THE DYNAMICS OF TECHNICAL PROGRESS IN THE AGRICULTURAL SECTOR OF THE BRAZILIAN STATE OF MINAS GERAIS: RESULTS AND CONTRADICTIONS OF THE MODERNIZATION POLICY FROM 1970 TO 1985*

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ABSTRACT - In this article, the efficiency of primary production factors, the spatial diffusion of technical progress, and the incorporation of new technology as determined by specific crop types were analyzed by applying statistical techniques to a data set from the Brazilian State of Minas Gerais for the years between 1970 to 1985. The findings indicate that the substitution of capital for labor was above the level suggested by the relative endowment of factors, that technological inequalities between several areas in the state increased over the period under study, and that technical progress was mainly directed toward the production of export products. Finally, hypotheses tests were performed to determined the importance of financial resources and Minas Gerias' varied agrarian structures on the incorporation of new technology. We then use the results of these tests to explain our findings.

Key words: Agricultural modernization, rural credit, agrarian structures, Minas Gerais.

* This article is based on the first author's master dissertation, defended on June,1997, in the Department of Agricultural Economics, Federal University of Viçosa, with financial support of CNPq and FAPEMIG.

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INTRODUCTION

The phrase "agricultural modernization" is used to indicate change in the technological base of an agricultural production system. In Brazil, the need for those changes was emphasized at the end of the 1950s when an increase in agricultural productivity of both soil and labor was required to support the urbanization and industrialization processes.

During that decade's "green revolution," a number of new agricultural techniques were made available, many of them developed in United States. These techniques were widely diffused throughout the world and had enormous influence on the Brazilian agricultural modernization model in particular,.

However, technology transfer between countries with different socioeconomic and environmental conditions is not unrestrained. In that respect, Schultz (1965), the major advocate of the *model of modern input*, had already noticed that such technologies and techniques could rarely be transferred directly from developed countries to underdeveloped ones and that the adaptation costs would justify their local development.

Technology generation, adapted to the conditions of each country or area, has a better chance of succeeding when production factors are readily available, as suggested by the Hayami and Ruttan (1988) model. However, factor availability is not the only force that affects the direction of the technical change.[3] In that sense, De Janvry (1977) developed a theory which incorporates the influences of social organization, economic reality, and local politics and institutions on the distribution of the benefits derived from technical innovation according to the position of *interest groups* in the socioeconomic structure. The position of interest groups is one of the major factors determining the orientation of the technical and institutional changes[4].

The process of economic development is jeopardized in multiple

[3] The presence of bias in technical change in Brazilian agriculture was found by Saints (1986). For an interpretation of the technological progress of Brazilian agriculture, in conformity with the hypothesis of induced innovation, see Alves and Pastore (1980).

[4] Monteiro (1984) and Lopes (1993) analyzed the Brazilian agriculture with emphasis in the action of the *groups of interests.*

complex ways if new agricultural technology cannot be adapted to local conditions. First, if there is a conflict between the restrictions imposed by factor availability and the implicit demand for adopted technology, an inefficiency source is created in resource employment. If the new technology is capital intensive and labor is an abundant factor, the human resources unemployment rate is increased, directly affecting the nation's income distribution with undesirable implications.

The substitution of capital for labor was one of the main causes for the accelerated rural exodus observed as Brazil's agriculture sector modernized in the 1970s. These migrations happened in a more accelerated rhythm than job creation and urban infrastructure development. This reduced labor remuneration in urban areas, promoted unemployment, disorderly metropolitan growth, and aggravated the urban problems of poverty and violence.

On the other hand, the inflexibility of the green revolution's technological package made it's adaptation to Brazil's socioeconomic and environmental diversity difficult and caused it's implementation to be partial and selective. The new technology was suitable for use in only specific regions and for only particular products or producer classes, leaving many producers and production areas outside the sphere of technological modernization. According to Müller (1989), in the period from 1960 to 1980, only 20% of the producers adopted the modern technology, the so-called dynamic agriculture; but these producers accounted for about 80% of the country's total product value. Homem de Melo (1985) identified a trend in the process of agricultural modernization which favored export products, analyzing the unfavorable distributive effects caused by an observed production and productivity decrease among domestic, agricultural goods' producers. That same differentiation was also found by Alves and Contini (1987), among others.

Regional variation in the implementation of new technology was addressed by Müller (1989). He identified the acceleration of agricultural modernization in Brazil's Center-West between 1970 and 1980, and the growth of a technological gap between the country's southern regions and the northern regions. Hoffmann (1992) also identified different rates of agricultural modernization between micro-regions within the states of Paraná, Santa Catarina, São Paulo, Mato

Grosso, Mato Grosso do Sul, Bahia, and Pernambuco from 1975 to 1980. His study also found relative technological stagnation in the Northeastern states of Bahia and Pernambuco and intensified capital use for technological improvement in the Center-West agricultural states of Mato Grosso and Mato Grosso do Sul.

The growth of regional inequalities restricts the sustainability of the development process, particularly because it is a source of distributive conflicts. The rural populations in the poorest areas migrate to more developed regions in search of better opportunities. However, these populations only add to the population that has already left the rural zone for the cities, increasing the unemployment base, and aggravating the problems caused by an overabundant, low skilled, working population.

Finally, the new technology's inflexibility, if not corrected by the national system of agricultural research, has a negative impact on the use of natural resources. In that sense, Graziano Neto (1986) exposed the ecological limitations of the green revolution's technology, documenting its inadequacy in tropical climates. Prior to Neto's observations, Paiva (1979) had criticized the exaggerated valorization of modern technology's potential in underdeveloped countries, due to frequent overestimation of the production base's response to the use of modern inputs. He ascertained that this muted response is often caused by the soil conditions and climate found in many underdeveloped countries.

In our article, the efficiency of primary production factors, the spatial diffusion of technical progress, and the incorporation of new technology as determined by crop types were analyzed by applying statistical techniques to a data set from the Brazilian State of Minas Gerais for the years between 1970 to 1985. In order to verify that these elements influenced the type and the degree of the technical progress achieved in several areas within the state, the modernization indicator's behavior was associated with rural financing, resource distribution, and agrarian structure differences found in Minas Gerais' State Planning regions.

The article is organized in five sections and this introduction. Second section addresses the dynamics of technological progress in Minas Gerais' agricultural sector from 1970 to 1985. It begins with an estimation of the modernization indicators using factorial analysis (principal components method), followed by an illustration of technological progress's spatial diffusion into various State Planning areas. Third section presents the technique used to determine the influence of financing distribution on the results shown in the previous section and analyzes these test results. Fourth section follows the same format as third section, but is focused on the differences in agrarian structures, and fifth section addresses the selective nature of technical progress as determined by product. Finally, sixth section contains a summary of our major conclusions with a bias toward the affect of new technology on sustainable development in Brazil.

THE MODERNIZATION DYNAMICS OF THE MINAS GERAIS AGRICULTURE: 1970 TO 1985

To describe the dynamics of the technological progress in Minas Gerais' agriculture sector it was assumed that the two more important dimensions of the modernization process occurred between 1970 and 1985. These two characteristics of agricultural modernization are an intensification of soil use and a growth in the capital/labor ratio. These changes are brought about by the use of chemical inputs (fertilizers, pesticides, herbicides, etc.), biological modifications (improved varieties), mechanization, and new production techniques.

However those dimensions are not directly observable, which requires the use of a set of correlated variables which can be observed. Thus, to reflect the two above specified dimensions, thirty-one indicators of agricultural technological progress were created using data collected from the state's homogeneous micro-regions (MRHs) for the years 1970, 1975, 1980, and 1985 and provided by the Agricultural Census of Minas Gerais.

Those indicators were combined by the *factorial analysis* (the main components method) in way to summarize most of the information contained in the data set and to reveal the defined dimensions of technological progress. For each observation, the *factorial score* is obtained by the multiplication of the value (standardized) of the variable *i* by the corresponding *factorial coefficient score.* [5]

The general expression for the jth *factor* estimate, Fj, is given by:

$$F_j = \sum_{i=1}^{p} W_{ji}X_i = W_{j1}X_1 + W_{j2}X_2 + ... + W_{jp}X_p \quad (1)$$

where Wji is the *factorial coefficient score* and *p is* the variable's number.

To measure the transformation speed characterized by the *factors* over the period, the *factors* must be comparable throughout the years. The *factors* can considered comparable only if they are extracted from the whole set of observations, i.e., including the four years. In order to accomplish that, the matrix of the values of the 31 variables, for the 46 observations, and for every year$\left(X^{ano}_{46x31}\right)$was combined so as to generate the matrix X184x31, as defined below:

$$X_{184x31} = \begin{bmatrix} X^{1970}_{46x31} \\ X^{1975}_{46x31} \\ X^{1980}_{46x31} \\ X^{1985}_{46x31} \end{bmatrix}_{184x31}$$

The variables specification

To reflect the two dimensions of technological progress referred to previously, the variables under consideration appear, whenever possible, as ratios of arable area (AE) or ratios of total occupied personnel (PO). As in Hoffmann (1992), the arable area was defined as the sum of the areas occupied with permanent and temporary plants, natural and planted pasture, and natural and planted forests. Occupied personnel is defined by the number of people in the following

[5] More detailed explanations on the factorial analysis can be found in Kim and Mueller, (1978) or Manly (1986) [chapter 8]. Applications linked to the agricultural economy can be found in Gontijo and Aguirre (1988), Kageyama and Leone (1990), Tarsitano (1992), Hoffmann (1992) and Sales (1995).

categories: permanent workers, temporary workers and partners, including the women and those who are younger than fourteen years, but not including unremunerated members of the farm owner's family.

The variables (PT) capture technological progress and include infrastructure indicators and the use of chemical and mechanical inputs; the variables (RP) represent the changes in production labor that are connected with the process of change in the technological basis. To represent the level of the establishment's capitalization and/or of the activity, we used the total value of capital goods(VB), production expenses (VD), and production (VP). Those variables were corrected for inflation using the IGP-DI index published by FGV and expressed in thousands "Reals" (Brazil's currency) as of August of 1996.

The variable list is used in the factorial analysis.

PT 01	Consumption of electricity (1000 kw/h) / AE
PT 02	Consumption of electricity (1000 kw/h) / PO
PT 03	Farms that use chemical fertilizer/ total farms
PT 04	Farms that organic fertilizer/ total farms
PT 05	Farms that use liming the soil/ total farms
PT 06	Farms that use animal force/ total farms
PT 07	Farms that use mechanical force/ total farms
PT 08	Number of tractors / AE
PT 09	Number of tractors / PO
PT 10	Number of animal traction plough / AE
PT 11	Number of mechanical traction plough / AE
PT 12	Number of animal traction plough / PO
PT 13	Number of mechanical traction plough / PO
PT 14	Number of vehicles of animal traction / AE
PT 15	Number of vehicles of mechanical traction / AE
PT 16	Number of vehicles of animal traction/ PO
PT 17	Number of vehicles of mechanical traction/ PO
PT 18	Consumption of gas and oil (1000 L) / AE
PT 19	Consumption of gas and oil (1000 L) / PO
PT 20	Capacity of the silos for forage (T)/forage area (natural and planted)
RP 01	Total of workers used (PO) / AE
RP 02	Workers in family / PO
RP 03	Permanent workers / PO
RP 04	Temporary workers / PO
RP 05	Farms with hired workers/total farms
VB 01	Total value of the value of capital goods (1000 Reais) / AE
VB 02	Total value of the value of capital goods (1000 Reais) / PO
VD 01	Value of the total production expenses (1000 Reais) / AE
VD 02	Value of the total production expenses (1000 Reais) / PO
VP 01	Value of the total production (1000 Reais) / AE
VP 02	Value of the total production (1000 Reais) / PO

The agricultural modernization factors

The determination of the number of *factors* necessary to represent the group of data is dependent on each *factor's* individual contribution to the variance "explained" (accumulated). Usually, only the *factors* whose *characteristic root is* larger than 1 (one) are considered, that is, those that correspond to a proportion of the variance greater than that attributed to an isolated variable.

Factorial analysis extracted four *factors* with a characteristic root larger than 1. Among them, only the first three were used to characterize the agricultural modernization process. The three selected factors account for 76.8% of the total variance (Table 1).

Because of space limitation, the presentation of the factorial matrix is omitted, concentrating directly on an interpretation of the descriptive meaning of the *factors* obtained. [6]

Table 1 - Extracted factors using the main component method

Factor	Feature root	Variance "explained" by the factor (%)	Accumulated variance (%)
1	14,68333	47,4	47,4
2	5,85022	18,9	66,2
3	3,28086	10,6	76,8
4	1,16548	3,8	80,6

Factor 1 is linked strongly and positively with the variables that indicate the use per arable area of modern technology (PT1, PT8, PT11, PT15 and PT18), capital (VB1 and VD1), and the value of production (VP1). It is also linked strongly and positively with the capacity of the silos for forage per natural and planted pasture area (PT20). Moreover, it linked in the same way with the variables that denote employment of fertilizers and soil additives (PT3, PT4 and PT5), expressed as percentage of the number of establishments that declared

[6] This interpretation is made relatively by the observation of the variables that present higher *factorial loads*, to each *factor*, since, when the *factors* are extracted from the method of the principal components, followed by rotation orthogonal, the factorial loads corresponds to correlation coefficients between the variable *i* and factor *j*

use of these inputs.[7] Thus, the pattern of relationship between the variables correlated with Factor 1 suggests its correspondence with the **intensity of soil use**. High scores for Factor 1 will be interpreted as high intensity of soil use .

Factor 2, in turn, is strongly and positively associated with the variables that indicate employment of modern technology, especially mechanization (PT7, PT9, PT13, PT17 and PT19) and capital (VB2 and VD2) per occupied personnel. There was also high and positive the correlation between the value of production per occupied personnel (VB2) and the variables that denote capital's relationship to production (RP3 and RP5). Although moderate, the negative correlation with the variables that express total employment per arable area (RP1) and use of family workers (RP2) reinforces the interpretation of Factor 2, as an indicator of **intensity labor use**, ratio of capital to labor. The higher the score for Factor 2, the larger the capital/labor ratio is in the micro-region.

Factor 3, contrary to Factors 1 and 2, presented a positive relationship with variables that denote the use of traditional technology, notably the use of the animal power, both for the arable area ratio and for occupied personnel (PT6, PT10, PT12, PT14 and PT16). Observe that it is the complement of the previous Factors, a result of the inclusion of traditional technological variables. Nevertheless, the retention of that *factor* will allow one to better qualify the technological differences among the areas. Areas with high Factor 3 *scores* will be understood as being areas in which **traditional agricultural methodology** is important. Areas which received low scores for that *factor* followed by low *scores* for the other *factors*, will be considered as areas in which agricultural activity has little economic importance.

The Minas Gerais agricultural modernization for planning areas

The average *factorial scores* were calculated for each planning region to illustrate the evolution of technological progress differentiated

[7] Those variables were expressed in that way due to data set limitations. The expenses with those input were not used, because of discontinuity of the series, which were not published in the 1985's Agricultural Census.

between the regions. Those values were represented in the Cartesian plan shown in Figure 1. Factor 2 *scores* (capital/labor ratio) are in Figure 1's vertical axis and the Factor 1 scores (intensity of soil use) are in the horizontal axis.

Once the standardized *factors* were obtained from the matrix X184x31, which encompasses the four years of the study, the value zero was used to indicate the four year state average. The sign of the *factorial score* for a given year represents deviations above or below the state average. Those values form the coordinates of the points presented in the Picture, which were linked in straight line segments, representing the medium evolution of the *scores* in each planning area observed for each 5-year period. Thus, the direction of the segment indicates the evolution of the intensity of soil use (horizontal change) and of the capital/labor ratio (vertical change). Additionally, since the time interval is constant, the length of those segments represents the fastest or slowest speed of increment of the characteristic indicated by the *factor.*

Figure 1 evidences three groups of differentiated dynamics. Areas IV (Triângulo/Alto Paranaíba), V (Alto São Francisco), and VI (Northwest of Minas) are in one group, a group which showed a higher speed of incremental change in the capital/labor ratio (Factor 2) relative to the process of intensified soil use (Factor 1). The opposite was shown in Area I (Metalúrgica/Campo das Vertentes); II (Zona da Mata), and III (South of Minas), which make up another grouping. The third group, formed by Areas VII (Jequitinhonha), and VIII (Rio Doce), is characterized by low evolution of the agricultural modernization indicators from 1970 to 1985. The greatest dynamism found was in the Triangle (IV) and the South of Minas (III). These two areas are located close to state of São Paulo's agroindustrial centers and, therefore, have a relative competitive advantage in relation to the other six areas.

In the following sections, we test the hypothesis that technological differentiation can also be attributed to the selective distribution of public resources and the interaction of these incentives for the adoption of a relatively inflexible technological package with each areas agrarian structure and environmental conditions. In general, Figure 1 suggests divergence in the technological level of agricultural production techniques between the areas from 1970 to 1985, which can be translated as growth in regional technological inequality. A detailed analysis of that subject can be found in Meyer and Braga (1997).

Figure 1 also shows a deceleration in the process of soil use intensification (Factor 1) and a decrease in the capital/labor ratio (Factor 2) in all the areas of the state over the last 5 years of the study.

Despite socioeconomic and environmental differences, the coincidence of change in the modernization dynamic in all areas of the state suggests the presence of a common element that affected the evolution of the agricultural technological indicators. If this element is rural credit availability, as it will later be verified, then there is evidence that the process of modernization of the Minas Gerais' agriculture sector doesn't rest in a sustainable base and that the orientation, decided on by policy makers, distorted the allocation of economic resources to induce the employment of capital as a replacement for labor at a higher level than would be required by relative factor availability.

Figure 1 - Evolution of the soil use intensity (F1) and the capital/labor ratio (F2), according to State Planning Areas: 1970, 1975, 1980 and 1985.

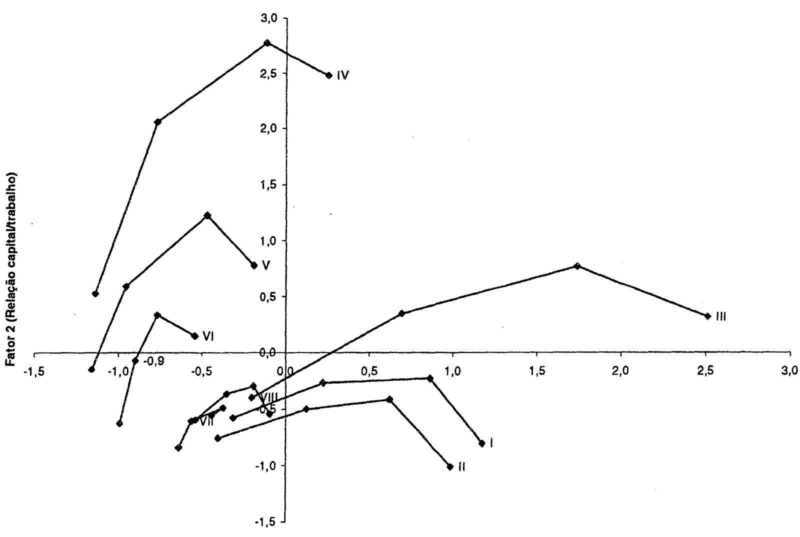
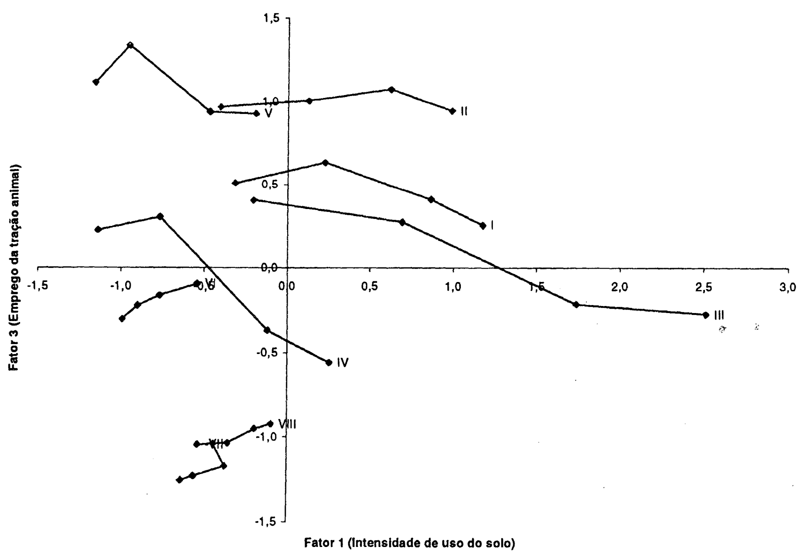


Figure 2 assists in completing the analysis and reinforces the characterizations of the Areas. It is observed that, from 1975, the expansion of agricultural technology in Minas Gerais's savanna wasn't the occupation of an "economic desert," but the substitution of that technology for traditional agricultural methodology. That is evidenced by the general decrease in Factor 3 *scores*, especially in Area IV (Triângulo/ Alto Paranaíba). It is observed that in Area V (Alto São Francisco), the importance of traditional agriculture was much greater than the state average and that the reduction in the use of animal power in that Area was interrupted over the last 5 years studied. That process's deceleration combined with the reduction in the intensity of soil use (Factor 1) and the reduction observed in the capital/labor ratio (Factor 2), reinforces the interpretation that the process of agricultural modernization started to lose force beginning in 1980.

Figure 2 - Evolution of soil use intensity (F1) and the capital/labor ratio (F2) in the state's Planning Areas: 1970, 1975, 1980 and 1985.



The behavior noted in the preceding paragraph was also observed in Area III (South of Minas). It is noticed, however, that in this case, traditional agricultural methodology had lost its importance in 1970. In Area I (Metalúrgica/Campo das Vertentes), the substitution for animal labor was much slower and insufficient to reduce its importance to below the state average for that period. In Area II (Zona da Mata), the evolution of Factor 3 *scores* demonstrates the importance of animal labor to the agricultural production process. That aspect explains the that Area's low capital/labor ratio, identified above, and can be attributed to mechanization difficulties.

Contrary to what occurred in the Areas that saw increased employment of modern agricultural technology, the employment of animal labor increased in Areas VI (Northwest), VII (Jequitinhonha), and VIII (Rio Doce) between 1970 and 1985. In these cases, however, the levels stayed below the state average for the period, characterizing the minimal importance of agricultural activity in those areas.

THE DISTRIBUTIVE POLICY OF THE GOVERNMENT'S FUNDS

Since the agricultural modernization process was strongly impelled by rural credit policy, which linked access to financial resources with the use of modern inputs, it is important to verify that the dynamic of the modernization *factors*, illustrated in Figure 1, associates with the distribution of financing resources to the state's regions.

To determine the amount of governmental funds distributed among the planning areas, one could simply calculate the average resource value granted to each Area per year. Yet, this would not determine the statistical significance of these resources. In order to determine statistical significance, the value of financing can be taken as the dependent variable in a regression model with *dummy* variables as explanatory variables *to* represent the interaction of the homogeneous micro-regions that compose each planning area for the four years considered in the study. Thus, the estimated model would have the following functional form;

$$VF_i = b_0 + b_1 D_t D_r + e_j \quad (2)$$

in that

VFi is the value of the financing, per arable area, allocated in the MRH i, between 1970 and 1985 (i = 1, 2,..., 184)[8];
Dt is the *dummy* for the years of the study (t = 1, 2, 3, 4);
Dr is the *dummy* for the planning areas (r = 1, 2,..., 8);
b_1 is the coefficient of the interactions DtDr, that expressed the average value of the financing received by the area r, in the year t;
b_0 is the constant of the equation, representing the average value of the financing per arable area, received by Area VII (Jequitinhonha), in 1970;
ej is random error.

For better visualization of the information generated by Model 2, the estimated regression coefficients for each area and year were added to the value of the equation's constant term which represents the financial resource volume per arable area within the Jequitinhonha region in 1970. Those results multiplied by one thousand are shown in Figure 3. The vertical axis shows the value of government financing per arable area, in hectares, within the region for every year, expressed in December 1996 "Reals." The horizontal axis delineates the eight planning areas for the four years of the study.

[8] The value of the financing divided by the arable area concerned the effect of distribution, whereas the difference crop types cultivated areas was concerned with agriculture activity among the regions. To become comparable the financing values over several years, and used the IGP-DI/FGV of December 1996 as the base.

Figure 3 - Distribution of government financing per arable area, by state planning areas (Dec. 1996 "Reals")

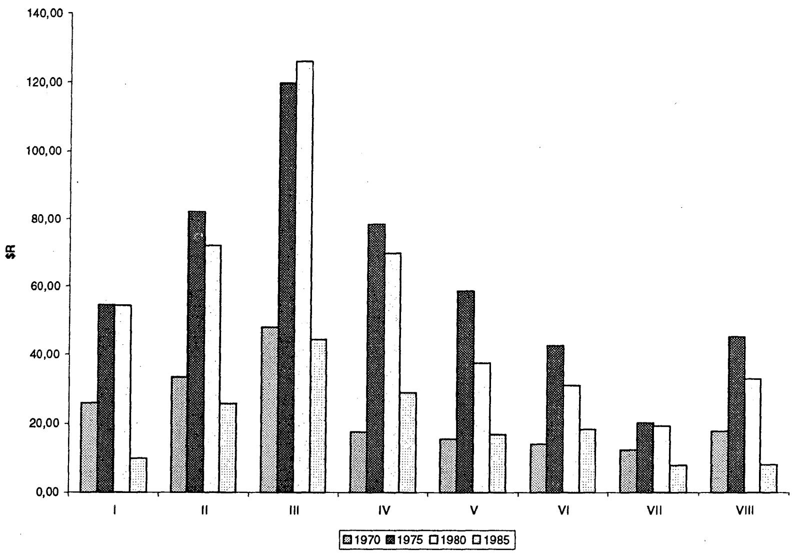


Figure 3 shows that public financial resources for Minas Gerais' agricultural sector have been preferentially directed to the South of Minas, Area (III). That tendency was more accentuated during the expansion phase of rural credit in the 1970s. Moreover, in the following five years, while all the other areas suffered financial reductions per arable area, the South Area actually received more resources in 1980 than that in 1975. In spite of the large fall in state support over the last five years of the study, the South continued to receive resources significantly greater than our control region, Jequitinhonha, Area (VII).

The Zona da Mata (II) and Triângulo/Alto Paranaíba (IV), received relatively the same amount of financing resources (per arable area) during the whole period. Both areas suffered during the phase of financial assistance reduction, particularly Area II in 1985 when it received less financing assistance than it did in 1970.

Excluding the Jequitinhonha Area (VII) that didn't show significant variation in credit incentives for agricultural development over the period covered in this study, the remaining areas had significant government financing growth during the expansion phase of government credit assistance.

A study of the results delineated in Figures 1[9] shows that there is a correspondence between the evolution and distribution of public financing for the state of Minas Gerais' agriculture sector and the dynamics of agricultural modernization per planning area.

Differentiated impacts of the credit policy among the state regions

Although generous government financing assistance associates positively with the evolution of the *factorial scores*, indicating the success of the modernization policy, unfortunately, in some situations success in the modernization policy led to quite unsatisfactory results for the local population. Financing incentives promoted technological modernization that interacted with the regions social, economic, and environmental diversity to cause different types of change in Minas Gerais' agricultural sector, not all of them positive

Model 3 attempts to capture those different alterations caused by government financing. In Model 3, the value of financing was multiplied by each region's *dummy variables* with the modernization *factors* taken as dependent variables. Thus, the parameter estimates express the impact of the average financing value allocated in each area on the intensity of soil use (Factor 1) and the capital/labor ratio (Factor 2) *scores* during the periods under study. This procedure allows one to differentiate the effect of the incentives by planning area. The model equation is;

$$F_j = b_0 + b_1 D_r VF_i + e_j \qquad (3)$$

where

Fj is the value of the factorial score j (j = 1 and 2) for the MRH i (i = 1, 2,... 184);

[9] The statistical formation of this relationship was omitted due to space restrictions, but it is available in Meyer (1997).

VFi is the value of the government financing, per arable area, in the MRH *i;*
Dr is the *dummy* for the planning areas (r = 1, 2,..., 8);
b_1 is the coefficient of the interaction of DrVFi, expressing the association of the financing value received by the area r with the factor j;
b_0 is the constant of the equation; and
ej is the error term.

The partial coefficients estimated by Model 3 suggest that the regional changes depicted by Figure 1 are a result of the government's credit incentives. The statistics strongly support the hypothesis that each Area's reaction to technological change, in this sense the substitution of capital for labor, is explained by the interactions between the incentive policy and the existing agrarian structure. Moreover, it suggests that the inability to adapt the technological package to different environmental conditions and that a lack of control over the use of the financing resources can explain results which were contrary to the ultimate policy objectives: to make a sustainable improvement in the lives of the Brazilian population.

It was observed that in Areas (I), (II), and (III), where the agrarian structure is less concentrated, government financing promoted significant changes in the intensity of soil use (Factor 1). In the first two Areas, where uneven topography hinders mechanization, the response to government incentives was an divert employees to the application of the fertilizers and other chemicals, causing non-significant or negative impacts on the capital/labor ratio (Factor 2).

Contrarily, the farms in Areas (IV) and (V), where large farms prevail, easily acquired agricultural credit. Easy credit led to the increased substitution of capital for labor and an increase in the intensity of soil use (Factor 1). That result probably means that the financing resources were diverted to the purchase of land for speculative purpose[10], especially in Area (IV), the area which received the largest share of public resources.

[10] According to the estimate of Sayad (1984), around 30% of the credit given was diverted to other activities and that proportion increased with as the size of the property receiving the credit increased approaching 100%. On the other hand, it was known that the principal purpose of this deviation was land acquisition.

Table 2 - Partial correlation among intensity of soil use (Factor 1) and capital/labor ratio(Factor 2), with the amount of government financing per arable area, by planning areas.

REGION	Factor 1	Factor 2
Metalúrgica/Campo das Vertentes (I)	19.9477***	-0.9124 ns
Zona da Mata (II)	11.8008***	-6.3125**
Sul de Minas (III)	18.6768***	8.8441***
Triângulo/Alto Paranaíba (IV)	-3.3860 ns	50.1004***
Alto São Francisco (V)	-10.4427 ns	27.4936***
Noroeste (VI)	-19.8051**	3.6196 ns
Jequitinhonha (VII)	-17.5648 ns	-26.9848**
Rio Doce (VIII)	-0.1924 ns	-7.7454 ns
Constante	-0.2205**	-0.2492**
R^2 ajustado	0.38	0.57
F	15.21***	31.42***

** significant at level smaller than 1,0%; ** significant at level smaller than 5,0%; non-significant ns.

In Area (VI), although the amount of available financing per arable area was small (Figure 3), the diversion of public resources may have been more accentuated and may have caused a reduction in the intensity of soil use and a significant impact on the capital/labor ratio.

Finally, the coefficients for Areas (VII) and (VIII) areas demonstrate the effect of small economic units, unfavorable climatic factors, and problem related with infrastructure and agrarian structure on the process of technological modernization. The small amount of public financial resources allocated to Area (VII) were enough to bring about an increase in employment of the agricultural population but not enough to technologically modernize. This is expressed by the negative sign of the capital/labor ratio. The coefficients derived for Area (VIII) showed that government financing assistance caused no significant agriculture system modernization.

TECHNICAL PROGRESS ACCORDING TO THE ESTABLISHMENT SIZE

The results in the previous section suggest that each planning region's reaction to agricultural modernization could be attributed, at least partly, to the interactions of the incentive policy with the particular region's agrarian structure. To investigate that hypothesis it enough to evaluate the relation between regional farm size, classified by "area strata," and the three modernization *factors*. Thus, the *factorial scores* and the partial correlation coefficients representing the proportion each strata makes up in the total farm area for each MRH and were considered..

The objective of these models was to characterize the area strata in terms of the modernization indicators. In these models, the *factors* were treated as independent variables, and d*ummy* variables were included for the years of the study to account for change in the relative percent of arable land each area strata represent in each Area throughout the years.

The functional form of the estimated model is as follow:

$$EA_{pj} = b_0 + b_i F_{ij} + b_t D_t + e_j \qquad (3)$$

Where

EApj is the average farm size or the participation of the area stratum *p* in the total farm of MRH *j* (*j* = 1, 2,..., 184);

Fij is the score for the factor *i*, in MRH *j*;

b_i are the partial correlation coefficients between average farm size or the participation of the area stratum *p* and the factor *i*;

Dt are the *dummies* for the years of the study (*t* = 70, 75, 80 and 85);

b_t are the partial correlation coefficients for the *dummies* Dt;

b_0 is the constant, that expressed average area or the participation of each area , in 1970; and

ej is the error term

Base on information shown in the Table 3, the larger the average farm, the less intensively it used the soil (Factor 1) and the less it employed traditional production factors, which is represented by positive association with Factor 2 scores (capital/labor ratio) and negative association with Factor 3 scores (employment of animal power).

Table 3 - Partial coefficients of the modernization factors and of the *dummy* variables by average farm size and per percentage each different area strata represented in the total farm.

Variables	Average	< 100 ha	100 < 500	500 < 2	2 mil < 10	10 mil <
F1	- 62.3050***	0.1223***	0.0282***	-0.0614***	-0.0559***	-0.0322***
F2	48.3463***	-0.0858***	0.0147**	0.0562***	0.0213***	-0.0053 ns
F3	-12.4015*	0.0320***	0.0177***	-0.0197***	-0.0179***	-0.0105**
D75	-3.4186 ns	-0.0225 ns	-0.0211 ns	0.0024 ns	0.0180 ns	0.0279**
D80	8.9191 ns	-0.0520**	-0.0444**	0.0025 ns	0.0288*	0.0666***
D85	27.1457 ns	-0.0976***	-0.0465**	0.0367**	0.0500***	0.0616***
Constant	110.1030***	0.3460***	0.3884***	0.1904***	0.0706***	0.0000 ns
R^2 ajust.	0.43	0.71	0.12	0.62	0.44	0.19
F	24.06***	74.12	5.33***	49.98***	24.71***	8.38***

* p < 0,1000 ** p < 0,0500 *** p < 0,0100 ns = non-significant

The combination of the *factor* coefficients in the strata of up to 100 ha indicates that farms which fall in that strata employed a large amount of modern input per arable area (Factor 1) and depended a great deal on a human labor (negative Factor 2) and animal power (Factor 3). In the next stratum, total area between 100 and 500 ha, the combination of the coefficients indicate that farms of this size depended somewhat on traditional production factors. Factor 1's positive coefficient suggests that, independent of the proportion those farms make up of the region's total area, farms of this area stratum are characterized as using "modern" agricultural technology.

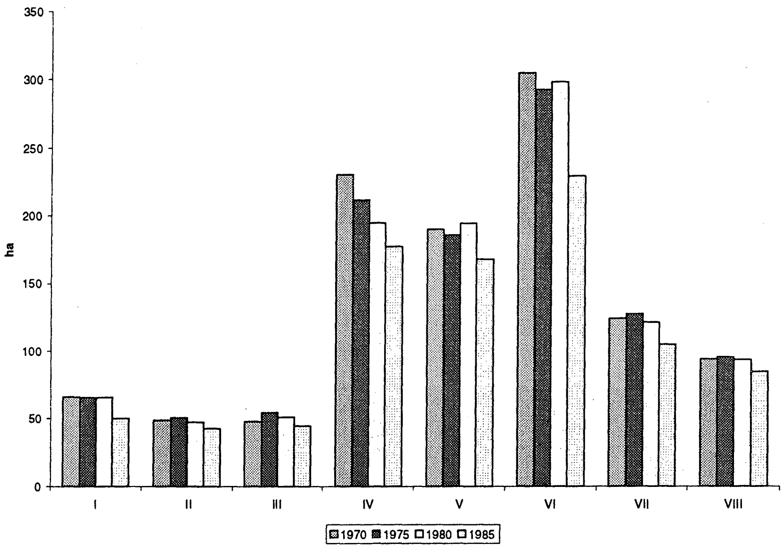
The two following strata combine high capital intensity (Factor 2) with low soil use intensity (Factor 1), suggesting that there is a positive association between moderately large farm holdings and an inclination to substitute technology for human labor, implied by the relationship of the modernization *factors* with farm in this area stratum. Finally, in the area stratum made up of 10 thousand to100 thousand ha farms, the associations with Factors 1 and 3 are negative and there is non-significant statistical association with the capital/labor ratio (Factor 2). Thus, regions which include a higher percentage of large farm holdings are relatively unaffected by technological modernization, a characteristic of unproductive large estates.

These characterizations are very aggregate. It is supposed that the each individual farm's technological characteristics are affected by the level of technological progress reached by the entire region in which it is located. There is general indication that concentrated agrarian structures, larger farm holdings, tend to guide the technical change more strongly toward the substitution of capital for labor than by increasing the intensity of soil utilization. Moreover, the correlation's suggest that very large farms (10 thousand to 100 thousand ha) are less predisposed toward technological change, which represents a restriction on the process of agricultural modernization, a proposition found in the "structuralist" thesis[11].

Figure 4 illustrates the contrast among average farm size in the Metalúrgica/Campo das Veetentes (I), Zona da Mata (II) and South of Minas (III) on one hand, and Triângulo/Alto Paranaíba (IV), Alto São Francisco (V) and, especially, Northwest (VI) on the other hand. This picture, in association with the characteristics discussed above, is congruent with Picture 2's representation of the dynamics of technical progress in Minas Gerais' agricultural sector, supporting the notion that land distribution is one of the explanatory factors of that configuration.

[11] The reference to the estruturalist thesis is based, mainly, on Furtado's work (1982). Nevertheless, Guimarães' thesis (1981) and Prado Júnior's (1981) also highlight the agrarian concentration as obstacle to the modernization, although they diverge regard to the means of overcoming it.

Figure 4 - Change in average farm size by State planning regions (Areas)



TECHNICAL PROGRESS AND AGRICULTURAL PRODUCTS

So far, the analyses has concentrated on explaining the regional disequilibrium observed in the process of technological modernization of Minas Gerais' agriculture sector. In this section, we investigate another unbalanced aspect of Brazilian agricultural modernization: selectivity in the implementation of new technology according to agricultural product.

To consider this aspect, the relationships between selected production activities and the indicators (*factors*) of agricultural modernization were evaluated. Given the association of those indicators with the government's financing incentive policy, we also investigated the influence of farm size in the homogenous micro-regions on the incentive policy in order to discover if there is a general bias in the allocation of these resources. We also identified the effects of general farm size and type of product produced in an MRH on the total expenses and total production generated in that MRH.

Thus, multiple linear regressions were estimated by ordinary least square. In all models, the right side of the equation considers the percentage each crop *l* (permanent and temporary plants) represents in the total production of micro-region *i*. The three *factors* of modernization were alternated as dependent variables with the value of government financing, the value of total expenses, and the value of total production (base = Dec. 1996) observed in each micro-region during the four years of the study.

Dummy variables were included to isolate the dependent variables' evolution and distribution among the planning areas during the period under analysis. Thus, a model was created that gave a general characterization, or average, of the technological *status* of the selected production activity but not a detailed evaluation of the different levels of technical progress for a given activity by Area over time.

Due to the great variation in the percent of land under cultivation in each of the homogeneous micro-regions, the error distribution was heterogeneous. The homoskedastic assumption was met by converting the initial values of percent of land under cultivation by their respective natural logarithms. The same procedure was used on the actual value of financing and production but not for the modernization *factors,* since they may take on negative values. Thus, the estimated model has the following functional form:

$$Y_i = \beta_0 + \beta_l C_l + \beta_t D_t + \beta_r D_r + e_i \qquad (4)$$

where

Yi is the *scores* of Factors 1, 2 and 3; the natural logarithm (ln) of the value of government financing; or ln of the total value of expenses or ln of the total value of production of the MRH *j* (*j* = 1, 2,..., 184);

Cl is the proportion of cultivated area (permanent and temporary), occupied with plant culture *l;*

β_l are the partial correlation coefficients between the proportion of the area occupied with the activity *l* and the dependent variable;

Dt is the *dummies* for the years of the study (*t* = 70, 75, 80 and 85);

β_t are the coefficients of partial correlation for the *dummies* Dt;

Dr is the *dummies* for the planning areas (*r* = 1, 2,... 8);

β_r are the coefficients of partial correlation for the *dummies* Dr;

β_0 is the constant;

ej is the error term .

The coefficients estimated by the regression are shown in Table 4. In short, the information reveals that coffee and soybeans are the only products that can be characterized as being produced using advanced technology in Minas Gerais between 1970 and 1985. Among the selected products, coffee was the only crop responsible for growth in the intensity of soil use, as represented by total arable area under cultivation (Factor 1). As Factor 1 refers to the employment of modern inputs in the total area under cultivation, this impedes the identification of that characteristic in the case of the soybean as expansion of soybean cultivation is restricted to Minas Gerais' savanna, an area poorly adapted for intensive soil use. The savanna lands were little represented in the group of cultivated areas within the state until 1985. Fortunately, the other indicators allowed us to verify that the areas cultivated with soybeans and coffee were amiable to the employment of modern inputs. Areas in which coffee and soybeans were under cultivation demonstrated an increasing capital/labor ratio (Factor 2) and reduced employment of animal power (Factor 3) in case of coffee, and unchanged use of animal power in the case of the soybeans.

From 1970 to 1985, government credit assistance in Minas Gerais was preferentially directed toward increasing coffee and soybean production, as it is shown by the those crops increased representation in the state's total production volume. The easy availability of credit positively affected expenses and agricultural production values, increasing both in Minas Gerais during the period.

For sugar-cane production, the relationship between credit, expenses, and production values and modernization Factors 1 and 2 was not significant. This may be explained by the diverse levels of technology employed in the cultivation of sugar-cane. In Minas, sugar-cane has traditionally been cultivated for the production of "cachaça" (a spirit) and for animal feed, which may be the reason cane cultivation has not been characterized as a modern agriculture .

The same reasoning is applicable to the cultivation of corn. In the case of corn, the coefficients give the impression that corn production in the state between 1970 and 1985 is typically a traditional farming operation. The direct association between agricultural modernization and the access to credit resources is expressed as an inverse relationship between the expansion of the corn culture and government financing assistance. Variations in the representation of corn cultivation in the state's total expense value and in total agricultural production value are minimal when compared to the representation of the other crops in the model.

Growers of rice, beans, and cassava achieved the smallest degree of technological development of all the cultures selected. Between 1970 and 1985, those cultures mimicked the modernization *factor* coefficients of corn, showing negative or no-significant association between technological progress indicators (Factors 1 and 2) and available financing, total expense value, and total production value.

Table 4 - Partial participation coefficients for crop cultures in the total area (permanent and temporary) for the three agricultural modernization factors, government financing, total expense value, and total production value.

% Cultivated areas	F1	F2	F3	VF	VD	VP
Coffee	0.1270***	0.0542*	-0.0740*	0.1529***	0.1059***	0.1359***
Rice	-0.2114*	0.0060 ns	0.4561***	-0.0197 ns	0.0429 ns	-0.0415 ns
Cane	0.0378 ns	0.0585 ns	0.0338 ns	0.1023**	0.0915***	0.0743**
Bean	-0.1469*	-0.2148***	0.1573*	-0.0962 ns	-0.1196**	-0.1426**
Cassava	-0.2215***	-0.1197 ns	0.0027 ns	-0.0956 ns	-0.0645 ns	-0.0530 ns
Corn	-0.4453*	-0.3065*	0.4353*	-0.4251*	-0.1717 ns	-0.0797 ns
Soybean	-0.0434 ns	0.1376***	0.0052 ns	0.0872***	0.0674***	0.0402 ns
D75	0.7377***	0.4845***	-0.0752 ns	0.9664***	0.6876***	0.67[illegible]***
D80	0.7369***	0.5740***	0.1406 ns	0.4634**	0.6578***	0.8964***
D85	1.3105***	0.0634 ns	-0.0174 ns	-0.7769***	0.4289***	0.4673***
DR1	1.2077***	-0.0146 ns	1.7024***	0.1931 ns	0.6800***	0.6631***
DR2	0.3388 ns	-0.3806 ns	2.1908***	0.2204 ns	0.4323*	0.4477 ns
DR3	1.1880***	0.3455 ns	1.5081***	0.9887***	1.1489***	1.1196***
DR4	-0.1323 ns	1.0926***	1.1745***	0.9358**	0.7979**	0.8899***
DR5	0.1349 ns	0.7736***	2.1471***	0.9541***	0.8088***	0.8282***
DR6	0.1267 ns	0.7866***	0.8925**	1.8568***	1.3705***	1.3029 ns
DR8	-0.1550 ns	0.0086 ns	0.2366 ns	0.0805 ns	0.3646 ns	0.6061**
Constant	-3.0730***	-0.4277 ns	0.3813 ns	9.6601***	10.6653***	11.1383***
R^2 ajust	0.71	0.84	0.61	0.72	0.66	0.6
F	20.22***	41.45***	12.85***	20.49***	15.64***	12.55***

*** significant at level smaller than 1,0% ; ** significant at level smaller than 5,0%; * significant at level smaller than 10%.

SUMMARY AND CONCLUSIONS

The results of this study support the critical vision of Brazilian agricultural modernization. As pointed out in the introduction, regional agricultural inequalities, partiality, and the selective nature of national and regional agricultural modernization programs have already been highlighted by several authors[12]. Nevertheless, in our work we tried to build a methodology to investigate this subject without the limitations of impressionist analyses and offer some empirical evidence based on statistical methodology directly related to the state of Minas Gerais.

We related the dynamics of the modernization indicators (*factors*) with the volume of government financing assistance and farm size. This was done to investigate the effect of the rural credit policy and the lack of an agrarian reform policy on the different rates and characteristics of the agricultural modernization process observed in the regions of Minas Gerais. Both policies are understood as institutional changes according the theoretical framework proposed by De Janvry (1977).

This paper's results give support to the following hypotheses:

1. Credit incentives together with agrarian density, as prevails in savanna regions of Minas Gerais, guided the technical change toward a substitution of capital for labor and also had a small effect, or even a negative effect, on the intensity of soil use. These effects may be attributed to the diversion of financing resources for speculative purposes.
2. The reversal of the capital/labor ratio's growth and the deceleration of the soil use intensification process between 1980 and 1985, were due to the rural credit policy's lack of funds; the coffers had been exhausted. This leads to a belief that the process of technological change in Minas Gerais's agriculture sector was not sustainable.
3. State intervention ended up causing results inconsistent with relative agricultural production factor availability, inducing substitution of

[12] Besides those referred in the Introduction, it should still be mentioned the paper by Kageyama and Whistles (1990), on the results of the agricultural modernization in the 70's.

capital for labor at a rate superior to that which would occur in the absence of intervention.

4. The selective pattern of public resource distribution combined with the effects of location and the differences in environmental conditions explains the growth of technological disparities among the agricultural systems and regions within the state.
5. Technological progress in Minas Gerais' agriculture sector reflects the predominance of those interests committed to industrialization, is affected by different organizational possibilities, and is biased by the political influence accorded to farmers engaged in the cultivation of a very few, specific crops.

As a corollary to the main theses of the model of groups of interests, the research presented in this paper contributes strong evidence for the argument that the incentives provided by easily available rural credit do not favor balanced development in the state of Minas Gerais' agriculture sector. In that sense, if agricultural modernization incentive policies don't consider the diverse socioeconomic and environmental conditions found within any state's regions, they can lead to economically inefficient and unbalanced combinations of the primary production factors and be extremely advantageous for a few, select, private interests.

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