AGRICULTURE MODERNIZATION AND THE TECHNOLOGY RANKING OF MUNICIPALITIES IN THE STATE OF MARANHÃO

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ABSTRACT

This work analyses the level of agricultural modernization and creates a ranking of 136 municipalities in the state of Maranhão. The data were obtained from the Brazilian Institute of Geography and Statistics (IBGE). The study uses factor analysis technique to describe current technologies and to generate the ranking. The results demonstrate variations in agricultural technology across the state, with only small portions of the municipalities employing modern technology as defined in terms of intensity of cultivation or by capital rates per unit of labor. On the other hand, the producers in the majority of municipalities employ rudimentary, even primitive, technologies. Thus, the study concludes that Maranhão shows differences in agricultural technology and which require urgent efforts to reduce technology disparities in agriculture and promote overall development.

Key words: Technology, ranking, municipalities, Maranhão.

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1 Introduction

Agricultural modernization in Brazil began with the industrialization of the country after the second world war. The increase in secondary sectors is related to the accelerated urbanization and industrialization in the country. Hoffmann (1996) described Brazilian agriculture's modernization as the consolidation of a number of transformations occurred in agriculture or as deepening of inter sector relationships with the increasing use of modern inputs such as tractors, chemical fertilizers, insecticides, fungicides and herbicides, produced in the country.

According to Kageyama (1996), the modernization of agriculture in Brazil incorporates the following three basic changes: first, the modernization is not only based on more intensive use of modern inputs, but also on a change in labor use. A second change is represented by mechanization in the productive process, beginning with the preparation of soil to harvesting the crop, therefore substituting the labor as well as the worker's manual ability and consequently, resulting in a qualitative jump in agricultural production. The third change is marked by the installation of basic industry (steel plant, petro-chemical, rubber and plastic industries) in the country, during the decades of the 50's and 60's, to produce agricultural machines and equipments.

During these decades, a package of modern techniques, based on agronomic sciences called "green revolution", was generated, mainly, in the United States and Japan. Later on, it was spread all over the world, particularly in the developing countries that were looking for modernization of their traditional agriculture.

The technology diffusion model assumed that the difference in agricultural productivity among countries could be reduced by using modern technologies in developing countries (Hayami & Ruttan, 1988).

The modernization of Brazilian agriculture was initially based on the American model which embodied the increase in labor productivity. This process had the decisive participation of government through the

implementation of various agricultural policy instruments, such as extension and technical assistance, mechanization and agricultural financing, etc.These have contributed to increase agricultural productivity and production (Monteiro, 1985). According to Muller (1982) and Saint (1988), agricultures' modernization policies in Brazil were oriented to the existing agrarian structure and the adoption of new technologies should benefit the medium and large farmers who did not reach the desired results in the form of increased productivity and production as mentioned by Silva (1981), Ribeiro (1973), Pastore & Alves (1984) and Santana (1997).

The modernization of agriculture in Brazil occurred in a heterogeneous form. In the regions of south, southeast and in few areas of the center-west, modern technologies were employed and farmers in the north and northeast regions were using rudimentary practices (Hoffmann (1992) ; Figueiredo & Hoffmann (1998)).

During the decade of 70, subsidized agricultural credit to buy fertilizer, agricultural machines and equipments contributed substantially to the sector's modernization. It is observed that the policy benefited export crops that were produced in the countries' center-south region. The Northeast, which was responsible for 22% of the agricultural production during the decade of the 70s, received only 12% of the total agricultural credit. On the other hand, the three states of center-south, producing wheat and soybean, received almost four times more credit than Northeast and were responsible for about 38% of the value of agricultural production (Goldin & Rezende, 1993).

Presently, in spite of the existence of several institutions responsible for promoting agricultural development in the Northeast, it is observed that low level of technology used in the region, comprised of various states, has condition to produce different crops, given a regular rainfall in large part of your area, for example, the state of Maranhão.

During the year 1995, the contribution of service, industry and agriculture sectors were 65%, 18,9% and 16,1%, respectively, to the state gross domestic product. It is important to know that 53,5% of the total

labor force is employed in the agriculture sector. The main crops produced in the state are: sugarcane, rice, bean, cassava, corn, soybean and banana (IBGE, 1998).

Agriculture is responsible for providing employment opportunities to a large part of the population, however traditional agricultural technology is still used in the state of Maranhão.

It is important to note that agriculture in the state presents great contrasts. A small number of large farmers are employing modern technologies, while a large number of small farmers are using traditional technologies, used in Brazil more than half century ago.

It is true that the implementation of policies stimulating an increase in agricultural productivity by the use of modern technologies should not only be compatible with the satisfaction of present human needs, but should also preserve the scarce resources for future generations (Khan, 1997). Due to this, all the strategies for modernization of agriculture should consider the types of technology used in each region. This justifies the realization of research that provides information about the relative level of agricultural development in the municipalities of Maranhão.

2 Data Source

The data related to variables representing modernization of agriculture for each municipality of Maranhão were obtained from State Agriculture Census, for the year 1995/96, published by IBGE.

3 Methodology

Factor Analysis

In a given region where the type of technologies used in agriculture cannot be measured directly, but may be reflected by means of the association of a large number of indicators related to the package of

technology employed in agriculture, it is important to use the statistical techniques capable to correlate different technology indicators to the smallest number of artificial variables that allow simple conclusions related to phenomenon under study.

Factor analysis technique allows interdependence among variables and transforms a large number of variables to a few variables called factors. This technique explains the variation of a group of variables from different orthogonal factors that are independent from each other (Hoffmann, 1992).

Factor analysis technique is of great importance, when a large number of variables has to be reduced by being grouped, since they have high correlation among themselves.

According to Norusis (1994), the basic factor analysis model may be written in the following form:

$$Z_i = A_{i1} F_1 + A_{i2}F_2 + ... + A_{iK}F_K + d_iU_i \qquad (1 \leq K \leq N)$$

In this expression A_{iK} is the value of standardized multiple-regression coefficient of variable K of factor K (factor loading); F_K is value of common factor K; U_i represents unique factor; d_i is the value of standardized regression coefficient of unique factor i.

In factor analysis, each factor is constituted by a linear combination of original variables included in the study. A linkage between factors and variables is given by saturation coefficients (factor loadings) which can have positive or negative values, but never more than unity. These factor loadings have the same interpretation as the regression coefficients (Simplício, 1985).

The square of saturation coefficient (A^2_{iK}) is the contribution of factor K to the variance of Z_i. The sum of squares of common-factor coefficients (saturation coefficients) is called the communality of variable Z_i and represents a proportion of total variation of each variable explained by a set of factors considered in the study. The sum of the squares of

common-factor coefficients for each factor is called "eigenvalue". The "eigenvalue" divided by the number of variables included in the research, represents the portion explained by a given factor to the investigated problem.

It is important to know that the communality in factor analysis has the same importance as coefficient of determination (R^2) in application of regression analysis.

For application of factor analysis, the variables representing modernization of agriculture, suggested by Hoffmann (1992), Meyer and Silva (1997), Figueiredo and Hoffmann (1998), were used.

The variables included in the study were calculated as per unit of explored area (EA), measured in hectares (ha), as per unit of labor use, measured in man-day (EH); as a portion of total number of farms (TE).

The explored area is defined as the sum of the areas occupied with permanent and temporary crops, cultivated and natural pasture and forest area. The term man-day means an adult working 8 hours/day during one year.

In factor analysis, the selection of appropriate variables related to phenomenon under investigation is of vital importance. Once these variables are selected, they have significant influence on the results obtained by applying factor analysis technique.

To verify the appropriateness of the data for factor analysis, Kaiser-Mayer-Olkin (KMO) index was calculated which may vary from 0 to 1.

Bartlett statistic was used to test the null hypothesis that the correlation matrix is an identity.

After selecting the indicators of modernization of agriculture, simple correlation matrix was calculated. From this matrix, factors were calculated using the Principal Component Method . The first factor has a higher weight in relation to the second factor, which is more important than the third, and so on (Hoffmann, 1994; Mayorga (1997)).

To simplify the readings of the results, factor rotation by Varimax method was made. This way, the factors remained directly related to the

specific group of variables, altering the contribution of each factor in explaining the variance of indicators of modernization, however, without changing the proportion of the total variance explained by these indicators.

After factor rotation, factor coefficient matrix was obtained by multiplying the transpost matrix of factor loadings with inverse of simple correlation matrix of variables considered in the study.

The matrix of factor scores is a product of factor coefficient matrix and transport matrix of standardized variables.

3.1 Definition of Variables

The variables considered to determine relevant factors related to the level of modernization in the municipalities of the state of Maranhão are following:

X_1 = number of mechanical ploughs per unit explored area;
X_2 = number of animal ploughs per unit explored area;
X_3 = number of tractors per unit explored area;
X_4 = number of tractors per unit labor;
X_5 = proportion of farms using insecticides;
X_6 = proportion of farms using organic and / or inorganic fertilizer;
X_7 = proportion of farms applying animal power;
X_8 = proportion of farms using mechanical power;
X_9 = proportion of farms having electricity;
X_{10} = proportion of irrigated area;
X_{11} = consumption of fuel per unit explored area;
X_{12} = labor per unit of explored area;
X_{13} = proportion of farms receiving technical assistance;
X_{14} = credit per unit of explored area;
X_{15} = investment per unit of explored area;
X_{16} = credit per unit of labor;
X_{17} = investment per unit of labor;
X_{18} = proportion of cooperative farms;

X_{19} = production value per unit explored area;
X_{20} = production value per unit of labor;
X_{21} = fertilizer, corrective and seed expenditures per unit explored area;
X_{22} = total expenditures per unit of explored area;
X_{23} = total expenditures per unit of labor.

4 Results and Discussion

Agricultural Technology used in the Municipalities of the State of Maranhão

The calculated value of the Kaiser-Mayer-Olkin Index (0,757) indicated that the original data is appropriate for factor analysis. The Bartlett test (662,12) rejects the hypothesis of identity of correlation matrix and suggests the use of factor analysis technique.

The application of factor analysis by using principal component method, based on simple correlation matrix, resulted in three characteristic roots with decreasing values of 8,41; 4,17 and 1,85. Together, these explained 62,75% of total variation of the 23 indicators of modernization of agriculture used in the study.

After factor rotation, the obtained factor loadings are presented in Table 1. These factor loadings correspond to the correlation coefficient between each factor and each of the variables considered in the research.

The communality value, obtained as the sum of square of factor loadings, for each variable, is given in Table 1. It represents the proportion of variance of each variable explained jointly, by three factors. The percentage of total variance of all variables explained by each factor is also shown in Table 1. This percentage is calculated from the ratio between the sum of square of loadings of each factor and a number of variables included in the model.

Table 1. Factor loadings (after varimax rotation) of three factors and communality of 23 indicators of agriculture modernization in "municipalities" of the State of Maranhão.

Variables	F_1	F_2	F_3	*Communality*
X_1	0,8120	0,1420	0,2080	0,7228
X_2	-0,0210	-0,0730	0,6340	0,4077
X_3	0,5920	0,0129	0,4590	0,5613
X_4	-0,0044	0,8930	-0,0440	0,7994
X_5	0,7310	-0,1290	-0,0032	0,5510
X_6	0,7450	0,2200	-0,1220	0,6183
X_7	-0,0740	0,0130	0,7390	0,5518
X_8	0,0425	0,5750	-0,1740	0,3627
X_9	0,7090	0,1780	-0,2230	0,5841
X_{10}	0,5800	0,0124	0,0468	0,3387
X_{11}	0,5720	0,2050	0,1850	0,4034
X_{12}	0,5550	-0,2530	0,4180	0,5468
X_{13}	0,4980	0,3410	-0,1370	0,3831
X_{14}	0,1860	0,1860	0,5750	0,3998
X_{15}	0,8750	0,0741	0,2060	0,8136
X_{16}	-0,0600	0,8620	0,1620	0,7729
X_{17}	-0,0330	0,8950	0,1020	0,8125
X_{18}	0,6060	0,3540	-0,0055	0,4926
X_{19}	0,9410	-0,0520	0,0540	0,8911
X_{20}	0,4100	0,8020	0,0097	0,8114
X_{21}	0,9280	0,0636	-0,0120	0,8654
X_{22}	0,9440	0,0139	0,0659	0,8957
X_{23}	0,2430	0,8810	0,1010	0,8454
% of Explained Variance	34,20	20,04	8,51	-

Source: Research results.

It is observed from Table 1 that factor 1 (F_1) is positively related to an intensive use of land (X_1, X_3, X_5, X_6, X_{10}, X_{15}, X_{21}), energy use per unit of explored area (X_9, X_{11}) and production value together with total expenditure per unit of explored area (X_{19}, X_{22}). The variables related to F_1 indicate that factor represents the intensive use of land.

Analyzing the loadings related to factor 2 (F_2), one may conclude that this factor is strongly related to variables, such as, X_4, X_{16}, X_{17}, X_{20} and X_{23}.

This factor represents the capital use per unit of labor in agriculture in the state of Maranhão.

Factor 3 (F_3) shows a strong positive association with variables X_2 and X_7, indicating the use of traditional agricultural technology in the State.

Ranking of Municipalities in the State of Maranhão

After gathering information about the nature of each factor (F_1 – land use intensity, F_2 – capital-labor ratio, F_3 – use of traditional technology), it becomes easier to interpret the scores obtained through factor analysis.

It is important to know that factor scores (F_1, F_2, F_3) are normally distributed with zero mean and unit variance. The factor scores with value close to zero means an average level of modernization of agriculture in relation to this factor. A larger factor score value, in relation to zero, represents an advanced use of technology in agriculture in the municipalities and low score value means that a traditional agriculture is practiced in the municipalities of Maranhão. The high value of factor score of F_1 above zero suggests an intensive use of land. Similar interpretation for F_2 and F_3 can be made.

Based on joint factor score, the ranking of municipalities were made by considering the relative level of technology used by each of them.

Index score and relative index (based on 100) for each municipality is shown in Table 2. The ranking of municipalities in relation to use of agricultural technology (Table 2) reveals that Tasso Fragoso, São Luis and São José de Ribamar expressed better level of agricultural technology, followed by the municipalities of Guimaraes, Barreirinhas, Imperatriz, Bacuri, Paco do Lumiar, Açailandia and Benedito Leite.

The municipality of Tasso Fragoso is located in the "cerrado" region of Maranhão where rice and soybean are the main crops. The variables such as total investment per labor unit, production value per unit of labor, total expenditure per unit of labor have contributed to put the municipality in first place.

Sugarcane and tomato are the principal crops produced in the municipality of São Luis. The variables such as intensive use of land due to scarcity caused by urbanization, high use of fuel per unit explored area, total expenditure per unit area, the high investment per unit explored area and high production value per unit explored area have contributed to place the municipality second in ranking.

São José de Ribamar, third placed in ranking, has more diversified agriculture among these three municipalities. The crops produced are: cassava, tomato, lemon, passionflower and papaya. Variables such as high expenditure per acre with modern inputs, intensive use of land, high production value and total expenditure per unit area and also per unit labor have contributed to this high ranking of the municipality.

On the bottom of the rank, it is observed that the municipality of Morros has the lowest level of agricultural technology in the state of Maranhão, followed by São Félix de Balsas, Presidente Juscelino, Timbiras, Santa Cruz, Passagem França, Presidente Vargas, Cajari, Chapadinha and Afonso Cunha.

The main crops produced in these municipalities are rice, corn, cassava and sugarcane, which are not decisive in relation to ranking received by them. The form in which these activities are planned as well as the factors of production that are used might have contributed to their low ranking.

In general, the municipalities using low level of agricultural technology showed a shortage in the following factors of production: number of tractors per unit area and also per unit labor and proportion of irrigated area. It is sure that these factors with combination to others have contributed to lower ranking of these municipalities.

Table 2. Ranking of municipalities in decreasing order in relation to use of agricultural technology in the State of Maranhão.

"Municipalities"	Index score	Index based on 100	Ranking
Tasso Fragoso	9.66	100.00	1
São Luís	8.82	92.22	2
São José de Ribamar	7.00	75.36	3
Guimarães	6.92	74.64	4
Barreirinhas	4.38	51.11	5
Imperatriz	3.64	44.22	6
Bacuri	3.52	43.09	7
Paço do Lumiar	2.51	33.75	8
Açailândia	2.17	30.62	9
Benedito Leite	2.17	30.60	10
Balsas	1.98	28.88	11
Palmeirândia	1.94	28.44	12
São Raimundo das Mangabeiras	1.81	27.23	13
Cururupu	1.52	24.63	14
Porto Franco	1.49	24.27	15
Mirinzal	1.15	21.16	16
Alto Parnaíba	1.00	19.78	17
Alcântara	0.98	19.56	18
Rosário	0.97	19.50	19
Miranda do Norte	0.96	19.44	20
Peri Mirim	0.90	18.83	21
Estreito	0.43	14.47	22
Sambaíba	0.36	13.87	23
Esperantinópolis	0.27	13.05	24
Bequimão	0.23	12.60	25
São Mateus do Maranhão	0.22	12.58	26
Coelho Neto	0.22	12.51	27
São Domingos do Maranhão	0.20	12.33	28
Fortaleza dos Nogueiras	0.18	12.14	29

Table 2. Ranking of municipalities in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continue)

"Municipalities"	Index score	Index based on 100	Ranking
Icatu	0.09	11.30	30
Olho d'água da Cunhãs	0.05	10.93	31
Bacabal	0.00	10.53	32
Pindaré Mirim	0.00	10.51	33
Vitorino Freire	-0.01	10.38	34
São Luís Gonzaga do Ma	-0.04	10.11	35
Riachão	-0.06	9.94	36
Presidente Dutra	-0.11	9.51	37
Tuntum	-0.13	9.29	38
Matinha	-0.14	9.19	39
Cedral	-0.16	8.99	40
Vitória do Mearim	-0.17	8.93	41
Penalva	-0.18	8.88	42
Barra do Corda	-0.19	8.74	43
Timon	-0.20	8.67	44
Magalhães de Almeida	-0.20	8.63	45
Montes Altos	-0.24	8.32	46
Carolina	-0.25	8.19	47
Santa Rita	-0.26	8.12	48
Arari	-0.28	7.89	49
Pinheiro	-0.31	7.67	50
Cajapió	-0.31	7.62	51
Lago Verde	-0.34	7.31	52
João Lisboa	-0.35	7.23	53
Zé Doca	-0.36	7.16	54
Santa Inês	-0.38	7.02	55
Luís Domingues	-0.38	6.95	56
São Vicente de Ferrer	-0.43	6.48	57
Monção	-0.44	6.42	58
São Bento	-0.46	6.27	59
Pedreira	-0.46	6.24	60

Table 2. Ranking of municipalities in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continue)

"Municipalities"	Index score	Index based on 100	Ranking
Lima Campos	-0.47	6.10	61
Araioses	-0.48	6.10	62
Itapecuru Mirim	-0.49	5.93	63
Cantanhede	-0.54	5.52	64
Brejo	-0.54	5.47	65
Nova Iorque	-0.54	5.46	66
Buriti Bravo	-0.55	5.40	67
Colinas	-0.56	5.34	68
Governador Archer	-0.56	5.31	69
São João Batista	-0.57	5.20	70
Anajatuba	-0.58	5.13	71
Amarante do Ma	-0.59	5.04	72
Dom Pedro	-0.60	4.99	73
Santa Luzia do Paruá	-0.61	4.87	74
Sítio Novo	-0.61	4.86	75
Grajaú	-0.62	4.74	76
Caxias	-0.62	4.74	77
Anapurus	-0.64	4.62	78
Santo Antônio dos Lopes	-0.65	4.49	79
Santa Helena	-0.65	4.46	80
Barão de Grajaú	-0.65	4.44	81
Godofredo Viana	-0.66	4.42	82
Loreto	-0.67	4.30	83
Tutóia	-0.69	4.10	84
Pio XII	-0.69	4.06	85
Codó	-0.71	3.88	86
São João dos Patos	-0.72	3.88	87
Santa Luzia	-0.73	3.71	88
Fortuna	-0.73	3.70	89
Pastos Bons	-0.74	3.65	90
Santa Quitéria do Ma	-0.75	3.53	91

Table 2. Ranking of municipalities in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continue)

"Municipalities"	Index score	Index based on 100	Ranking
Parnarama	-0.75	3.52	92
Igarapé Grande	-0.77	3.41	93
Altamira do Maranhão.	-0.82	2.92	94
Matões	-0.82	2.89	95
Gonçalves Dias	-0.83	2.77	96
Carutapera	-0.84	2.71	97
Viana	-0.84	2.68	98
Humberto de Campos	-0.85	2.59	99
Urbano Santos	-0.86	2.55	100
São Bernardo	-0.87	2.49	101
Axixá	-0.87	2.48	102
Mirador	-0.87	2.45	103
Cândido Mendes	-0.87	2.45	104
Vargem Grande	-0.87	2.42	105
Paraibano	-0.88	2.33	106
Bom Jardim	-0.89	2.25	107
Lago do Junco	-0.89	2.23	108
Poção de Pedras	-0.90	2.19	109
Aldeias Altas	-0.90	2.18	110
Coroatá	-0.91	2.11	111
Turiaçu	-0.91	2.10	112
Duque Bacelar	-0.91	2.09	113
Graça Aranha	-0.91	2.08	114
Nina Rodrigues	-0.91	2.04	115
Joselândia	-0.92	1.99	116
Lago da Pedra	-0.92	1.99	117
Paulo Ramos	-0.92	1.94	118
Pirapemas	-0.93	1.92	119
Arame	-0.93	1.85	120
Governador Eugênio Barros	-0.95	1.73	121

Table 2. Ranking of municipalities in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continue)

"Municipalities"	Index score	Index based on 100	Ranking
Sucupira do norte	-0.96	1.63	122
São Benedito do Rio Preto	-0.96	1.58	123
Buriti	-0.97	1.48	124
São Francisco do Maranhão	-0.98	1.45	125
Mata Roma	-0.98	1.43	126
Afonso Cunha	-0.99	1.38	127
Chapadinha	-1.01	1.10	128
Cajari	-1.02	1.07	129
Presidente Vargas	-1.02	1.05	130
Passagem Franca	-1.03	0.99	131
Primeira Cruz	-1.06	0.69	132
Timbiras	-1.06	0.68	133
Presidente Juscelino	-1.07	0.55	134
São Félix de Balsas	-1.10	0.29	135
Morros	-1.13	0.00	136

Source: Research results

The contrast observed among municipalities of Maranhão, in relation to level of agricultural technology used requires the government to create new development programs to reduce disparity among municipalities.

Some of the action already taken by the government, such as implantation of irrigation projects, distribution of irrigation kits and technical assistance are good examples, along with giving the priority to the low ranking municipalities, except to the ones with no agricultural potentialities.

5 Conclusions

The results of the study showed that 131 out of 136 municipalities of the State of Maranhão demonstrated that less than 50% of level of technology observed in the first ranked municipality.

The five municipalities using more advanced level of technology were Tasso Fragoso, São Luis, São José de Ribamar, Guimaraes e Barreirinhas. On the other hand, five low ranked municipalities are listed as: Morros, São Felix de Bolsas, Presidente Juscelino, Timbiras and Primeira Cruz.

The government support in the form of constructing infrastructure of highways and electricity network in the rural area, technical assistance of good quality is of fundamental importance for rural development of these municipalities. In addition to this, the government should also encourage agricultural technical teaching in the rural area, formation of association and cooperative societies of farmers and increase credit facilities by reducing existent bureaucracy in public and private financing institutions.

The government should take concrete and effective action to reduce the existing contrast in technology used in the state of Maranhão. In order to obtain full potential of each region, it is necessary to use an adequate package of technology which is competitive with environment preservation. The modernization of agriculture that contributes to increase economic returns does not necessarily mean the use of large amount of modern inputs, but the rational use of natural resources by using appropriate techniques of production.

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