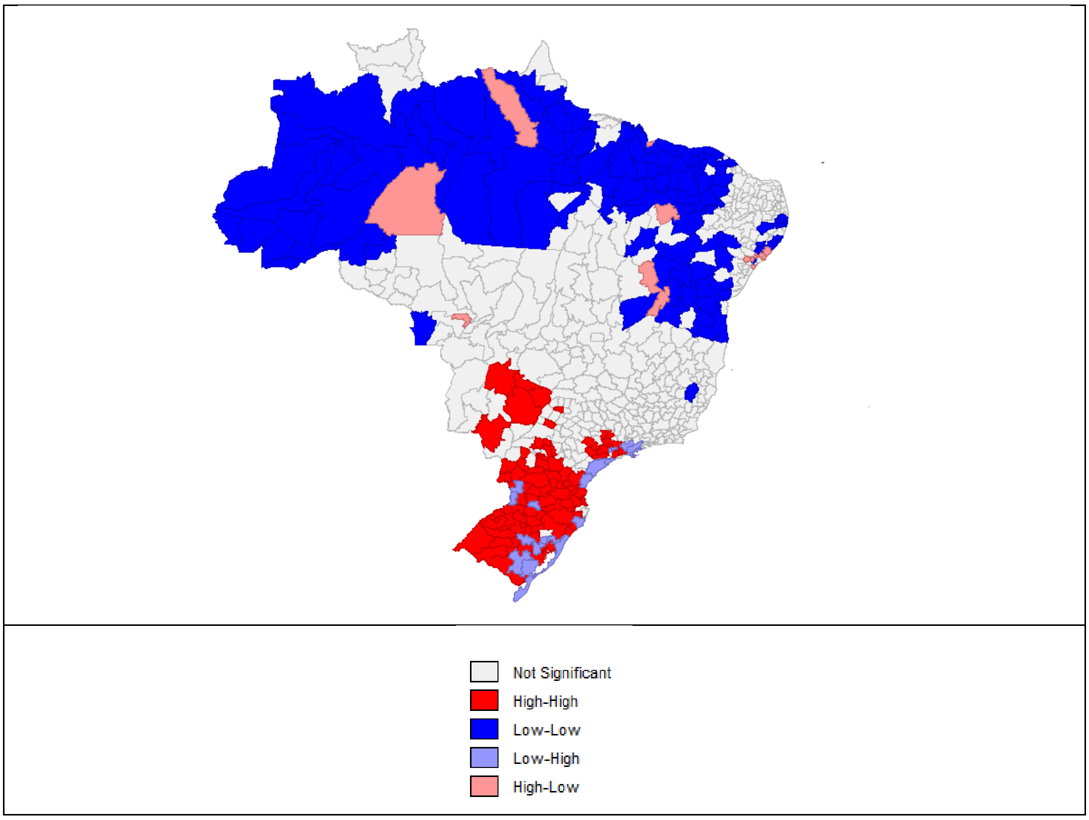


Fig. 31: Bivariate clusters for family and non-family farming´s labour use intensity factor scores

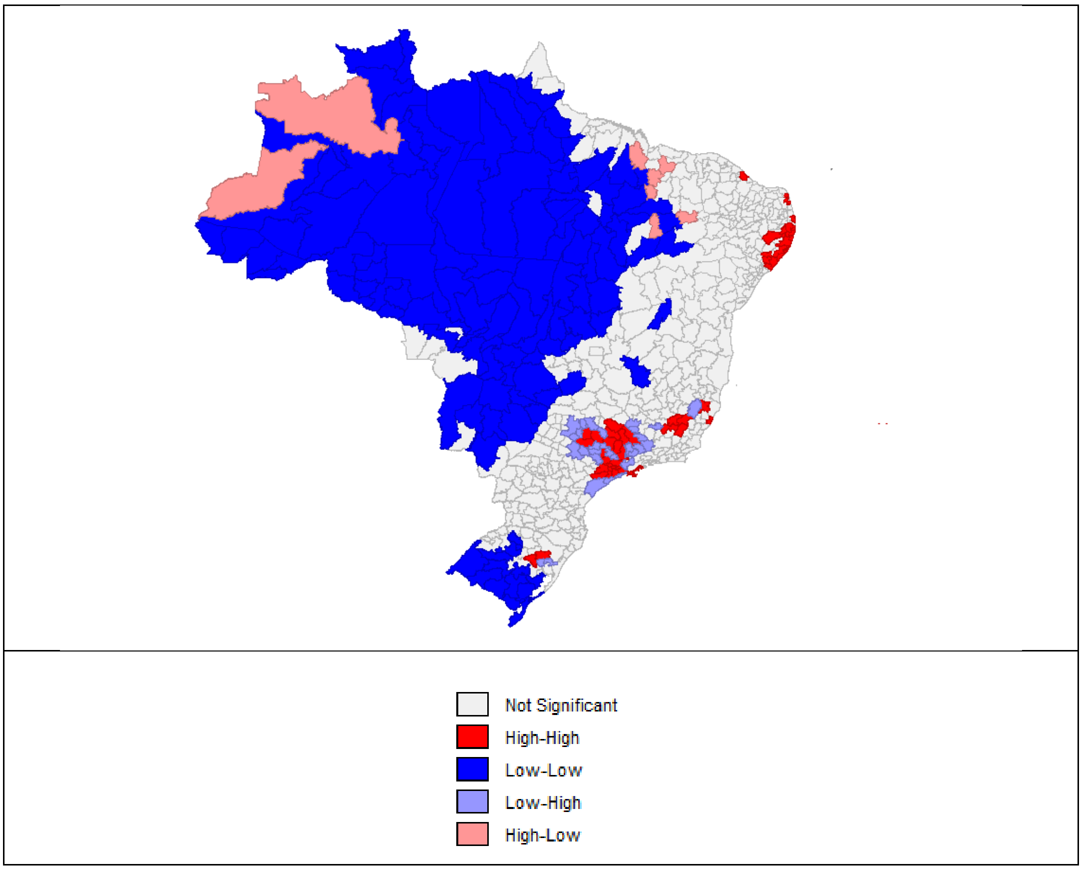


Fig. 32: Bivariate clusters for family and non-family farming´s for investment factor scores