

# IMPACTS AND EXTERNALITIES OF AGRICULTURAL MODERNIZATION IN BRAZILIAN STATES

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**Abstract:** This study aimed to analyze the relationship between the levels of agricultural modernization and socioeconomic indicators of the Brazilian federation units. A multivariate approach to data analysis led to the creation of the Index of Agricultural Modernization (IAM). The Spearman correlation test was used to verify the relationship between levels of agricultural modernization and a set of economic and social indicators. As a result of the survey, we obtained the Index of Agricultural Modernization (IAM) which allowed the ranking of Brazilian states in terms of level of modernization. The correlation analysis demonstrated the existence of significant and positive correlation between the agricultural modernization and the following indicators: per capita GDP, trade balance per capita and IFDM. This means that agricultural modernization contributes to increased production, exports and the levels of socioeconomic development of the states. For the variable urbanization rate, test results showed a negative correlation with the IAM, which suggests a contribution of agricultural modernization for fixing people in the countryside. Indicators of inequality in income distribution showed no significant correlation. In conclusion, it can be inferred that the positive relationship of the IAM with indicators of production, exports and socioeconomic development shows the presence of positive externalities and impacts of the agricultural modernization process for the Brazilian states.

**Key words:** multivariate analysis, agricultural modernization, socioeconomic indicators, externalities.

## 1. Introduction

The agribusiness is one of the main sectors of Brazilian economy and has a leading position in foreign trade, accounting for 37.9% in the country's total exports in 2010. According to the Ministry of Agriculture (2011), in 2010, exports in the sector totaled \$ 76.4 billion, a record for the sector. Taking into account the values of 2009, exports grew by \$ 11.7 billion, representing an increase of 18.1% and exceeding in \$ 4.6 billion the previous record of \$ 71.8 billion, achieved in 2008 - the record for foreign sales of Brazilian agribusiness until then.

According to Correa and Figueiredo (2006), several instruments were used to allow the Brazilian agribusiness

reach this high level of productivity and competitiveness in the international market. For Martine and Beskow (1987), the process of modernization and implementation of technological innovations in Brazilian agriculture began in the 1930s, with the first policies of the government based on import substitution of consumer goods.

Innovations in agriculture, according to its effect on the production process are classified into: mechanical innovations, which modify the intensity and pace of work; physical-chemical innovations, which alter the natural conditions of soil; biological innovations that reduce the production period and enhance the innovations mentioned above; agronomic innovations that permit new forms of organization, allowing the increase of labor productivity in

general (Graziano da Silva, 2003). According to Brum (1988), among the main reasons for agricultural modernization are the increase in labor productivity in order to increase profit; the reduction of the unitary cost of production to beat the competition; and to enable the implementation of the agroindustrial complex in the country.

The modernization of agriculture in Brazil occurred basically in three moments. In the first moment, modernization happened with the constitution of the agroindustrial complex of the 1970s, in the second, the process is intensified with the consolidation of the industry related to the manufacture of agricultural machinery and equipment and, finally, in the third moment, with the integration of financial capital in the agricultural sector (Silva, 1996).

According to Hoffman and Ney (2004), with the objective of facilitating the access to new technologies in the field, the government has relied mainly on rural credit, in this sense, the distribution of rural credit is placed as being directly linked to the different existing levels of agricultural modernization in Brazil. The policy of modernization of Brazilian agriculture is characterized by the predominance of the policy of abundant and subsidized rural credit, yet available in a very concentrated manner.

Defant et al. (1999) argues that from the 1970s, the government encouraged the national agriculture to modernize, through resources for investments, and from the 1980s, for costing. The resources for costing were certainly destined, for the most part, to large producers, aiming their production to reach, together with the investments made earlier, productivity gains and increase of products to export, contributing by one side to the external competitiveness, but on the other hand it also contributed to increase the levels of inequality.

Given this context we must emphasize the negative impacts the agricultural modernization process developed in the country, which contributed to land concentration and therefore income concentration.

According to Hoffman and Kageyama (1985), there are evidences that the process of modernization occurred in the agriculture of the country has contributed to the income concentration especially in the countryside. For Ehlers (1999), the use of new technologies in Brazilian rural sector, and the quick way in which the process of agricultural modernization in the country occurred, contributed to the intense process of rural exodus in the country and consequently for the population concentration in the main urban centers of Brazil. In this same direction, Balsan (2006) affirms that the strong rural exodus begins more intensely in the more developed regions, where the process of capitalization and mechanization of agricultural activities occurred first and in a stronger way. Corroborating the arguments presented above, Graziano da Silva (2000) points out that agricultural modernization in Brazil contributed to the evolution of the exclusionary and concentrating land structure, thus hindering access to land by the rural workers.

In relation to socioeconomic indicators, as shown by

Graziano Neto (1985), it can be noticed that if on one hand, modernization has brought economic gains and income generation, on the other there were several negative impacts resulting from this process. Among papers discussing the effects of agricultural modernization stand out Nicholson (1984), Herdt (1987), Hayami and Ruttan (1985), Otsuka, Cordova and David (1992), Lomar et al., (2009)

Having said that, this work aims to analyze the relationship between levels of agricultural modernization and economic indicators of the Brazilian federation units, that is, it is intended to evaluate the impacts and externalities of the agricultural modernization process in 27 states.

As a contribution, it is hoped that this paper stimulates discussions about agricultural modernization and about strategies that may be useful for reducing the negative effects of modernization on the levels of income concentration, indicators of socioeconomic development and the rural exodus, without letting the country reduce its level of international competitiveness.

## 2. Methodology

The process of agricultural modernization has a multidimensional character, that is, the magnitude of this process requires the consideration of a set of variables capable of capturing the use of modern technologies associated with it as shown in Hoffmann (1992), Cunha (1995), Meyer (1997), Souza and Lima (2003) and Gasques et. al (2004).

This situation is not exclusive to the Brazilian economy. In international economic literature, there are many works that addressed the conditioning factors of the process of agricultural modernization, as well as disparities in the process. Among the studies that have shown the existence of conditioning factors of agricultural modernization the ones by Schultz (1965), Mellor (1966), Falcon (1970) and Gibbons and Koninck and Hasan (1980) stand out.

Given this multidimensional nature of modernization the present study was based on a multivariate data approach, involving a set of 24 variables related to the use of new technologies in agriculture. The application of multivariate analysis allowed the description of the modernization process in the Brazilian states, allowing also the construction of the Index of Agricultural Modernization (IAM), which allowed to classify the relative performance of the federation units.

### 2.1. Variables and Data Source

Given the multidimensional nature of the concept of agricultural modernization, it becomes necessary to survey a wide range of variables and indicators capable of capturing the level of agricultural modernization in a region. In order to determine the factors affecting the modernization, 12 variables were selected for each state, representing different dimensions of agricultural modernization, aiming to verify

the adoption of new technologies and the productivity growth of production factors.

The selection of variables used in this article was based on several studies that have focused on the analysis of the process of agricultural modernization. To capture aspects related to the use of machinery and equipment, the variables selected were number of tractors and value of investments in agricultural machinery and tools; to analyze the issues associated with improvements in infrastructure and logistics the variables used were value of investments in facilities and other improvements, value of investments in vehicles and other means of transportation and fuel expenses; the aspects related to the use of inputs were evaluated using the variables costs of fertilizer and correctives, expenses with seeds and seedlings and costs of pesticides, and finally to consider the issues associated with the use of capital the variables used were total investments, total expenditure and production value.

All variables were worked with relative values in the global context of each state, allowing a better comparative analysis between them, expressing, more appropriately, their relative contribution. For the relativization of the variables, all data collected is expressed in relation to the explored area (EA) and man-equivalent (ME). This is because, according to Souza and Lima (2003), the aspect of interest is not the volume but the intensity of the use of modern technology. That said, it is justified the variables being expressed in relation to the labor occupied, in man-equivalent (ME), and in relation to the explored area (EA). The concept of man-equivalent (ME) used in this study refers to the homogenization of the work of men, women and children. The concept of the explored area (EA) refers to the sum of areas with permanent and temporary crops, planted pastures, planted forests, areas with natural pastures and natural woods.

With the relativization of data by EA and EM, the number of variables used in factor analysis doubled. In this sense we used 24 variables to determine the rate of agricultural modernization. All information is available on the Agricultural Census of the Brazilian Institute of Geography and Statistics (IBGE) 2006.

## 2.2. Factor Analysis

In Brazilian literature there are a vast number of studies that used multivariate approach, specifically the factor analysis to identify and explain the agricultural modernization, among which are: Hoffmann (1992), Meyer (1997), Espirito Santo (1998) Souza and Lima (2003), Cespedes (2004) and Cruz Ribeiro (2006).

According to Hair et al. (2009), factor analysis is used to synthesize information from a large set of variables in a reduced number of variables or factors. For Mingoti (2005), the goal of factor analysis is to describe the behavior of a given set of variables, from the dependence structure between them, through a smaller number of variables called factors. The variables most correlated are combined on the same factor, being independent of those that make up the other factor, that is, the factors are not correlated.

The factor model obtained after factor analysis explains, theoretically, the structure of latent factors responsible for the observed correlations between the original variables. Naturally, the model assumes that there are a number of factors below the original number of variables that are able to explain a high percentage of the total variance of the original variables. The rules of the eigenvalue (characteristic root) superior to a Scree-plot are usually used to decide the minimum number of factors needed to explain a considerable proportion of the total variance of the original data. However, these rules only help to select the factors needed to explain the observed variance-covariance, and say nothing about the quality of the factorial model deduced (Maroco, 2007).

To evaluate the validity of factor analysis, we used the criteria Kaiser-Meyer-Olkin (KMO), the Bartlett's test and the percentage of total variance explained by factors. The KMO and the Bartlett's test are two statistical procedures for measuring the quality of the correlations between variables in order to proceed with factor analysis. The KMO near 1 indicates small partial correlation coefficients, while values near zero indicate that factor analysis is an unacceptable option, because there is a weak correlation between the variables.

After obtaining and identifying the factors, and determining the respective factor scores, it is possible to study the stage of agricultural modernization of Brazilian states. Thus, the factor analysis contributes to a view on the process of agricultural modernization, using the values of the factors to obtain the measures of modernization and subsequently the ranking of states. In the next section it is presented the procedures used to create the Index of Agricultural Modernization for the Brazilian states.

## 2.3. Agricultural Modernization Index (AMI)

From the factors obtained in the factor analysis, it is possible to create an index of intensity of agricultural modernization. The methodology to calculate the indicator follows the procedures used by Cunha et al (2008) to calculate the General Index of Degradation (GID) and Shikida (2010), who estimated the Crude Index of Socioeconomic Development (CISD) for municipalities with sugar cane cultivation in the State of Parana.

To enable the construction of the Crude Index of Agricultural Modernization (CIAM) it is required the aggregation of factors obtained through the equation:

$$CIAM_i = \sum_{j=1}^p \frac{\lambda_j}{\sum \lambda_j} F_{ij}, \quad (1)$$

The  $CIAM_i$ , represents the Crude Index of Agricultural Modernization for the  $i$ -th analyzed state,  $j$  is the  $j$ -th characteristic root,  $p$  is the number of factors obtained through factor analysis,  $F_{ij}$  is the  $j$ -th factor score of the  $i$ -th municipality, and  $\sum \lambda_j$  is the sum of characteristic roots referring to the  $p$  factors extracted.

Following the procedures adopted by Cunha et al. al (2008), to make all values of the factor scores ( $F_{ji}$ ), greater than or equal to zero, all the factors were placed in the first quadrant, before construction of the CIAM, using the algebraic expression:

$$F_{ji} = \frac{F_j - F_j^{\min}}{F_j^{\max} - F_j^{\min}} \quad (2)$$

where  $F_j^{\min}$  is the lowest score observed for the factor j-th, and,  $F_j^{\max}$  is the highest score observed for the factor j-th.

Having the CIAM, and by means of weighting, in which the greatest value considered is 100, it was obtained the Relative Index of Agricultural Modernization (IAM) for each Brazilian state, allowing their ranking. All calculations were performed using the SPSS 15.0 (Statistical Package of Social Science), using the licensed version.

#### 2.4. Correlation Analysis

After constructing the IAM, it was analyzed the relationship between the modernization process of agriculture and economic and social indicators of the Brazilian states. For such, we performed the Spearman Correlation Test, which according to Martin (2001) is a technique widely used in empirical studies that seek to evaluate the association between variables. The possible existence of a relationship between variables oriented the analysis, the conclusions and the disclosure of the findings on this investigation.

According to Triola (2008), the Spearman's rank correlation test is a nonparametric test that uses positions of sample data consisting of matched pairs. The test is used to test the association between two variables so that the null hypothesis and alternative are as follows (where  $\rho_s$  designates the coefficient of rank correlation for the entire population):

- H0:  $\rho_s = 0$  (there is no correlation between two variables)  
 H1:  $\rho_s \neq 0$  (there is correlation between two variables)

Also according to Triola (2008), there are several advantages of using the Spearman's rank correlation test. Among them are: (i) the Spearman test can be used in a wider variety of circumstances than the parametric method of linear correlation. Using this test it is possible to analyze paired data that are posted or that can be converted into posts, and (ii) the rank correlation can be used to detect some relations that are not linear.

The Spearman test is also used when data from some of the variables studied shows a very asymmetric distribution or outliers. In this case, the analysis of the coefficient r (commonly used) may be compromised, which justifies the implementation of the non-parametric approach of Spearman, which uses only the ordering of values (Barbetta, 2008).

#### 2.5. Variables Used in Correlation Analysis

The process of agricultural modernization in Brazil started in the 1960s, as part of the policy of import substitution and as a reflection of the green revolution. It was also during this period that the industry of capital goods for agriculture (tractors, implements, fertilizers and pesticides) was consolidated, and the expansion of processing agroindustries led to profound changes in the technical basis of agriculture.

In this light, we see the contribution that these changes represent to the strong international competitiveness of Brazilian agribusiness. To identify the economic impacts of agricultural modernization in the Brazilian states the variables selected were: trade balance of agribusiness and GDP, both per capita. It is hoped that the levels of agricultural modernization present high positive correlation with the trade balance of Brazilian agribusiness states and GDP per capita, in other words, states with higher rates of modernization have had the highest trade balance and higher values for gross domestic product per capita.

Nevertheless, for some authors as Scott (1985), Graziano Neto (1985), Ramachandran (1991) Ehlers (1999), Graziano da Silva (2000), Hoffman and Ney (2004) and Balsan (2006) the process of agricultural modernization favored an increase in efficiency, leaving in the second plan, social issues such as inequality of income distribution, regional inequalities, socio-economic development and rural exodus.

In order to analyze the externalities of agricultural modernization on the indicators of inequality in income distribution were used the ratio of the income earned by the richest 10% and poorest 40%, the Gini coefficient. Considering that the process of agricultural modernization has contributed to increased inequality in income distribution, it is expected that the selected indicators present high positive correlation with the IAMs.

From the assumption that the modernization process contributes to the process of income concentration it is feasible to say that their externalities on the level of socioeconomic development of the states present negative and high correlation with the IAM, as it is impossible to think of socioeconomic development in a context of inequality in income distribution. The variable used to analyze the relationship between agricultural modernization and the level of socioeconomic development was the FIRJAN Index of Municipal Development (FIMD) of the Brazilian states. Finally, the impacts on the rural exodus were evaluated from the variable urbanization rate. It is expected that the rate of agricultural modernization presents high and positive relationship with the high migration process from rural to urban areas, given the fact that the use of new technologies in production processes demand a smaller number of workforce in steps previously demanding, such as planting and harvesting.

The variables GDP per capita and the trade balance of agribusiness per capita were collected in the website of the Institute of Applied Economic Research (IAER) and from



the website of the Ministry of Agriculture, Livestock and Supply were obtained the values for export and import of the agribusiness sector. The variables of inequality in income distribution, social and economic development and rural exodus were collected in the website of the Institute for Work and Society (IWS). All data were collected for the year 2006, as well as the data used in factor analysis.

### 3. Results and Discussion

This section was divided in three subsections. In the first one it is presented the factors for agricultural modernization in the Brazilian states, in the second it is presented the rank of the Index of agricultural modernization (IAM) of the 27 Brazilian states, obtained from the factor analysis, in the third subsection it is presented the results of Spearman correlation test between the levels of agricultural modernization and socioeconomic indicators.

#### 3.1. Factors Agricultural Modernization

Initially, it was performed the factor analysis in order to synthesize the information contained in the 24 original variables. To identify the quality of fit of the model of factor analysis it was used the KMO index, which presented a value of 0.538, which, although low, can still be considered a reasonable measure of suitability. Another method used to analyze the validity of the factor analysis was the Bartlett's test, which showed a value of 1.489, significant at 1% of probability. Thus, both tests have concluded that the sample used is appropriate to the analysis procedure, that is, the use of factor analysis.

According to the results presented in Table 1, the factor analysis generated three factors with characteristic roots ( $\lambda$ ) greater than 1. The contribution of the factors 1, 2 and 3 for the explanation of total variance of the indicators used was 39.8, 39.3 and 8.6%, respectively, so that their cumulative contribution is equal to 87.8% of total variance, a very significant percentage. The results of the percentage explained by each factor corroborate the results found by Kageyama and Leone (1992), which draw attention to the association of the modernization process of Brazilian agriculture to a production supported by the combined and intensive use of modern inputs, resulting in high productivity of labor and land.

According to Souza and Lima (2003), to facilitate the interpretation of the factors, it should be made their rotation by the Varimax method. With this procedure, the contribution of each factor to the total variance is altered, without, however, modifying their joint contribution. As an advantage, the factors obtained after the rotation are more closely related to certain groups of variables, allowing a more logical interpretation of them.

After applying the Varimax rotation method, the indicators that are associated with factors had factor loadings with a value greater than 0.60, that is, the highest factor

loadings are indicative of higher correlation coefficients between each factor and each of 24 variables and indicators of modernization (Table 1).

Table 1: Matrix of components after orthogonal rotation

Variables	Factors		
	1	2	3
Number of tractors (EA)	0.899		
Total value of investments (EA)	0.930		
Value of investments in facilities and other improvements (EA)	0.890		
Value of investments in agricultural machinery and instruments (EA)	0.868		
Total amount of funding (EA)	0.856		
Total value of production (EA)	0.925		
Total expenditures (EA)	0.888		
Costs of fertilizers and correctives (EA)	0.782		
Costs of seeds and seedlings (EA)	0.806		
Costs of agricultural defensives (EA)	0.698		
Fuel expenses (EA)	0.951		
Number of tractors (ME)		0.815	
Total value of investments (ME)		0.896	
Value of investments in facilities and other improvements (ME)		0.781	
Value of investments in agricultural machinery and instruments (ME)		0.892	
Total amount of funding (ME)		0.958	
Total value of production (ME)		0.814	
Total expenditures (ME)		0.972	
Costs of fertilizers and correctives (ME)		0.939	
Costs of seeds and seedlings (ME)		0.903	
Costs of agricultural defensives (ME)		0.937	
Fuel expenses (ME)		0.960	
Value of investments in vehicles and other means transport (EA)			0.697
Value of investments in vehicles and other means transport (ME)			0.779
% of Variance explained by the factor	39.83	39.35	8.68

Source: research results.

From the results presented in Table 1, we proceeded to analyze each of the factors obtained.

### Factor 1 – Use of new technologies in relation to explored land use

The variables of this factor are more closely related to land use, since all the variables associated with factor 1 were relativized by the explored area. In this sense, it is clear which factor contributes to explain the use of technology applied to a better performance of a given explored area, more specifically, the use of new technologies in order to optimize the use of the land input.

The factor 1 was composed by 11 variables that represent the various dimensions related to agricultural modernization. Thus, it is noticed that the higher the factor scores in this factor, the greater were the incorporations of the guidelines that have oriented the process of agricultural modernization, that is, in states with good performance in this factor, there was probably a greater concern for increasing the productivity of used lands instead of the expansion of farmland. It is emphasized the importance of this factor to explain the phenomenon of agricultural modernization as a whole, this factor was responsible for 39.83% of the explained variance of selected variables to analyze agricultural modernization in the Brazilian states, thus putting the land use as the main responsible for the modernization of agriculture in the area studied.

### Factor 2 – The usage of new technologies in relation to labor

The variables that compose the factor use of new technologies in relation to labor are the same which formed the first factor, the difference between the variables from the first and the second factor is the variable used to relativization. All variables of the second factor are relativized by the equivalent-man, that is, the variables were standardized in relation to labors.

From the set of variables that compose the second factor, it is important to notice that if the factor score of factor 2 for a given state is high and positive, it means that it has a high intensity of use of technological resources and less intensive use labor, that is, higher level of modernization in agriculture.

### Factor 3 – New Technologies for Logistics and Transportation

It was observed that the third and last factor heavily incorporates the indicators related to technological tools designed to transport and logistics processes (vehicles and other means of transport). Thus, by strongly capturing the use of means of transport, a high value of investments in these processes is related to the needs of a more efficient production flow. Thus, the higher this indicator, the better will be the conditions of logistics and transport of the Brazilian states.

## 3.2. Index of Agricultural Modernization (IAM)

After the identification of factors associated with agricultural modernization from the factor analysis, it was performed the construction of the index of agricultural modernization (IAM) from factor scores. The motivation for building the index refers to the difficulties faced in the classification of Brazilian states in relation to the level of agricultural modernization using only the values of the factor scores (F1, F2 and F3). By aggregating the three factors, the IAM allowed a more appropriate classification of the states. Table 2 presents the IAM and its ranking for the 27 Brazilian states.

**Table 2:** Index of Agricultural Modernization and its ranking for the 27 Brazilian states

Classification	Estate	IAM
1°	Distrito Federal	1.000
2°	São Paulo	0.905
3°	Mato Grosso	0.776
4°	Santa Catarina	0.743
5°	Paraná	0.680
6°	Mato Grosso do Sul	0.677
7°	Rio Grande do Sul	0.609
8°	Goiás	0.509
9°	Espírito Santo	0.424
10°	Minas Gerais	0.382
11°	Pernambuco	0.341
12°	Rio de Janeiro	0.332
13°	Alagoas	0.330
14°	Sergipe	0.292
15°	Tocantins	0.287
16°	Bahia	0.226
17°	Rio Grande do Norte	0.222
18°	Rondônia	0.222
19°	Roraima	0.215
20°	Pará	0.195
21°	Paraíba	0.180
22°	Ceará	0.174
23°	Maranhão	0.168
24°	Piauí	0.164
25°	Amapá	0.153
26°	Acre	0.152
27°	Amazonas	0.142

Source: research results.

The average of the Index of Agricultural Modernization (IAM) obtained by the Brazilian states was 0.389. This low value is the result of poor performance shown by some federation units (FUs), including, Acre, Amapá and Amazonas, confirming the thesis presented in the literature that the main excluded states from the process of agricultural modernization in Brazil were the states of north-northeast.

The results presented by the state of Amazonas confirm the view of Mellor (1966), who points some restrictive factors for agricultural modernization, such as the excessive land concentration and the poor use of land. The condition of the state of Amazonas relates mainly to the high land concentration, for in the state there are high levels of concentration. It is the same situation presented by the state of Pará, which is among the ten worst indexes of agricultural modernization (IAM).

It is noticed that the states of North and Northeast regions had low modernization. Among the main factors responsible for this poor performance, there are the high concentration of land in cases such as the state of Amazonas and the historical differences occurred mainly between the states of North-Northeast and the other federation units.

Among the states with intermediate level of modernization, two belong to the Northeast region, Pernambuco and Alagoas. According to IBGE data (2011), the state of Alagoas is the penultimate in area, but stands out as one of the largest producers of sugar cane in the country, an activity that requires investments in technology and due to the small area available requires a great intensity in the use of these technologies in relation to the explored area.

Regarding the state of Pernambuco, it is noticed that its high performance in relation to the first factor is also credited to historical and cultural factors that favor agribusiness in the state. It is emphasized the importance of Pernambuco for the country economy in the colonial period, especially in relation to the sugar economy. Another aspect that contributes to the prominent position of the state is the investments made in the agriculture of the state through public irrigation projects and other government investments, which enabled the state to achieve great prominence in the production of fruits for the foreign market.

In relation to states with the highest level of modernization, it is noticed their concentration in the South, Southeast and Midwest regions. The high levels in the intensity of agricultural modernization in the states of these regions are credited to historical advantages and to the projects that aimed to improve the economic indicators of the Midwest, an extremely important region for the Brazilian agribusiness. The states of Mato Grosso do Sul and Mato Grosso have had such prominence thanks to the performance achieved in relation to the factor 2, due to the low rates of population density, which makes it necessary the intensive use of new technologies in relation to labor.

The Distrito Federal had the highest rate of modernization due to its performance in relation to the factor 1, since it has the smallest area among the Brazilian states, requiring a great productivity in relation to the explored area,

mainly achieved by the use of new technologies. The other states are in that position thanks to the advantages obtained over time, for example, large volume of rural credit received, the need of agro-industries for raw materials, one of the main inducers of agricultural modernization.

The results obtained from the creation of the IAM corroborate the studies of Correa and Figueiredo (2006) who, based in the agricultural census, identified evidence of a pattern of concentration of this phenomenon in some regions and states, particularly in the state of São Paulo, and in states of South and Midwest regions. This study confirms the pattern of concentration indicated by the authors.

### 3.3. Relationships between Modernization, Inequality, Socioeconomic Development and the Rural Exodus

In this section it will be analyzed the relationships between measures of agricultural modernization, obtained through factor analysis, and some economic and social indicators in the Brazilian states.

As presented in the section of methodological procedures, in order to analyze the relationship between modernization and economic indicators the variables used were: trade balance of agribusiness and gross domestic product, both per capita. To analyze the relationship between the level of agricultural modernization and the inequality in income distribution the variables used were the ratio between the income earned by the richest 10% and the poorest 40%, and the Gini index. To analyze the socio-economic development and the rural exodus the variables used were: the FIMD and the urbanization rate, respectively.

Table 3 presents the results of the Spearman correlation test between the IAM and the selected variables.

Table 3: Spearman correlation test

	Correlation coefficient	Level of significance
Trade balance of agribusiness per capita	0.485	0.010
GDP per capita	0.412	0.033
Gini Index	0.047	0.818
Ratio between the income earned by the richest 10% and the poorest 40%	-0.201	0.315
FIMD	0.436	0.023
Urbanization rate (%)	0.384	0.048

Source: research results

As presented in the literature, the process of agricultural modernization in Brazil aimed to strengthen the competitive position of agribusiness of country in the international market. From the results presented in Table 3, it is identified empirical evidences that agricultural modernization actually

contributes to the trade balance of agribusiness per capita, as the result of the Spearman test indicates the presence of positive and significant correction at 10 %. This result supports the argument that the process of agricultural modernization favored an increase in efficiency as shown by Ehlers (1999), Graziano da Silva (2000), Hoffman and Ney (2004).

Another economic effect of agricultural modernization would be the increase in gross domestic product, since the increase of productivity in the sector has made the agribusiness one of the main sectors of Brazilian economy. The sector is responsible for generating jobs, being prominent in foreign trade, with significant share in the total of Brazilian exports. The correlation test results also corroborate the importance of modernizing agriculture to generate wealth in the Brazilian states, demonstrating the existence of a positive and significant correlation between IAM and state GDP per capita.

It is also highlighted the relationship between the level of modernization and socioeconomic development, in this study represented by the index FIMD. From the results presented in Table 3, it can be verified that an increase in levels of modernization leads to increased levels of socioeconomic development. The findings from this analysis allows us to disagree with the arguments presented in previous studies, which show that the modernization would be an obstacle to socioeconomic development and quality of life, causing, among other things, a detriment of health conditions, employment and income.

The rural exodus presents itself as an issue that has significant relationship with the studied phenomenon. The results contradict the points elicited by Balsan (2006), which suggest a contribution of the modernization process to the rural exodus. The results of the Spearman correlation test suggest that changes occurred in agriculture, in the sense of the use of new technologies, reduce the flow of migration from the countryside to the city. This situation can be credited to the stabilization of migration flows, but also to the increase of productivity that occurred in the countryside, which decreases the necessity for labor in some phases of production such as planting, but started to require more labor in other steps such as transport and distribution.

Concerning the income concentration, reported by Hoffman and Kageyama (1985), Ehlers (1999) and Graziano da Silva (2000) as being directly linked to processes of agricultural modernization, this study showed different results from the others, since the relationship was not significant. This difference is mainly due to the fact that there was, in the analyzed period, several other mechanisms aimed to prevent the income concentration. In this sense, the effects of modernization levels had no significant relation to the issue of income distribution today as in past decades, when the generation of income in the country was more dependent on the agricultural activity.

## 4. Conclusion

This study aimed to analyze the relationship between the levels of agricultural modernization and economic indicators of the Brazilian states. The main factors responsible for agricultural modernization in the Brazilian states were related to the use of new technologies in relation to the use of explored land, use of new technologies in relation to labor and new technologies of transportation and logistics.

Based on the factors responsible for agricultural modernization it was created the index of agricultural modernization (IAM). The analysis of the IAM showed a great heterogeneity among the Brazilian states, this situation also applies to other indicators covered in this study.

The levels of modernization were significantly related to per capita GDP, trade balance of agribusiness per capita, FIMD and urbanization rate. In this sense, this relationship can be considered positive, since the effects from the process of agricultural modernization can enable, among other things, an increase in income and quality of life, and contribute to keep the population in the rural areas. In relation to the indicators of income concentration mentioned in the literature as being negative and directly related to agricultural modernization, this study could not observe such situation, given that the relationship presented was not significant.

The improvement in socioeconomic indicators and in reducing the rural exodus is related to the issue of modernization, due to, among other things, the economic gains brought by the increased competitiveness of Brazilian agribusiness sector, which generates an increase in the production of the country and in trade balance.

It is hoped that the considerations presented in this study contribute to demonstrate the importance of policies of agricultural modernization, and also that their focus should not only be in the increase in levels of productivity and the potential economic gains coming from the same, but they should also take into account the possible impacts and externalities caused by this process.

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