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CASSAVA SUPPLY RESPONSE IN MINAS GERAIS STATE, BRAZIL:
AN EMPIRICAL EVALUATION

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CONTENTS

	Page
INTRODUCTION.	1
THE PROBLEM	9
OBJECTIVES.	12
METHODOLOGY	13
THE DATA.	21
RESULTS AND DISCUSSION.	22
POLICY IMPLICATION.	26
SUMMARY, IMPLICATIONS, LIMITATIONS AND NEEDED RESEARCH	29
BIBLIOGRAPHY	33
APPENDIX	35

LIST OF FIGURES

Figure	Page
1. Illustrations of cassava yield in Minas Gerais State.	16
2. Illustrations of cassava acreage in Minas Gerais State.	28

LIST OF TABLES

Table	Page
1. Energy yield of some crops in Minas Gerais State.	3
2. World's largest cassava producing countries	4
3. Ethanol required for complete replacement of gasoline and 80% alcohol-diesel fuel blend	8
4. Energy output/input ration for producing ethanol from various agricultural raw materials	10
5. Additional agricultural capacity required to produce four billion liters of ethanol	11
A. Energy balance for ethyl alcohol production from various agricultural raw materials	35

INTRODUCTION

When the Portuguese and Spanish navigators landed on the American continent in the 15th century, they found cassava being grown by Indians and used to prepare food and alcoholic drinks. For this reason, cassava can be considered a native American plant which has spread to other regions of the tropics.

Cassava refers to any of several plants (family Euphorbiaceae, genus *Manihot*) which are grown widely in many areas of the tropics for their fresh, starchy, edible root stocks. It is known as cassava in English speaking regions, as manioc in French speaking areas, as tapioca in English speaking parts of Southeast Asia, as mandioca in Brazil, and as yuca in Spanish speaking regions of South America.

Cassava is successfully grown in zones ranging between latitudes 30° north and south, and is tolerant of temperatures from $18 - 35^{\circ}\text{C}$ ($65 - 85^{\circ}\text{F}$) and to a wide range of precipitation. This zone coincides with the less developed countries, and its prominence in less developed countries could be explained by its agricultural characteristics. For example, it is easily propagated (i.e., seeds or roots are not required; rather, it can be done by stalk cuttings), and it has a relatively high energy

yield compared to some other crops, as we can see in Table 1. It is inexpensive to produce because it is easily planted and harvested and does not have a critical planting or harvesting time. The farmer can plant and harvest after other more crucial tasks at times when his opportunity cost of labor is very low. Cassava's resistance to drought, pest and diseases means that labor and other requirements for growing are relatively lower than for other crops. Also, it is planted one year and harvested the next, with the option of delaying harvesting an additional year. So, these attributes make it a good crop for small scale, subsistence agriculture.

Brazil, as the world's largest producer of cassava, Table 2, has traditionally used it mainly for (a) human food, (b) animal feed, (c) industrial starch and (d) more recently for motor alcohol production.

(a) - Human food. Four principal kinds of food products are produced from cassava: meal, flour, starch and a stock for sauce and soups. Phillips (1) suggests that less developed countries will continue to find it difficult to achieve or maintain self-sufficiency in agricultural commodities. It is expected that demand for agricultural goods will increase more rapidly than supply. Also, he found that cassava in 1970 provided 28.6% of calories in Africa, and 11.7% in Latin America. By 1980 it is predicted that cassava will continue to provide 37% of calories consumed in Africa and 11% in Latin America, although he points out these forecast

Table 1. Energy Yield of some crops in Minas Gerais state (K Cal/La)

Year	Cassava ^a	Tomato ^b	Potato ^b	Sugar cane ^b	Corn ^b	Sweet Potato ^b
1973	21,360,007	3,545,040	4,968,880	135,885,150	4,548,360	11,185,680
1974	21,236,812	7,200,000	8,328,080	146,300,000	6,281,400	10,714,860
1975	23,366,940	4,385,760	7,392,520	125,648,600	4,979,880	10,104,960
1976	22,620,607	5,445,840	7,477,640	139,200,600	4,840,680	11,216,460
1977	22,199,452	5,998,320	7,520,960	156,156,000	5,303,520	11,281,440

^aThe energy yield for cassava was calculated using source (2), (19), and (20).

^bThe energy yield for those crops was calculated using source (2) and (18).

Table 2. World's largest cassava producing countries (MT)

Year	Brazil	Zaire	Indonesia	Nigeria	World
1970	29,464	10,090	10,478	9,084	96,627
1971	30,258	8,430	10,042	9,172	96,742
1972	31,000	9,917	10,385	9,570	103,366
1973	26,559	8,595	11,185	9,600	99,665
1974	24,715	8,879	13,031	10,000	99,425
1975	25,812	9,172	12,323	10,500	101,702
1976	26,816	9,832	12,500	10,800	104,952

Source (3)

consumption rates may not be achieved because of insufficient cassava supplies.

(b) - As a compound feed. The analyses made by Phillips (1) in the EEC reveals that the 1980 demand for cassava in the EEC may be from 246% to 634% greater than the 1970 demand. In order of importance, the maximum consumption levels are (in 1000 metric tons):

	<u>Low</u>	<u>High</u>
Netherlands	1020	2380
France	157	1950
Denmark	558	1227
Germany	677	1161
United Kingdom	472	947
Belgium	472	725
Italy	117	577
Total	3473	8967

The growth in demand for cassava as an ingredient in animal feed coincides with the development in the EEC's Common Agricultural Policy. The economic potential of the EEC as a market for cassava has grown rapidly: in 1962 demand for cassava was 413,704 tons; by 1971 the market had expanded to 1.5 million tons, an increase of 363%.

(c) - As a starch. The major markets for cassava starch are Japan, the United States and Canada, although cassava starch accounts for less than 10% of total starch utilization.

In the United States, maize starch accounts for 92% of the current American starch output, and the largest competition for maize starch may come for cassava starch, whose imports have exceeded all other kinds of starch. In the Canadian starch market maize starch predominates; however, it is imported because of the lower maize production. The cassava starch exporter wishing to access the Canadian market potential must therefore continually supply cassava in sufficient quantity and quality (1).

(d) - As a raw material for alcohol production. In recent years Brazil has been spending \$4 billion annually on petroleum imports of 950,000 barrels daily with domestic production of only 172,000 barrels in 1977 (4). To economize foreign exchange through import substitution of petroleum-based fuels, the main chance for Brazil may be photosynthesis.

In October, 1975, the Brazilian government announced the decision to create a National Alcohol Program aimed at permitting the use of alcohol both as fuel, in a 20 percent mixture with gasoline, and as a raw material for the chemical industry. Brazil's aim is to increase the alcohol content of its automotive fuel supplies to 20 percent by 1980. This and other purposes mentioned below are the rationale for the special program to support the production of alcohol from sugar cane and other raw materials, such as cassava and sweet potato, by substantial increases in new areas planted to these crops.

The alcohol program was created with the purpose of:

- (a) economizing on foreign exchange through import substitution of petroleum;
- (b) reducing regional income disparities since the whole country, including low-income regions, is capable of producing an adequate amount of raw materials, especially cassava;
- (c) reducing individual income differences because of the program's concentration on labor-intensive products in the agricultural sector;
- (d) increasing domestic income by employing factors of production, principally land and labor, that are currently unused or underutilized.

For example, to the extent that cassava rather than sugar cane is used for direct conversion to alcohol, low quality lands without alternative uses can be employed.

Research shows that complete substitution by ethanol and up to 80% blends of ethanol-diesel fuel are possible. Based on 1977 gasoline and diesel fuel consumption rates, Table 3 lists the quantities of alcohol required for this longer range goal, and complete replacement of gasoline and 80% substitution of diesel fuel might be achieved within 8-10 years (4).

Brazil already has 715 automobiles using alcohol instead of gasoline. In this case, using only alcohol instead of gasoline, the consumption of fuel has a slight edge in kilometers-per-liter compared to gasoline used exclusively. Furthermore, a liter of alcohol costs 5.50 cruzeiros while a liter of gasoline costs almost 9 cruzeiros

Table 3. Ethanol required for complete replacement of gasoline and 80% alcohol-diesel fuel blend

	Consumption in 1977, (billion liters)	Ethanol required (billion liters)
Gasoline	15	15
Diesel	18 - 20	<u>15</u>
	Total	30 billion liters

Source (4)

to the consumer (8).

Table A, in the appendix, shows an energy balance for ethanol production from sugar cane, cassava, plant sorghum and ratoon sorghum, calculated by Goldemberg (5). All produced a positive energy output/input ratio (See Table 4).

According to Mears (7), if Brazil wants to substitute alcohol completely for gasoline, alcohol demand would approach 25 billion liters per year for the mid-1980s. Table 5 shows the land required to produce this amount of alcohol per year, half from sugar cane and half from cassava. The new land requirement (6.6. million ha) compares with approximately 45 million ha now cultivated in Brazil, and 4.5 million ha now cultivated with cassava and sugar cane. This represents a need for a 15 percent increase in cropped land or an increase of 150 percent of land cropped in cassava and sugar cane.

THE PROBLEM

As one of the largest countries in the world, and with the necessity for much greater emphasis on increased production to feed a growing population and a growing industry, the need to implement policies which will induce substantial expansion of cassava production is becoming continually more urgent in Brazil.

Minas Gerais is a state in Brazil with an area of

Table 4. Energy output/input ratios for producing ethanol from various agricultural raw materials

Raw Material	Ratio (Energy output/ Energy input)
Sugar cane	2.40
Cassava, without heat from stems	1.16
Cassava, with heat from stems	1.45
Plant sorghum, stems and grain	1.92
Ratoon sorghum, stems and grain	1.82
Plant sorghum, stems only	2.06
Rat on sorghum, stems only	1.94

Source (5)

Table 5. Additional agricultural capacity to produce 25 billion liters of ethanol

Raw Material	Ethanol Production Liters/ Metric Ton)	Raw material required (Million Metric Tons)	New land area required (Million hectares)	Ethanol Production (Billion Liters)
Sugar cane	67	187	3.1	12.5
Cassava	180	69	3.5	12.5
			6.6	25

Source (7)

587,172 km², 32% of it being savanna (217,500 km²) (21). In 1976 the total area planted in Minas Gerais was 4,080,138 ha and the area planted with cassava 134,410 ha, 3.29% of the total area planted. Cassava being an option for the savanna area, research must be done to improve its cultivation in Minas Gerais. To improve the development of the state, by bringing the savanna area into production as well as contributing to the alcohol program and the nutrition, feed livestock problems, cassava can be a great option for the government.

In spite of cassava being traditionally grown in Minas Gerais State, there has not been empirical research to evaluate this crop economically. As shown above, it is a very important crop for Minas Gerais State and it is a crop that has been a part of the traditional farmers' subsistence diet and a component of animal feed. Estimation of supply response is important for agricultural price and income policy, for short term forecast and long range projection of land use and resource needs. For crops, acreage projection are required under alternative levels of prices, government programs, and input costs.

OBJECTIVES

Although in the introduction section an exposition of the alcohol program was done, a further and more sophisticated work must be done for this purpose. One of the in-

tentions of this program, as was said before, is to improve cassava cultivation, and so, new behavioral patterns have appeared since the alcohol program was created in 1974. Thus, the time series analysis used in this work, from 1947 to 1976, may not be sufficient to handle the complex issues of the alcohol program, because new and relevant variables appeared into the cassava production that was not possible to identify before 1975 so they were not analyzed in this study.

The objectives of this research therefore are:

(a) to estimate empirically a relation of cassava supply in the state of Minas Gerais; (b) to estimate the price elasticity of supply for short and long run; (c) to suggest policies to the state of Minas Gerais government in order to improve the cultivation of this crop.

METHODOLOGY

Since time series of planned output are not available, some other approach must be utilized. One would be the actual output. As Behrman (9) points out, realized output often differs considerably from planned output because environmental factors remain beyond the farmer's control. The discrepancies between planned and actual agricultural production have led most research to approximate planned output, not by actual output, but by area. So the area planted in a particular crop is, to a much greater degree than output, under

farmer's control and thus a much better index of planned production.

Caution must be taken against too easily assuming that the correlation coefficient between planned output and planted area is necessarily close to one (9), because land is often taken as a heterogeneous factor. That is, the assumption that an increase in the planned output of a specific crop will be realized by devoting more land to it can be unrealistic because a farmer can also increase the planned output of a specific crop by devoting less land with better quality soil to the crop. It must be clear that in Brazil cassava is generally planted in poor soil, and, if this raw material could get a good price, the farmers could decide not to cultivate the poor soils but to choose the quality soil zones in which to increase cassava production, thus decreasing the total planted area of cassava.

The relationship between the planned output and planted area of cassava can be illuminated further by consideration of the relationship between their respective elasticities. Let Q^* be the planned output, A^* be the planned planted area, A be the actual planted area, Y^* be the planned production per unit planted area, let P be the price of cassava per unit on which Q^* is dependent and let E_{Q^*P} be the elasticity of Q^* with respect to P , E_{AP} the elasticity of A with respect to P and E_{Y^*P} be the elasti-

city of yield with respect to P. Assume that the farmer has great control over area which is planted so that $A^* = A$. The relationship between the elasticities of Q^* , A and Y^* with respect to P is:

$$E_{Q^*P} = E_{AP} + E_{Y^*P}$$

This relationship is true only if area planted is equal to area harvested; that is one assumption of this study.

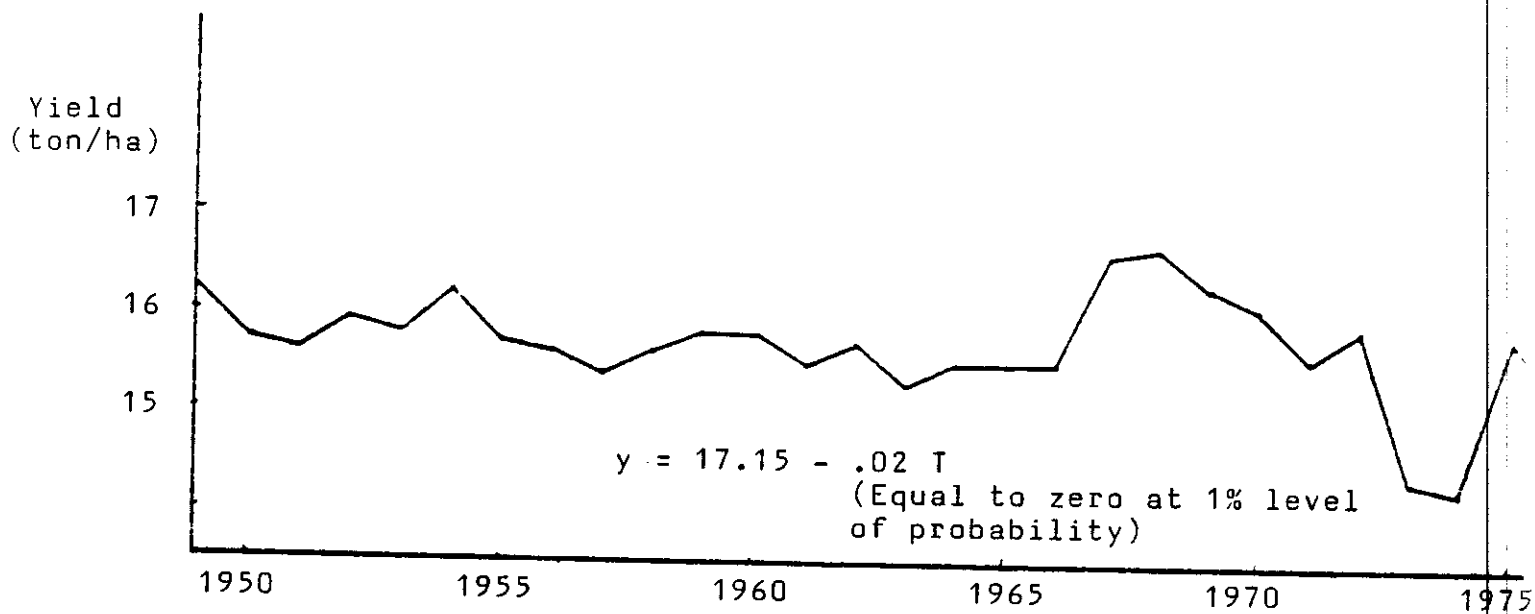
The elasticity of interest is E_{Q^*P} , while the elasticity which is obtained in the estimations which are presented in the next section is E_{AP} . The smaller is the absolute value of E_{Y^*P} , ceteris paribus, the better will E_{AP} approximate E_{Q^*P} . Between 1947 and 1976, yield has not varied greatly, as we can see in Appendix 2 and in Figure 1. Since yield has been almost a constant, no equation will be estimated for it. On the other hand, the effect on supply has been due to the increase of land. So, an equation of acreage is to be estimated.

A Nerlovian dynamic supply model for the area planted is postulated here.

The symbols utilized are:

- Y_t^* = the desired planted area of cassava;
- Y_t = the actual area planted of cassava;
- X_{1t}^* = the expected normal farmer's price of cassava;
- X_{1t} = the actual farmer's price of cassava;

Yield of Cassava in Minas Gerais State



Yield as a percentage of the yield mean

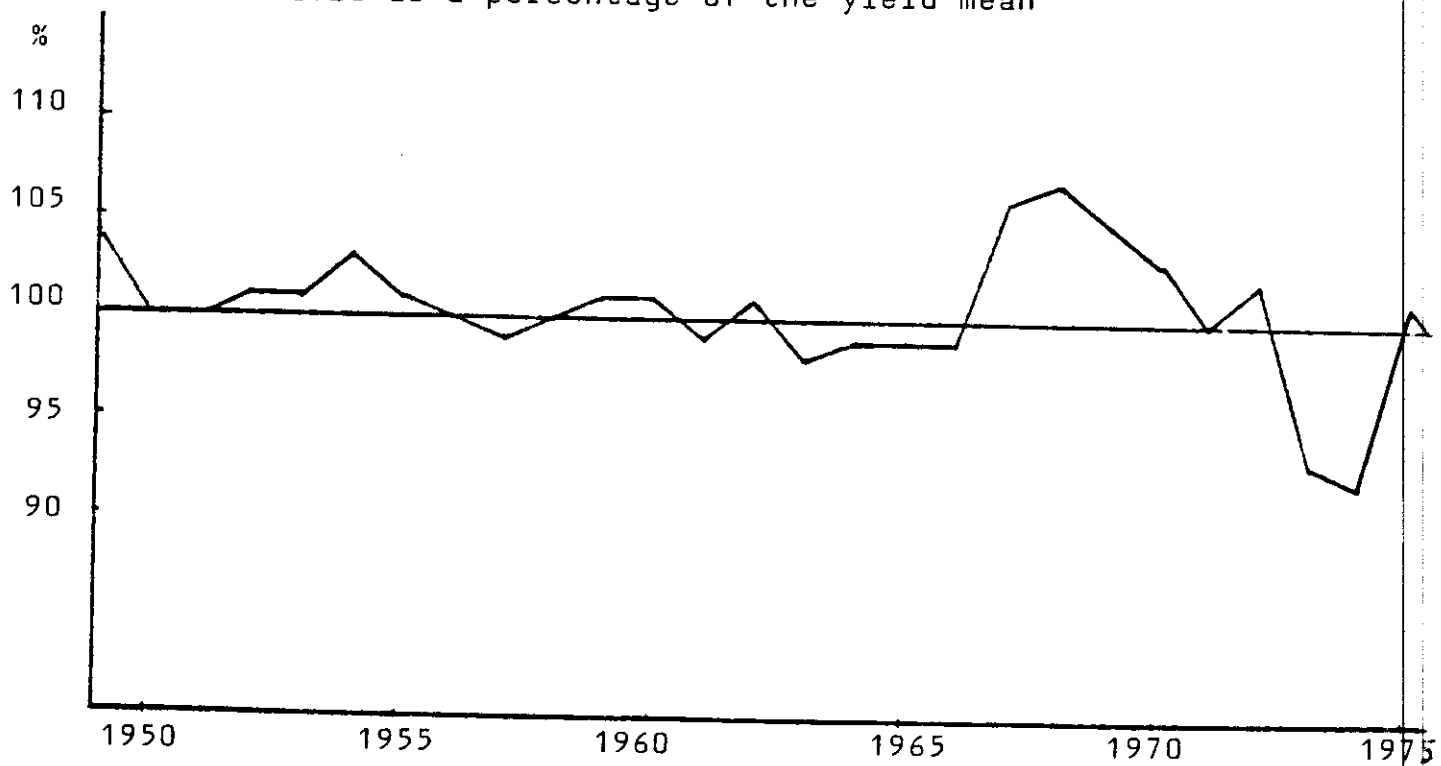


Figure 1. Illustrations of cassava yield in Minas Gerais State

- X_{2t} = the standard deviation of the price of
 cassava over the three preceding production
 periods;
 X_{3t} = mean of the yield over the three preceding
 production periods;
 X_{4t} = the minimum wage stipulated by the government
 for the state of Minas Gerais;
 X_{5t} = rural population in the state of Minas Gerais;
 T = trend variable and
 U_t = disturbance term.

The model:

$$Y_t^* = a_0 + a_1 X_{1t}^* + T + U_t \quad (I)$$

The dependent variable Y_t^* and the independent variable X_{1t}^* are unobservable. The expression of these variables in terms of observable variables is now discussed.

Equations (II) and (III), respectively, relate the desired area planted and the expected normal price to observable variables. The relations are identical to Nerlove's formulation:

$$(II) Y_t = Y_{t-1} + b_1 (Y_t^* - Y_{t-1})$$

$$(III) X_{1t}^* = X_{1t-1}^* + b_2 (X_{1t-1} - X_{1t-1}^*)$$

The area planted adjustment equation (II) states that the area actually planted in production period t equals the area actually planted in the previous period plus a term proportional to the difference between the

desired planted area in the t^{th} period and the actual planted area in the previous period. The proportionality parameter (b_1) is called the area adjustment coefficient. The expected normal prices equation (III) states that the expected normal price in production period t equals the expected normal price in the previous period, plus a term proportional to the difference between the expected normal price and the actual price in the previous period. The proportional parameter in this relationship (b_2) is called the price expectation coefficient.

Equations (II) and (III), the desired planted area and the expected normal price of cassava respectively, may be expressed explicitly in terms of distributed lags (15).

We will assume that an equilibrium situation existed at and prior to time $t = 0$. Further we will assume that all prices are expressed as deviations from the equilibrium price existing at time equal to zero. Then the initial condition may be taken to be equal to zero. Equation (IV) gives the expected normal price of cassava in the t^{th} period as a sum of all past prices.

$$(IV) \quad x_{1t}^* = \sum_{i=0}^t b_2 (1 - b_2)^{t-i} x_{1i-1}$$

If we substitute (IV) in (I) we have

$$(V) \quad y_t^* = a_0 + a_1 b_2 \sum_{i=0}^t (1 - b_2)^{t-i} x_{1i-1} + U_t$$

If we substitute (V) in (II) we get

$$(VI) \quad Y_t = Y_{t-1} + b_1 \left[a_0 + a_1 b_2 \sum_{i=0}^t (1-b_2)^{t-1} X_{1i-1} + U_t - Y_{t-1} \right]$$

Shifting (VI) one period backward, multiplying both sides by $(1-b_2)$, and subtracting the results from equation (VI), we have

$$(VII) \quad Y_t = a_0 b_1 b_2 + a_1 b_1 b_2 X_{1t-1} + Y_{t-1} (2-b_2-b_1) + Y_{t-2} (b_1 + b_2 - b_1 b_2 - 1) + b_1 (U_t - (1-b_2)U_{t-1})$$

It suggests an equation of the form

$$(VIII) \quad Y_t = B_0 + B_1 X_{1t-1} + B_2 Y_{t-1} + B_3 Y_{t-2} + W_t$$

where W_t is the residual term.

Thus, the model to estimate acreage relationships in Minas Gerais State is the following

$$(IX) \quad Y_t^* = A_0 + A_1 X_{1t}^* + A_2 X_{2t} + A_3 X_{3t} + A_4 X_{4t} + A_5 X_{5t} + A_6 T + E_t$$

where the variables are defined above.

There is no theoretical expectation of the sign on the price term (A_1) in the acreage equation, since the farmer can increase the planned output of a specific crop by devoting less land with better quality soil to the crop.

The standard deviation of the price of cassava over the three preceding production periods (X_2) was used as a risk aversion variable. Just (10) suggests that for near subsistence farmers, characteristics of the probability distribu-

tions other than the expected values are very important in the determination of the desired planted area and we could expect the associated parameter (A_2) to be negative because increases in variances, ceteris paribus, would make production of the crop less desirable.

The mean of the actual yield in the last three production periods (X_3) was included in the model because not only the expected value per unit of production seems relevant to production plans, but also the number of units one might expect to produce. We would expect (A_3) to be negative since land is a limited resource for the farmer and as a subsistence crop an increase in the yield, ceteris paribus, might result in a decrease in a desired area in cassava and an increase in the desired area of more profitable crops.

Since data for rural wages in the state of Minas Gerais were not available, the minimum wage for the state of Minas Gerais that is stipulated by the government (X_4) was used as an indicator. It is expected that an increase in the real wage would make the farmer use less labor and consequently decrease the planted area of cassava (A_4).

Near subsistence farmers may attempt to lessen the impact of market fluctuations by first planting enough area of cassava to assure sufficient consumption on the farm and only thereafter allocating the remainder of their land on the bases of expected returns. To test this hypothesis,

the rural population (X_5) is included in the derived planted area relationship for cassava. If farmers attempt to assure enough cassava production for on-farm consumption needs, the associated parameter (A_5) should be positive.

In terms of observable variables the model would become

$$(X) \ Y_t = b_0 + b_1 X_{1t-1} + b_2 Y_{t-1} + b_3 Y_{t-2} + b_4 X_{2t} + \\ b_5 X_{3t} + b_6 X_{4t} + b_7 X_{5t} + b_8 T + U_t$$

THE DATA

The acreage planted and price of cassava data utilized in this study for the period 1947 to 1973 consist of series published by SUPLAN (11). Since the acreage planted and harvested is not computed separately in Brazil, in this research it is assumed that the areas are the same. The same approach (area planted equals area harvested) was used by Pastore (22) and also "The Production Yearbook", FAO, suggests that in underdeveloped countries this assumption can be considered true. As we can observe in Appendix 2, there are some variations of the data not explained by the source (SUPLAN) utilized. Since another source available (12) did not present different data, they were utilized in the estimation procedure.

For 1974 - 1976 the data for acreage planted to cassava were obtained from Anuario Estatístico do Brasil (12); for 1974 - 1976 the data for price of cassava were obtained from

Prognostico Regiao Centro-Sul (13). The series are presented in the Appendix.

The data for rural population were available only for 1940, 1950, 1960, 1970 - 1976 from Anuario Estatistico do Brasil (12). To pull out the data, an approach suggested by Shryock (14), a polynomial interpolation, was used to obtain the intermediate data. Also, since the rural wage was not available, the minimum wage for Minas Gerais State, that is stipulated by the government for every state in Brazil, was used as an indicator (12). Those data series are presented in the Appendix.

RESULTS AND DISCUSSION

Single equation methods were applied to test each variable presented. Cassava supply response, as is the case for nearly all crops, is influenced by price expectations which have existed in the past. Therefore, lagged values of variables determined within the system were considered as independent.

The equations are fitted using the method of ordinary least squares. Thirty observations were available to fit the equations, but, since some variables with one or two lagged periods were used as independent variables, the number of observations became 29 or 28 depending upon the lag of those variables. Thus, it was possible to consider a relatively complete model without suffering a lack of reli-

ability due to insufficient degrees of freedom.

To facilitate evaluation and comparison, certain statistical tests of significance were applied. The t test is applied to test the hypothesis that the regression coefficient tested does not differ significantly from zero against the alternative hypothesis that it is significantly different from zero. If the ratio of the parameter to its standard error is greater than $t_{\alpha/2}$, the hypothesis that the parameter is equal to zero is rejected. The t value is obtained from the "students" distribution with $n-k-1$ degrees of freedom, where k is the number of independent variables in the model and α is the probability of rejecting the hypothesis that b is zero when in fact it is true.

One of the assumptions made in the estimation process is that of serial independence of the residuals. Generally, the Durbin-Watson test is applied to determine the degree of independence. The inclusion of lagged values of the left hand side variable as an explanatory variable makes the use of this test, according to Kmenta (16), Nerlove (15) and others, inappropriate. This must be considered since the model presented does include lagged acreage as an explanatory variable.

Among the estimated linear equations, based on equation (X), the best one, but still with some statistical problems, is presented below with the standard error of the estimated coefficient shown in parentheses.

$$\begin{aligned}
 Y_t = & 79095.3 + 22.1760X_{1t-1} - 66.2809X_{4t} - .07008Y_{t-2} + \\
 & \quad (54.2395) \quad (43.5882) \quad (.20480) \\
 & + 2405.63T \\
 & \quad (463.74) \\
 R^2 = & .96
 \end{aligned}$$

As we can observe, the signs on the parameters are consistent with our expectations but we cannot capture the statistical significance of two important variables in the intended model, cassava price (X_{1t-1}) and lagged acreage (Y_{t-2}).

It was possible to capture the statistical significance of those variables only by estimating the equation using the logarithmic form. The logarithmic form chosen to represent the cassava acreage response is the following:

$$\begin{aligned}
 \log Y_t = & 8.05006 + .02984 \log X_{1t-1} - .07924 \log X_{4t} + \\
 & \quad (.02025) \quad (.02944) \\
 & + .27311 \log Y_{t-2} + .23164 \log T \\
 & \quad (.14683) \quad (.04744)
 \end{aligned}$$

$$\bar{R}^2 = .958 \quad DW = 1.87 \quad h = .546$$

The model explains a considerable portion of the variance in planted cassava area. The coefficient of determination is .964 ($R^2 = .964$) and the corrected coefficient of determination .958 ($\bar{R}^2 = .958$). As this equation was estimated using logarithmic transformations, the coefficients

are directly the elasticities. The trend variable (T) is significantly different from zero at the .01 level. The variable X_{4t} , the minimum wage in Minas Gerais State, is significantly different from zero at the .02 level. The price of cassava at time $t-1$, X_{1t-1} , is significantly different from zero at the .20 level. The variable Y_{t-2} , the acreage planted lagged two periods, is significantly different from zero at the .10 level. The incorporation of planted area lagged one period was also considered for this equation. However, this variable was not statistically different from zero at acceptable levels of significance.

The Durbin-Watson statistic computed is 1.87 and provides evidence to reject the hypothesis of serial dependence of residuals at the .05 level; but as was said above, the Durbin-Watson statistic is not applicable to a regression in which the place of an explanatory variable is taken by the lagged value of the dependent variable.

Durbin (17) suggested a statistical test "h" for serial correlation when there is a regressor as a lagged dependent variable. The value of h is given by the relation:

$$h = d^* \frac{b}{\sqrt{1 - n\text{Var}(b)}}$$

where d^* is equal to $1 - .5d$; n is the number of observations; $\text{Var}(b)$ is the variance of the lagged dependent variable co-

efficient; d is the Durbin-Watson statistic, and test this as a standard normal deviate. The critical value of h at the level of .001 of probability is equal to 2.358, where the hypothesis of serial correlation of the residual will be accepted for values of h above this limit. The value of h calculated for this model is .546, that is, less than the critical value at the .001 level. Thus the hypothesis of serial correlation of the residual is rejected.

As was observed, price is positively correlated with acreage. On the other hand, this does not imply that in the future the farmers will use fertile land to produce cassava. The data do not permit analysis in this sense, since we cannot predict what are the incentives that the government will give for this product.

POLICY IMPLICATIONS

There are many ways in which the government could interfere in cassava production which are not related to the results discussed here. Therefore, the policies suggested below must be restricted to the variables included in the analyzed model.

Analysis of the short and long run elasticities can suggest some alternative policy directions for the cassava sector in Minas Gerais State. A short run price elasticity of about .0298 implies that a 10 percent increase in price will increase the supply .298 percent. The estimate of the

long run elasticity implies that a 10 percent increase in the price of cassava will generate an increase in supply of .411 percent.

It is known that one of the policies of governments in developing countries is to increase rural income. An alternative government policy to increase rural income is to increase rural wages, but this policy can have a negative effect on the supply of many agricultural products when the production is closely associated with the rural wage as is the case of cassava in Minas Gerais State. As was observed, the wage elasticity of cassava supply is - .0792. This result implies that a 10 percent increase in wages generates a reduction of .792 percent in supply in the short run, and in the long run this reduction in supply is about 1.09 percent.

An analysis of the trend variable, which had the highest estimated response, must be done at this time. Over time, as can be seen in Figure 2, the acreage of cassava, which in the end represents the supply of this product considering constant yield, can be interpreted as a straight line with positive slope. Economically, this tendency can be interpreted as the growth in demand for this product for many different uses such as human food, compound feed and as starch.

As we can see, the elasticities of price and wage are very low. Specifically, in this study, a price policy is

Actual and calculated cassava acreage, Minas Gerais State

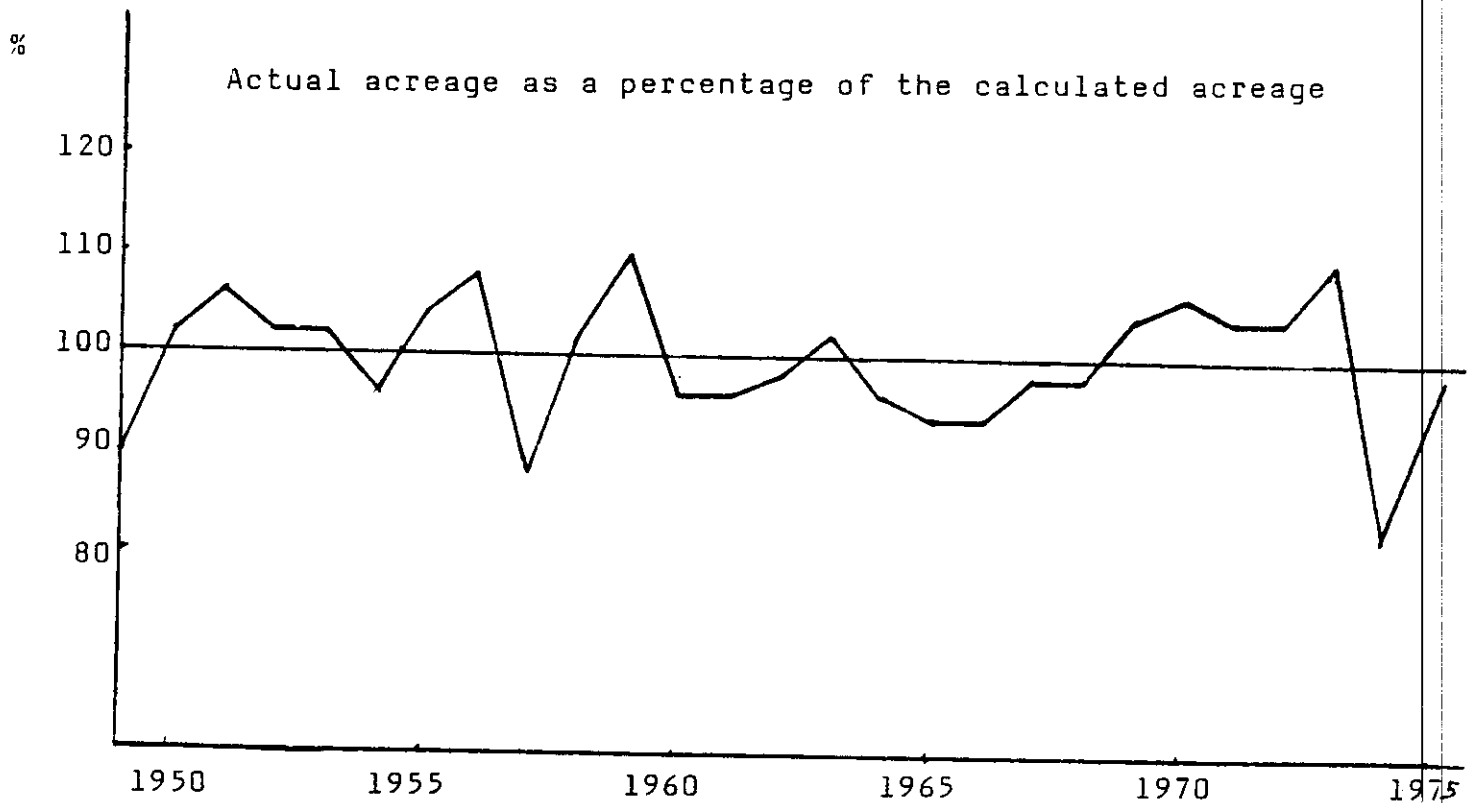
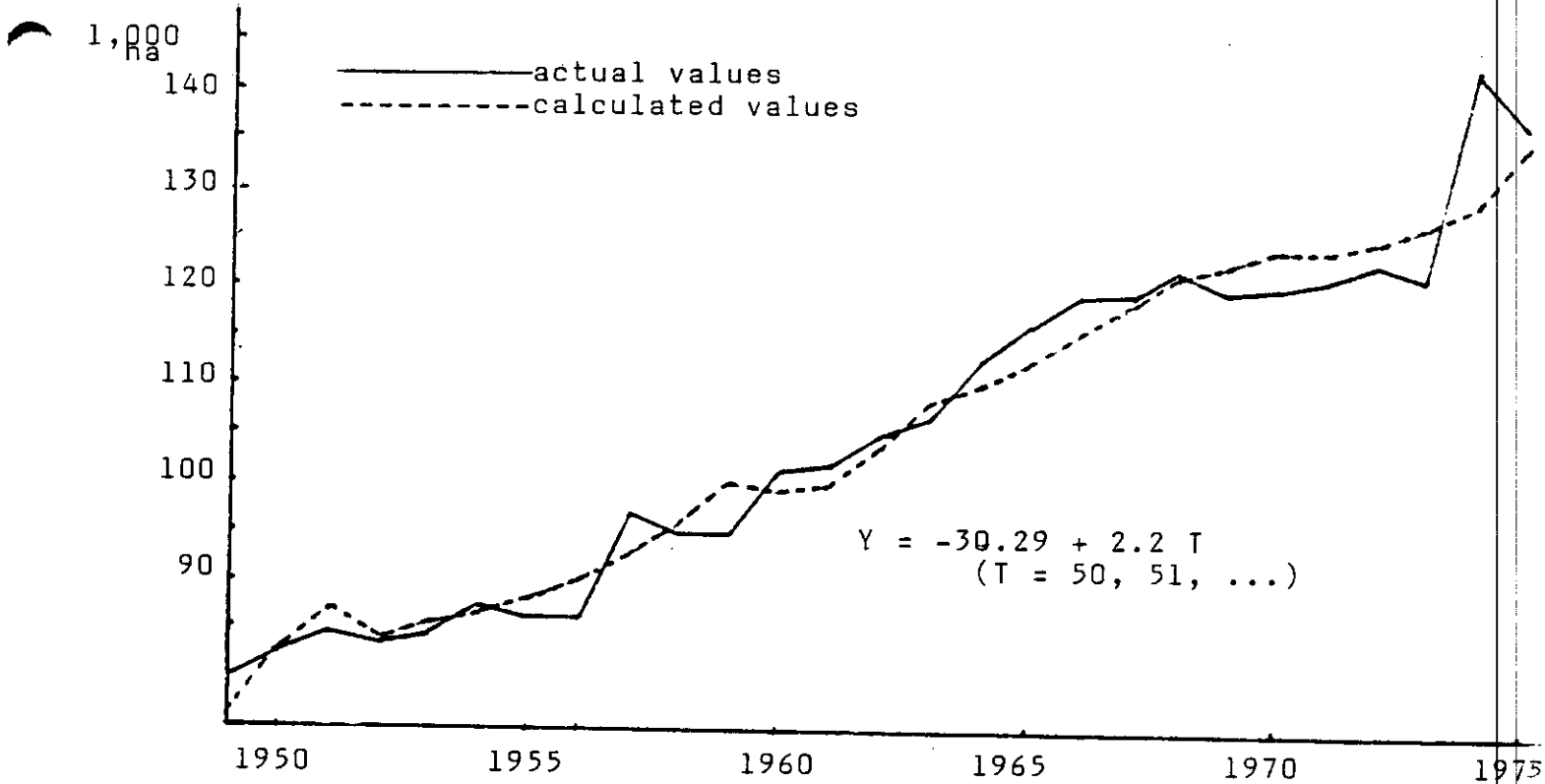


Figure 2. Illustrations of cassava acreage in Minas Gerais State

not recommended since in the short run as well as in the long it will not be very effective. What is suggested, considering the estimated equation for acreage and tendency of yield presented in Figures 1 and 2, is that the government should place a strong emphasis on research. We cannot accept the idea of increasing cassava production just by increasing acreage. As the government is going to provide incentives for alcohol production using cassava as the main raw material, cassava research can offer two basic contributions: first, to increase the production of cassava at low price; and second, to increase the rural income and thus the welfare of the rural population.

SUMMARY, IMPLICATIONS, LIMITATIONS AND NEEDED RESEARCH

Cassava has been a subsistence crop in tropical countries as a subsistence culture. Its importance is associated with its use as human food, compound feed, starch and more recently as raw material for alcohol production. In the Brazilian State of Minas Gerais, this crop has no less importance in traditional farming and its importance has been discussed as one main source of raw material for alcohol production and other uses in the future.

The empirical results suggest that price elasticities of supply are .0298 and .0411 for the short and long run respectively. Also this result implies that the wage elasticities of cassava for short and long run are - .0792 and

- .109. Considering a more effective policy to increase rural income and production of cassava in Minas Gerais State, we can conclude that the government should put emphasis on research of this product. The fact that led to the conclusion is that yield over time has not increased and production increases have been due to increases in acreage alone.

The data limitations of this study are those related to the wage, acreage planted, acreage harvested, and rural population variables used in the estimation. The minimum wage of the state was used as an indicator of the rural salary, assuming that the rural sector has the same wage variation as the urban sector. For the rural population variable, a linear interpolation was done between census years. Also, acreage planted and harvested are not computed separately in Brazil; in this research it is assumed that the areas are the same.

The limitations concerned with the model and results, i.e., the elasticities estimated, are related to the nature of the cassava economy. In other words, those values do not apply if ceteris paribus conditions do not hold. In this sense, the results of this research do not apply if the economy of the studied products expands. There are many ways in which the government could interfere in cassava production which are not related to the results discussed here. Therefore, the policies suggested must be restricted

to the variables included in the analyzed model.

The lack of detailed data and the poor available time series is also a limitation for econometric analysis of other important studies. A suggestion for a complete economic knowledge of the cassava sector is a cross-section analysis. Using this analysis it would be possible to capture influences of other crops on cassava production and vice versa. It would also be possible to determine with more detail the requirements for labor, capital and land more accurately than using secondary data analysis.

The National Alcohol program started in 1975 aimed at permitting the use of alcohol both as fuel and as raw material for the chemical industry. It has become a new and recent frontier for the cassava production. The time series analysis used, from 1947 to 1976, may not be sufficient to handle the complex issues of the alcohol program, because suitable time series for this analysis do not exist. Therefore, cross section analysis could indicate scales of production, including potential large exploration, medium and marginal farmers. From this analysis it would be possible to formulate production policies associated with the market reality and also to identify problems felt by farmers at the moment of marketing their product. Despite the high cost of a cross-section study, its usage would identify the necessary institutional changes and/or creation of new one that could improve the cassava economy.

As this study considered only data for Minas Gerais State, limitations on generalizations for other states must be cautioned.

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APPENDIX

Table A. Energy balance of ethyl alcohol production

	Agricultural Yield	Alcohol Production		Energy - Mcal/ha/year				Balance				
		t/ha	t/ha/yr	L/t	L/ha	Produced			Expended			
						Alcohol	Residue			Total	Agric.	Industry
Sugar Cane	72	54	66	4,752	3,564	18,747	17,550	36,297	4,138	10,814	14,952	21,345
Cassava (1)	29	14.5	174	5,046	2,523	13,271		13,271	2,573	8,883	11,456	1,815
(2)	29	14.5	174	5,046	2,523	13,271	5,512	18,783	3,868	8,883	12,751	6,032
Sweet Sorghum												
(Stems and Grains) (3)												
Plant Sorghum	(4)			3,775	3,775	19,856	11,830	31,686	4,671	11,883	16,554	15,132
Ratoon sorghum				2,383	2,383	12,535	7,280	19,815	3,350	7,501	10,851	8,964
Total				6,158	6,158	32,391	19,110	51,501	8,021	19,384	27,405	24,096
Sweet Sorghum												
(stems)												
Plant sorghum	32.5	32.5		2,600	2,500	13,391	11,830	25,505	4,671	7,722	12,393	13,113
Ratoon sorghum	20.0	20.0		1,600	1,600	8,416	7,280	15,696	3,350	4,752	8,102	7,594
Total	52.5	52.5		4,200	4,200	22,092	22,092	41,202	8,021	12,474	20,495	20,708

(1) No utilization of stems for steam production.

(2) Utilization of stems for steam production.

(3) 32.5 metric tons of stems and 3.0 metric tons of grains per ha.

(4) 20.0 metric tons of stems and 2.0 metric tons of grains per ha.

Source (5).

Appendix 2

The data.

The symbols utilized:

- Y_t = the actual area planted of cassava (hectares).
 X_{1t} = the actual real farmer's price of cassava (Cruzeiros/metric ton).
 X_{2t} = the standard deviation of the price of cassava over the last three preceding production period (Cruzeiros).
 X_{3t} = mean of the yield over the last three preceding production period (metric tons/hectare).
 X_{4t} = the minimum real wage stipulated by the government for Minas Gerais State (Cruzeiros/month).
 X_{5t} = rural population in Minas Gerais State (1000 persons).
 X_{6t} = the actual real farmer's price of corn (Cruzeiros/metric ton).

	y_t	x_{1t}^1	x_{2t}	x_{3t}	x_{4t}^1	x_{5t}	x_{6t}^1	Yield
1947	82449	29.4	2.14	16.01	28.04	5342	115.7	14.04
1948	85352	28.5	1.71	14.64	26.20	5381	117.9	15.77
1949	80071	30.1	2.76	15.08	14.50	5420	109.1	16.73
1950	82603	29.9	.80	15.51	22.02	5459	92.7	16.18
1951	84902	30.9	.87	16.23	18.90	5513	87.4	16.15
1952	83872	27.9	.53	16.35	55.14	5566	114.1	16.35
1953	84500	27.4	1.52	16.23	76.29	5620	131.9	16.26
1954	87587	23.2	1.89	16.25	97.58	5673	117.4	16.67
1955	86879	22.7	2.58	16.43	97.51	5727	107.9	16.20
1956	96791	18.9	2.58	16.38	106.67	5781	90.0	16.13
1957	97069	20.9	2.35	16.33	93.33	5834	101.0	15.91
1958	94973	20.9	1.90	16.08	82.57	5888	57.1	16.14
1959	95248	18.9	1.15	16.06	86.91	5941	106.2	16.32
1960	101540	16.6	1.15	16.12	107.68	5945	85.4	16.31
1961	102292	16.9	2.15	16.26	109.95	5943	79.1	16.00
1962	105033	21.2	1.25	16.21	113.04	5892	105.3	16.23
1963	107005	18.6	2.57	16.18	86.36	5840	74.4	15.80
1964	112839	21.0	2.17	16.01	85.90	5788	95.7	16.01
1965	116613	27.6	1.45	16.01	95.98	5737	73.3	15.99
1966	119234	18.8	1.76	15.93	78.91	5685	73.7	16.02
1967	119744	20.7	1.75	16.01	76.91	5634	73.3	17.08
1968	121840	22.5	1.58	16.36	78.49	5582	64.6	17.22
1969	120161	21.2	1.95	16.77	76.25	5530	59.0	16.84
1970	120631	20.2	.93	17.05	77.22	5427	58.2	16.61
1971	121691	19.4	1.15	16.89	77.98	5406	74.9	16.12
1972	123038	22.6	.90	16.52	82.96	5385	84.9	16.37
1973	121655	29.4	1.65	16.37	83.65	5325	100.9	14.91
1974	143000	95.3	5.08	15.80	85.28	5264	115.6	14.83
1975	137655	55.1	40.18	15.37	86.92	5299	124.0	16.32
1976	134410	43.6	33.25	15.35	88.68	5134	124.3	15.79

¹The price of cassava (x_{1t}), price of corn (x_{6t}) and the minimum wage for Minas Gerais State (x_{4t}) were deflated by the general price index with 1965/67 = 100.