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AN ECONOMETRIC ANALYSIS OF SUPPLY RESPONSIVENESS IN TRADITIONAL AGRICULTURE: MILLET, SORGHUM AND RICE FARMERS IN MALI

by

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FOREWORD

The African Rural Economy Program was established in 1976 as an activity of Michigan State University's Department of Agricultural Economics. The African Rural Economy Program is a successor to the African Rural Employment Research Network which functioned over the 1971-1976 period.

The primary mission of the African Rural Economy Program is to further comparative analysis of the development process in Africa with emphasis on both micro and macro level research on the rural economy. The research program is carried out by faculty and students in the Department of Agricultural Economics in cooperation with researchers in African universities and government agencies. Specific examples of ongoing research are, "Economics of Dairy Farming in Northern Tanzania," "Economics of Long Distance Livestock Marketing in West Africa," "Income Distribution and Technical Change in Africa," "Rural Small Scale Industry," "Female Participation in the Development Process in West Africa," and "Alternative Farming and Marketing Systems in sub-Saharan Africa."

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Professor of Agricultural Economics
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ABSTRACT

AN ECONOMETRIC ANALYSIS OF SUPPLY RESPONSIVENESS
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AND RICE FARMERS IN MALI

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Self-sufficiency in grain has always been the main objective of the Malian economic plans. The droughts of the early and late 1970's, and increased urbanization, have made it an even more important policy goal.

The Malian government, with the support of many international organizations and AID agencies, is currently striving to re-establish Mali as a net exporter of foodstuffs to neighboring countries. Despite the many efforts made in this respect, the import gap continues to widen. According to some official documents, domestic cereal production has been increasing at a rate of 0.4 percent whereas population has been increasing at a rate of 2.5 percent.

This paper reviews grain policies in Mali, tests several hypotheses about farmers' responsiveness in traditional agriculture, and analyzes the welfare effects of government grain pricing policies. The data used are annual production and sale figures between 1960 and 1979.

The major findings of the study strongly suggest that: (1) crop production and sale responds positively to government determined prices, and (2) the government program of subsidized imports has a definite adverse effect on producers, and overall social welfare in Mali.

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I. INTRODUCTION

The agricultural sector in Mali, is as in most developing countries, the mainstay of the economy. Agricultural products, including grains and those from fishing, livestock, and forestry, account for about 45 percent of the gross domestic product. Agriculture employs about 90 percent of the working population, and comprises virtually all of Mali's exports (65 percent).

Cropland is limited to the southern half of the country, where sufficient rainfall exists, where irrigation is possible, or where flooding from rivers takes place. Small scale farming comprises about 90 percent of the 1.4 million ha (3.4 million acres) under cultivation.[1]

Mali's agricultural production areas and a regional division are shown in Tables I and II, respectively. These figures are somewhat difficult to interpret as a consistent series, because variation in rainfall (droughts) influences them. Nonetheless, patterns of regional specialization are evident.

Cotton is grown on ferrugenous soils in Sikasso province, the region surrounding Segou, and in the Sahelian zone above the city of Kayes. These soils support, in addition to cotton, more intensive cultivation of millet and sorghum than do the eroded soils of the

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[1]Kelly Harrison and Kenneth Schwedel (1974, p. 1) give a working definition of small scale farming as the following: 1) the bulk of the labor force, management, and capital come from the same household; 2) production is either consumed on the farm and/or traded in local markets; 3) the decision making process is hampered by limited access to marketing and political institutions; and 4) the farmers do not live much above the culturally determined subsistence level.

Table I. Areas Planted to Selected Crops in Mali: 1968 to 1976*

Crops	1968	1969	1970	1971	1972	1973	1976
Millet/Sorghum	882	580	546	1,008	576	736	667
Rice	198	162	133	172	169	167	145
Groundnuts	126	101	96	148	151	147	127
Cotton	76	91	76	75	79	86	48
Corn	31	25	33	77	35	27	43
Other							523
TOTAL	1,738	1,805	1,673	1,696	1,748	1,775	1,553

NOTE: All figures are in 1000 hectares.

*WARDA, "Rice Policy in Mali," pp. 3a-3b.

Table II. Regional Cropping Patterns in Mali: 1974*

Crops	Kayes	Bamako	Sikasso	Segou	Mopti	Gao	Total
Millet/Sorghum	138	72	87	155	200	15	667
Rice	1	2	9	74	39	13	145
Groundnuts	82	7	15	17	6	--	127
Cotton	---	11	29	6	2	--	48
Corn	21	4	10	3	5	--	43
Other							523
TOTAL	242	103	150	255	252	28	1,553

NOTE: All figures are in 1000 hectares.

*WARDA, op. cit., p. 3b.

peanut zones, and they also support small amounts of rainfed rice in southern Mali. Nearly all of the rice in Mali is grown on the hydromorphic soils of the Niger and Bani river basins, which support the greatest densities of rural human and animal populations in the country. Almost no cotton and peanuts are grown in the river basins. Fishing, herding and rice cultivation provide opportunities for cash incomes.

Until 1972, Mali's greatest agricultural resource was livestock, totaling 5 million cattle, and 10 million sheep and goats. However, the national herd was seriously depleted by the 1972 drought. Despite these losses, the livestock industry will continue to be important for Mali's future as an area of potential growth for the country's economy.[2] Low rainfalls have remained one major constraint to Mali's agricultural sector in recent years.

In 1973 and 1974, Mali's GDP declined due to drought losses, yet it increased at an exceptionally high rate in 1975 and 1976, partially because of the improvement in the agricultural sector. Nevertheless, until Mali can effectively manage and exploit its water resources, its economic well-being will always be prey to cyclical climatic conditions.

In the past Mali was self-sufficient in grains. But diminished harvests, a growing population and changing dietary habits have resulted in small grain deficits each year since 1965, with major shortages occurring in 1969 and 1971 and from 1972 through 1974. Currently one of Mali's prime policy objectives is to increase local

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[2] Marches Tropicaux et Mediteraneens, p. 3570.

production. The long-term goal is to re-establish Mali as a net exporter of food stuff to neighboring states.

In the intermediate term the government hopes to increase food self-sufficiency by:

1. decreasing grain imports gradually;
2. transferring hectarage from cash crops to grains;
3. opening up new lands; and
4. increasing grain yields per hectare.

The first policy goal is politically and economically sensitive. Restricting grain imports means higher domestic prices for consumers, the majority of whom spend a large percentage of their income on food. As a result, the government and private agencies may feel pressure to increase wages, which in turn increases inflation. This may also make it more difficult for non-wage households, especially the urban poor, to obtain an adequate diet.

The second policy may affect the country's foreign exchange supplies which are derived mainly from cash crop exports.[3] In 1970 cotton production was discontinued in the Office du Niger area in order to increase rice production.[4]

The third policy is very costly and may carry a low return to investment due to the need to improve or build new infrastructures

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[3]In 1977 cotton alone accounted for 60 percent of the country's exports and peanuts 14 percent. See Marches Tropicaux et Mediteraneens, p. 3565.

[4]West African Rice Development Association, "Mali Office du Niger," Identification Report. Final Edition. June, 1974.

such as irrigation systems, roads and other transport systems, health care services, etc.[5] Large plains in southern Mali remain unused because the area is infested with similium damnosum, a carrier of onchocerciasis or "river blindness" (see Figure 1). The Office du Niger is also reported to be underutilized.

The fourth policy involves the developing and expanding new techniques of production, and increasing the rate of adoption of new technology. Market forces can be used to attain these goals if policy can influence prices and improve the terms of trade under which farmers make production and investment decisions. Improvement in farm terms of trade may be done either by increasing farm level commodity prices or by subsidizing input costs. This study contributes to our understanding of the former policy: increasing agricultural production by raising and/or stabilizing farm level commodity prices. It depends critically upon the hypothesis that farmers respond to changes in commodity prices. Hypothesis about supply responses may be divided into three major categories:

1. "The hypothesis that farmers in under-developed agriculture respond quickly, normally and efficiently to relative price changes;
2. The hypothesis that marketed production of subsistance farmers is inversely related to price.
3. The hypothesis that institutional constraints are so limiting that any price response is insignificant."[6]

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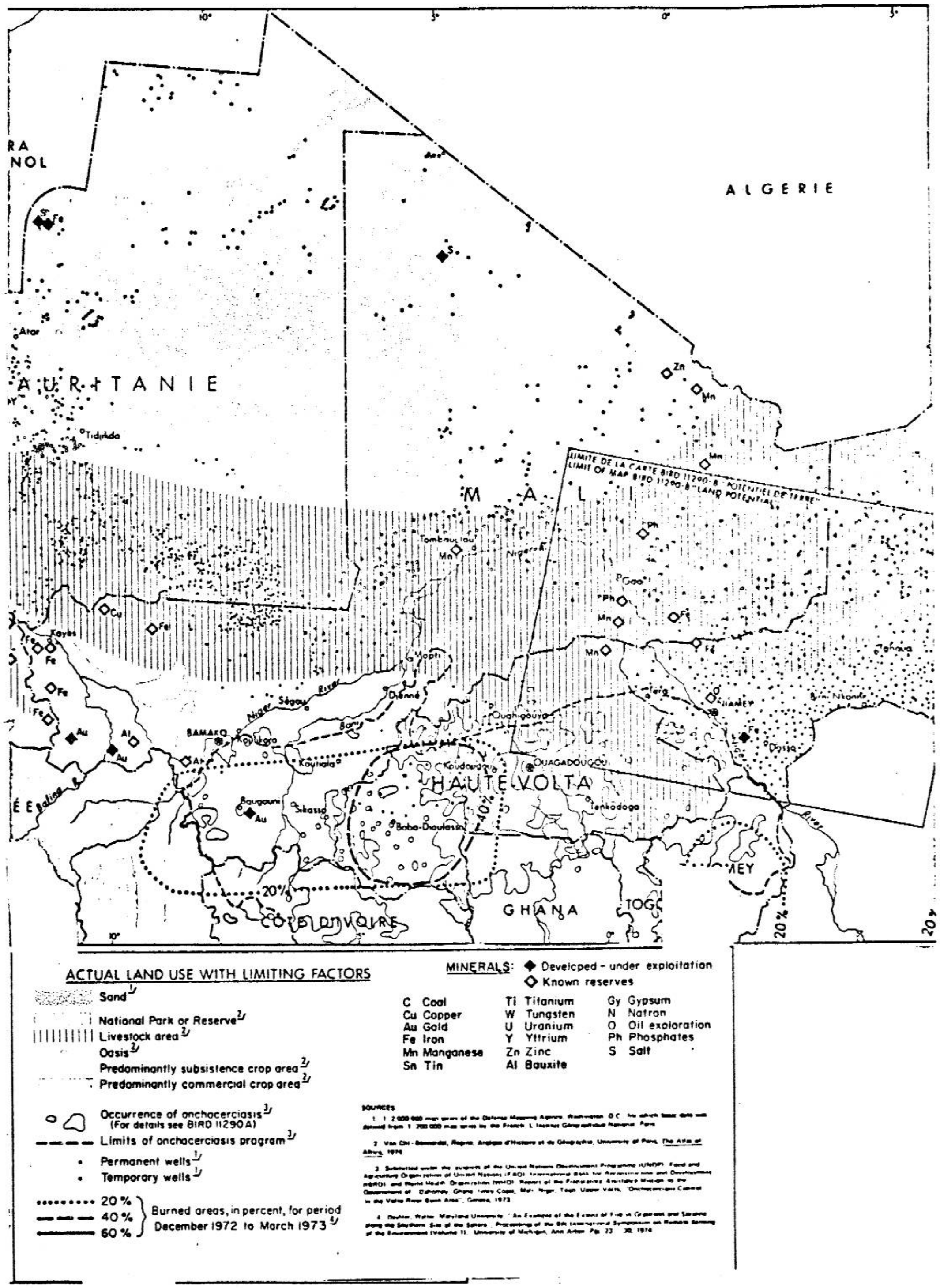
[5]Mellor, Economics of Agricultural Development, p. 187.

[6]Behrman, "Supply Response in Underdeveloped Agriculture," p. 4.

Figure 1: Land Use in Mali



A major proponent of the first hypothesis is T.W. Schultz, who repeatedly and emphatically says:

> "The rate at which farmers have settled into a traditional agriculture accept a new factor of production depends upon its profit with due allowance for risk and uncertainty and in this respect the response is similar to that observed in modern agriculture . . . The doctrine that farmers in poor countries either are indifferent or respond perversely to changes in prices . . . is patently false and harmful. Price policies based on it always impair the efficiency of agriculture."[7]

Schultz' emphasis on profitability, however, does not exclude the relative importance of risk and uncertainty involved in the adoption of the new technology. He also concedes that some cultural and institutional restraints may have adverse effects on output. Nonetheless, he insists that such restraints leave considerable leeway for responses to economic variables, and that in the economic equilibrium of traditional agriculture, these responses result in the efficient utilization of existing factors of production.

A number of economists agree with Schultz' prediction that traditional agriculture responds to relative price changes. Robert Stern emphasized that the price system seems to work fairly well in both the short and long run in the less developed countries.[8] P.T. Bauer has argued that Africans respond rapidly and in an orthodox manner to price fluctuations.[9] Earl O. Heady contends that "at every point over the world where sufficient time series data are

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[7]Schultz, Transforming Traditional Agriculture, p. 33.

______, Economic Crisis in World Agriculture, p. 49.

[8]See Stern, "The Price Responsiveness of Primary Producers."

[9]See Bauer, West African Trade.

available, computation of supply function shows farmers to be responsive to prices of factors and products."[10]

The second hypothesis, that marketed surplus of subsistence farmers is inversely related to prices, is advocated by D.R. Khatkate. He bases his thinking on the fact that subsistence farmers may have fixed money obligations and therefore sell only as much of their production as necessary to obtain the desired income.[11] It is often asserted that African farmers respond to price changes in an unpredictable fashion, that they either tend not to respond at all, or that they respond perversely to price changes.[12] If these assertions are true, they of course make difficult or even impossible the efficient functioning of a market economy.

The proponents of the third hypothesis argue that the institutional and cultural constraints limit responsiveness in traditional agriculture to various incentives. The first subset of such constraints is referred to by Wharton as "human inelasticities" to signify limited knowledge of the "possible," limited tastes, natural conservatism, etc.[13] The second subset of institutional constraints includes various aspects of market imperfections that prevent

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[10]Heady, "Processes and Priorities in Agricultural Development," p. 61.

[11]Deena R. Khatkate, "Some Notes on the Real Effects of Surplus Disposal in Underdeveloped Economies," <u>The Quarterly Journal of Economics</u>, vol. 76, 1962, pp. 186-196.

[12]Jones, "Economic Man in Africa," p. 108.

[13]See Wharton, "The Inelasticity of Southern Asian Agriculture."

traditional agriculture from exhibiting significant price responses.[14] Such imperfections include lack of competition in the credit market, where small farmers often face discrimination. Perhaps more significant is imperfect knowledge of new factors and/or new techniques c production. Transportation and storage facilities also can be inadequate, and therefore increase marketing costs.

A. Some Clarifying Distinctions

Most debate over the supply responsiveness in underdeveloped agriculture has failed to make explicit two important distinctions. The first is the distinction between produced and marketed supplies. These two supplies do not necessarily respond identically to given incentive. Production and marketed supply differ by the amount of on-farm consumption. Second is the very important distinction between the short run and the long run responses.[15] For most agricultural commodities the length of the growth cycle limits very short run responses. The shorter the growth cycle the more quickly quantities produced respond to given incentives. The longer the growth cycles the more lagged would be the response to given incentives.

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[14]Lele, "Considerations Related to Optimum Pricing and Marketing Strategies in Rural Development," pp. 501-522 lists as imperfections such things as: 1) poor dissemination of price information, and poor communication facilities; 2) inadequate and unreliable transport facilities between producing and consuming centers; 3) poor storage and handling facilities that result in losses; and 4) failure to enforce standard weights and measures.

[15]Tomek and Robinson, <u>Agricultural Product Prices</u>, p. 79. The authors give a working definition for the short run and long run responses as the following:

> "1) The short run elasticities are based on responses which occur within one or two production periods;
>
> 2) the long run elasticities are based on the effects of a price change allowing whatever time is necessary for all adjustment to occur."

B. Purpose and Specific Objectives of the Study

Numerous studies conducted in the 1950's focused on industrialization, with little attention paid to the agricultural sector. Limited aspects of the sector were considered in some studies, where surplus rural population was said to be a potential source of labor in the industrial sector.[16] This "Surplus Labor" approach, however, is not adequate for a developing country such as Mali where food shortages are serious problems and where agriculture is the mainstay of the economy.

To evaluate the role of the agricultural sector in development, the responsiveness of that sector to various incentives must be known. Only with knowledge of this responsiveness can the effects of various specific policies on agriculture and overall economic growth be determined.

The purpose of this study is to develop economic models and apply econometric techniques to data from Mali to measure farmers' responsiveness to price and other factors in an underdeveloped agricultural sector. Only rice, millet and sorghum are examined. These types of farming have been considered for three specific reasons:

1. Since 1969, Mali has lost its self-sufficiency in grains and has become a net importer, except in 1975 and 1976;

2. The drought of 1973-1974, with it's disastrous consequences, has created a new interest in agriculture, and some drought recovery programs were undertaken to re-establish self-sufficiency; and

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[16]Lewis, Economics of Development with Unlimited Supplies of Labor, pp. 139-191.

3. The growing population, the increased urbanization and the changing dietary habits have increased demand for grains during recent years.

The specific objectives are to:

1. Review recent grain marketing policies in Mali;

2. Predict domestic production of millet/sorghum, rice and their respective amounts sold to the "office des produits agricoles du Mali," also called OPAM—the National Grain Agency;

3. Evaluate the impacts of government policy on the rice and millet/sorghum production and sales.

This analysis may serve as a guide to policy makers and development planners in implementing strategies for self-sufficiency in rice and millet/sorghum in Mali.

C. Methodology and Data Collection

Methodology. This study analyzes several factors that are hypothesized determinants of production and official marketed supply of rice and millet/sorghum in Mali. Multiple linear regression is used to estimate models and test hypotheses based on theory and knowledge of economic theory in the Malian grain markets. These results are then used to develop policy recommendations that contribute to the Malian government goal of increasing domestic food production.

Data Collection. This study relies primarily upon time series data from 1960 to 1979, but other data are employed when relevant. Most data were found in the Marches Tropicaux et Mediteraneens (1979), in the C.I.L.S.S. documents (1977), and the West African Rice Development Association document (1979). The 1960 starting point of the data series corresponds to the advent of Mali's independence.

In almost any empirical policy study the quality and reliability of the data used pose some measurement problems. Numerous sources of data were consulted for this study and each often gives a different estimate for a given magnitude. This study uses what seems to be the most accurate figures when conflicting estimates exist. The raw data used in this study are presented in Appendix I and the simple correlation matrices in Appendix II.

D. Plan of the Remaining Chapters

Chapter II takes a detailed look at Mali's grain policies since independence. Chapter III explains the specification of several supply response models, the results of which are discussed in Chapter IV. Chapter V is a discussion of the effects of government pricing policy on the grain subsectors. This chapter is followed by a summary, recommendations, and suggestions for further research in Chapter VI.

II. OVERVIEW OF THE GRAIN POLICIES

During the early years of independence, the essential objective of Mali's economic policy was to achieve a socialistic transformation of the economy and society. The basis for that transformation was a system of planning based on a combination of the French and eastern bloc models. Actions undertaken by the post independence government included the nationalization of industries, the establishment of state industrial and commercial firms and large investment in transportation.

Producers and consumers cooperatives were set up to play both economic and political roles. Their members were party affiliates and they assumed the responsibility for all commercial operations associated with the sale of agricultural products and purchases of consumer goods for the entire rural population. In practice, if not in theory, this required a complete ban on domestic and international private trading and the establishment of state monopolies.

The objectives of Mali's agricultural policy during this period were twofold: a supply of cheap cereals to urban populations in order to hold down the cost of living for the urban consumers and foster industrial capital accumulation, and increased exports of cotton and groundnuts to finance imports of capital goods.

The government attempted to establish collective fields in every village during the first five-year plan (1961-1966). The move was based on the premise that collective agriculture was the original and most productive African model. Modibo Keita, the head of state during that era, outlined the basic policy as follows:

". . . we ask each village to act so that it's collective fields develop in such a way so as to attain in five years, at the end of the plan, an area of one hectare per family . . . Also in these five years, each village must organize a permanent work team which will spend one or two days each week in each family field. Thus, these teams, trained and equipped by agricultural extension workers, will be the elements of technical progress in each village . . ."[17]

The government adopted a strict policy of fixed producer prices for all crops. Table II indicates that there was very little variation in cereal and cash crop prices. It also indicates that government pricing policy was intended to stimulate cash crop production as opposed to cereal production. In fact, the prices of millet/sorghum and rice were lowered to maintain Mali's competitiveness in the French zone. Prices were also kept low to avoid heavy subsidies on exports, thereby saving tax revenues, and to provide cheap domestic cereals.[18]

Government policies on the whole were destined to transfer income from producers to consumers and, as William I.Jones puts it:

". . . it was government policy to keep food prices low in the towns not only because town dwellers were politically powerful but because most of them were government or state enterprise employees. Raising their costs of living was bound to alter the government wage bill, and to diminish the profits (or increase the deficits) of the Mali Corporation. In the interest of accumulation, farmers were asked to market more for patriotism sake."[19]

Although farmer prices were kept fixed and low, the prices of most goods they purchased rose. Mali's national accounts show that the

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[17]Jones, Planning and Economic Policy, pp. 197, 226.

[18]The minimum wage and the wage paid to government employees did not increase throughout the eight years of the first regime. Cereal prices did increase in that time. See C.I.L.S.S. document (vol. I, p. 136).

[19]Jones, op. cit., p. 301.

Table III. Official Producer and Retail Prices of Various Crops (1959-1979)[a]

Years	Millet/Sorghum (Retail)[b]		Rice (Retail)[c]		Cotton[d]	Peanuts[e]
1959	16	(n.a.)	12.5	(n.a.)	34	16.8
1960	11.5	(n.a.)	12	(n.a.)	34	15.6
1961	10	(16.5)	9	(30)	34	14
1962	10	(16.5)	9	(30)	34	14
1963	10	(16.5)	11	(37)	34	14
1964	10	(16.5)	11.5	(42)	34	14
1965	11	(17.5)	12.3	(45)	34	13
1966	11	(17.5)	12.5	(45)	34	13
1967	16	(25)	16	(57)	34	16
1968	16	(25)	18	(56)	40	24
1969	16	(25)	18	(56)	40	24
1970	18	(25)	25	(76.5)	45	30
1971	18	(35)	25	(76.5)	50	30
1972	20	(35)	25	(80)	50	30
1973	20	(35)	25	(88)	50	30
1974	32	(51)	25	(88)	50	30
1975	32	(51)	40	(111.5)	50	40
1976	32	(51)	40	(111.5)	75	40
1977	32	(51)	40	(111.5)	75	45
1978	36	(n.a.)	45	(n.a.)	90	50
1979	40	(n.a.)	50	(n.a.)	95	60

[a]Sources are WARDA, "Rice Policy in Mali," p. 11a; Marches Tropicaux et Mediteraneens, pp. 3563, 3564, 3566 and Assises du Commerce, p. 3.

All prices are in Malian francs/kg. All years are the second year of the crop season, i.e., 1966/67 is written 1967. Retail prices are shown in parenthesis.

[b]Mali has never established separate prices for millet and sorghum. Before 1967 there were separate prices by surplus or deficit region; the prices shown here are surplus region prices.

[c]Rice quality is white paddy. It's quality is 40 percent broken.

[d]First quality seed cotton.

[e]Peanuts in shell.

[f]The Malian franc was devaluated by 50 percent in 1967 as a condition for its convertibility.

general price index rose by as much as 68 percent between 1959 and 1967, and this is indicated in Table IV. There is no way of quantifying the price changes for rural purchases, but there is reason to believe that they were greater than those affecting town dwellers or at least town dwellers who were willing to limit their purchases of imports.

Table IV. General Price Index*

1959	1962	1964/5	1965/6	1966/7
100	n.a.	150.5	153	168

Source: William I. Jones, p. 301, 1976

*Other years not tabulated

The impact of these policies on farm production was not considered, or rather it was hoped that collectivization and the reduction of transport costs and commercial margins would expand production despite lower prices.[21] Theoretically, improvements that result in lowering the percent costs of marketing services will lead to three desirable results in competitive markets: 1) retail prices of food will fall; 2) the quantity of food demanded will increase; and 3) farm level prices will increase. On the other hand collectivization has not proven itself as a strategy for raising farm productivity in the Soviet Union or other state-controlled economies. It has enjoyed,

[20]15,000 million franc CFA were directed to this sector, or 20 percent of total planned investment (see Africa South the Sahara 1980-1981, London: Europa Publications Limited, 1981), p. 646.

however, some success in Israel. Collective farming did not succeed in Mali.

By 1968 there were only 13,535 hectares of millet or sorghum farmed collectively, with an average yield of 260 kilograms per hectare, and 16,560 hectares of rice farmed collectively with a yield of 136 kilograms of paddy per hectare. This compares with other farms of 867,000 hectares in millet or sorghum with yield of 840 kilograms and 135,000 hectares in rice with yields of 727 kilograms.[21]

The coup d'etat in 1968 brought new changes in government policies regarding grain prices and the organization of the farming sector. Price policy has been used to stimulate production within the system of fixed producer/consumer prices and the official monopoly of domestic and international cereals trading. Collective fields were discontinued and replaced by the traditional land tenure system based on private ownership and by new state and parastatal farms.

Table III indicates that there were major price increases starting in 1970 and more increases were recorded during the 1976-1978 plans to stimulate domestic production, especially for grains. Trends in crop production figures are presented in Table V. Data indicate a negative trend for most crops during the early years of independence and during the droughts of 1969, 1973, and 1974 that affected all Sahelian countries. Production increased exceptionally in 1975 and 1976; the country became self-sufficient and was able to export.

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[21] See IBRD, Economic Report on Mali.

Table V. Production of Major Crops[a]

Years	Paddy[b]	Millet/Sorghum[c]	Groundnuts[d]	Cotton[e]
1960	188	800	n.a.	n.a.
1961	185	850	122	n.a.
1962	188	800	138	n.a.
1963	200	870	167	n.a.
1964	195	755	182	n.a.
1965	158	710	148	33
1966	162	700	153	18
1967	158	737	159	28
1968	172	830	119	37
1969	135	556	26	55
1970	162	503	136	46
1971	163	715	156	56
1972	195	705	152	71
1973	100	624	135	73
1974	20	660	132	55
1975	250	850	188	71
1976	300	865	205	100
1977	350	1,050	n.a.	n.a.
1978	220	820	n.a.	n.a.
1979	270	910	n.a.	n.a.

[a]All productions are in 1000 of tons, and all years are the second year of the crop season: i.e., 1978/79 is written as 1979.

[b,c]1960, 1962 and 1964-1979. Marches Tropicaux et Mediteraneens, pp. 3560 and 3561. 1961 and 1962: WARDA, op. cit., p. 3c.

[d,e]WARDA, op. cit., p. A-3.

Another feature of Mali's post independence agricultural policy was the creation of state agencies that were legal monopolies for the marketing of grains and of cash crops. OPAM was created for three main objectives: 1) to control the grain market so that producers can be guaranteed a remunerative minimum price; 2) to guarantee grain supplies for deficit regions, including urban areas; and 3) to stabilize prices to both consumers and producers. A second agency was created for the marketing of cash crops. A general lack of financial and organizational capacity in marketing agencies has limited their impact. They are financed by the National Development Bank (BDM); but the level of financing is low in comparison to the demand for food products. These agencies tend to enter the market when prices are low and farmers need cash. Thus they do provide a modicum of income support. Nonetheless farmers are often offered higher prices by illicit private traders, particularly in years of poor harvest.

Open market and government prices are displayed in Table VI. There is insufficient information on the range of prices actually offered to producers in the open market, but the figures available indicate a large gap between government and open market prices during the drought of 1972, 1973 and 1974. Open market prices fell back in line with government prices in 1975 due to increased production of rice and millet/sorghum.

As in most Sahelian countries, the farming sector is not strongly market-oriented. Approximately 10 to 15 percent of the total cereal production is marketed annually.

Table VI. Consumer Market Prices for Cereals in Mali: Official Prices and Open Market Prices (in MF, Malian franc)[a]

	Millet/Sorghum		Milled Rice	
Years	Official	Open-Market	Official	Open-Market
1972	91	132	132	n.a.
1973	70	99	61	122
1974	37	76	169	184
1975	60	70	n.a.	n.a.

[a]Montgomery, The Economics of Fertilizer Use on Sahelian Cereals, p. 24.

This means that farmers are mainly concerned with their family's consumption needs and only sell the surplus necessary to pay Mali taxes, cash production expenses, and other expenses (marriage, religious ceremonies, etc.).

Table VII reports the government purchases of cereals between 1961 and 1979. It appears that rice has a much larger share of government marketing. This pattern stems from the fact that nearly all of the officially marketed rice comes from the Office du Niger, where control of access to the irrigation system enables the Office's administration to collect most of the rice grown there. This disproportionate share of rice also results because most farmers save millet/sorghum for their own consumption and sell rice.

Prior to the price increases of 1967 and 1968, the government was able to buy, at most, 18 percent of rice production but only 4 percent of millet/sorghum production. High prices during 1967 and 1968 induced farmers to sell more of their production (on average 23 percent

Table VII. Official Purchases of Millet and Rice (1961-1977)

Years	Rice Production 1000 tons[a]	Millet Production 1000 tons[b]	Rice Sales 1000 tons[c]	Millet Sales 1000 tons[d]	Percentage Rice Sale/ Production	Percentage Millet Sale/ Production
1961	185	850	45	20	11	2
1962	188	800	26	20	14	3
1963	200	870	33	29	17	3
1964	195	755	31	17	16	2
1965	158	710	27	17	17	2
1966	162	700	29	26	18	4
1967	158	737	37	56	23	8
1968	172	830	40	60	23	7
1969	135	556	32	8	24	1
1970	162	503	49	26	30	5
1971	163	715	42	12	26	2
1972	195	705	51	29	26	4
1973	100	624	50	11	50	2
1974	90	660	57	9	63	1
1975	250	850	83	40	33	5
1976	300	865	93	71	31	8
1977	350	1,050	93	31	27	3
1978	220	820	66.4	37	30	5
1979	270	910	62.7	34*	23	4*

*Estimates

SOURCES:

[a]1961 and 1963: WARDA, op. cit., p. 3c; all other years data are available in <u>Marches Tropicaux et Mediteraneens</u>, p. 3561.

[b]1961 and 1963: WARDA, op. cit., p. 3c; all other years data are available in <u>Marches Tropicaux et Mediteraneens</u>, p. 3561.

[c]1961 and 1963: WARDA, op. cit., p. 8a; 1978 and 1979: <u>Marches Tropicaux et Mediteraneens</u>, p. 3564.

[d]C.I.L.S.S., vol. 1, table 9.

[e]Proportion of rice production sold to OPAM.

[f]Proportion of millet production sold to OPAM.

and 8 percent for rice and millet/sorghum, respectively). Despite the drought losses, the government collected 50 to 60 percent of rice production during 1973 and 1974. These same years it collected only 1 to 2 percent of millet/sorghum production. Millet/sorghum increased, however, to 5 and 8 percent in 1975 and 1976 due to good harvests, while rice purchases dropped to 30 percent. The low percentages of grain sales to the government denote the grain agency's failure to attain and sustain a monopoly. This is in spite of the fact that the government has used coercive means such as setting quotas, and prosecuting private traders.

WARDA has estimated the per capita availability of cereals for both the urban and the rural sectors. The results are presented in Table VIII. The total cereal production has been adjusted for seeds, losses and official marketings to give an estimate of the per capita cereal availability to rural people. Also, official marketings have been added to cereal imports to give an estimate of the per capita cereal availability for urban consumers, assuming all imports and official marketings have been directed toward urban dwellers. It appears that the per capita availability of millet/sorghum is much higher for rural than for urban people, a situation that prevailed despite the excellent harvests of 1961 through 1964. Although information about the privately marketed supplies are lacking, this gap indicates the potential for private trade between rural producers and both urban and rural consumers. The generally low per capita availability of millet and sorghum to urban consumers is also a direct measure of OPAM's inability to supply grains to urban consumers.

Table VIII. Per Capita Cereals Availability, 1961-1975*
(kilograms)

	1961	1963	1965	1967	1969	1971	1973	1975
Millet and sorghum								
Rural[a]	187	179	140	169	101	122	104	133
Urban[b]	0	62	41	140	47	40	105	65
Total	187	169	130	166	96	114	104	124
Percent imports in total	0	0	0	1	3	2	10	0
Rice								
Rural	17	20	15	12	10	12	2	7
Urban	42	44	33	50	77	71	119	99
Total	19	21	15	16	17	18	15	18
Percent imports in total	0	0	0	0	22	15	54	18
Total of millet and sorghum and rice								
Rural	204	199	155	181	111	134	105	140
Urban	49	106	74	190	124	111	224	164
Total	206	190	145	182	113	132	119	142
Percent imports in total	0	0	0	1	6	4	15	2

SOURCE:
*WARDA, op. cit., p. 11c.

[a]Rural cereals availability is defined as the sum of production minus seed, losses and official marketings (paddy marketings are converted to rice at a milling ratio of 0.65) divided by rural population.

[b]Urban cereals availability is defined as the sum of official marketings plus imports (or minus exports) divided by urban population.

This picture is reflected in the agency's financial losses and the growing gap between official and open market prices.

Table IX reports the agency's sales revenues and profit figures between 1961 and 1974. It appears that OPAM's losses were more or less proportional to its sales volume. The agency lost money because of high transport costs and large retail price subsidies.[22] Its profits increased, however, were high during 1972 and 1973, probably because of large sales of grains donated under the drought relief program.

OPAM's inability to supply urban consumers is also reflected in the gap between prices offered by government cooperatives and the open market. Except for good years when production is high and market prices are low, the grain agency always has a smaller share of the market. It has been noticed that even in good years OPAM is often unable to purchase all the grains supplied by farmers due to a lack of sufficient financing, which means that the grain agency has not been able to maintain a floor or ceiling price on grain purchases and sales, and has not been able to stabilize consumer or producer prices seasonally or interannually.[23]

From the evolution of official and market price indexes presented in Table X, it can be seen that government food pricing policy is biased toward consumers. This bias is also reflected in the

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[22]Prices are set equal anywhere within national boundaries, and the "bareme" which means marketing margin in French are not covered by OPAM's retail prices. Based on Berg estimates, the subsidies on rice imports alone amounted to 25 percent of the country's budget revenues in 1974 (Berg, 1975, p. 76).

[23]Berg, Reforming Grain Marketing Systems in West Africa, p. 1.

Table IX. Total Sales and Profits of OPAM
(Millions of CFA or MF)

Years	Sales Revenues	Profits
1961	n.a.	n.a.
1962	108	-9
1963	337	-31
1964	229	-21
1965	757	-117
1966	1,072	-166
1967	1,938	36
1968	2,250	-258
1969	n.a.	n.a.
1970	n.a.	n.a.
1971	n.a.	n.a.
1972	n.a.	241
1973	n.a.	238
1974	n.a.	88

SOURCE: IDET - CEGOS Etudes des Structure de prix et des Mecanismes de la Commercialisation des Mils et Sorghos, IDET-CEGOS, 1976, p. 6.

Jones, op. cit., pp. 239, 250.

Table X. Price Indices (1963=100)

	Food price indices[a]		Millet price indices		Rice price indices[b]	
	Cooperatives	Bamako market	Official retail	Bamako market	Official retail	Bamako market
1963	100	100	100	100	100	100
1964	n.a.	n.a.	100	128	114	118
1965	117	162	106	261	122	202
1966	122	179	106	311	122	236
1967	148	191	152	255	154	241
1968	171	191	152	233	151	227
1969	161	191	152	267	151	200
1970	169	193	152	233	207	222
1971	188	234	212	270	207	252
1972	197	251	212	400	216	284
1973	214	298	212	672	238	332
1974	256	331	309	461	238	361
1975	316	350	309	405	301	341
1976	351	279	309	383	301	332

SOURCE: WARDA, op. cit., p. 12a.

[a]Mali has no true consumer price index.

[b]Rice quality is 40 percent broken.

gap between official and world market prices, as indicated by the magnitudes of the nominal protection coefficients presented in Table XI. The nominal protection coefficient is defined as the ratio of the domestic prices to the CIF price. It indicates to what extent import prices are subsidized to consumers in order to protect their income against the rising cost of food in the world market. Notice, however, that this benefits only the few consumers who can buy from the state cooperatives. The bulk of consumers get their supplies in the open market where prices are higher and more clearly reflect world prices.

Table XI. Nominal Protection Coefficients, 1961-1976*

	(1)[a]	(2)[b]	(3)[c]	(4)[d]
1961	n.a.	n.a.	n.a.	n.a.
1962	---	n.a.	---	n.a.
1963	---	n.a.	---	.78
1964	---	n.a.	---	.89
1965	---	n.a.	---	1.62
1966	---	.74	---	1.60
1967	---	.48/.55	---	1.00
1968	---	.53	---	.94
1969	.60	.55	.88	.81
1970	.96	1.02	1.12	1.19
1971	.97	1.11	1.28	1.46
1972	.97	.92	1.40	1.33
1973	.64	.57	1.07	.97
1974	.35	.34	.58	.57
1975	n.a.	.70	n.a.	.87
1976	n.a.	1.00	n.a.	1.21

*SOURCE: WARDA, op. cit., p. 12b.

[a]Ratio of wholesale cooperative prices of 40 percent broken rice to the c.i.f. Bamako price of similar grade rice.

[b]Ratio of the wholesale cooperative price of 40 percent broken rice to the c.i.f. Bamako price of 25-30 percent Thai broken rice.

[c]Ratio of the Bamako market price of 40 percent broken rice to the c.i.f. Bamako price of similar grade rice.

[d]Ratio of the Bamako market price of 40 percent broken rice to the c.i.f. Bamako price of 25-30 percent Thai broken rice.

III. MODEL SPECIFICATION

A crucial problem for all economic theorists is whether their theory is applicable throughout the world or relevant only in developed countries with large and complex markets. In this chapter we deal with one aspect of this important question: the supply response of traditional farmers, specifically millet/sorghum and rice farmers in Mali. The analysis combines two steps. The first step is to develop an econometric model, describing in a consistent manner the variables hypothesized to influence the domestic production and official purchases of millet/sorghum and rice. The second step involves the explicit definition of equations which are to be estimated and the underlying hypothesis to be tested. Relevant to this step are data availability and the identification of the appropriate functional relationships.

A. Millet/Sorghum

The millet/sorghum model consists of two economically meaningful relationships: 1) an equation to predict domestic production, and 2) an equation to predict domestic sales to OPAM. This two equation system is recursive. Equation one relates domestic production of millet/sorghum (TPM_t) to lagged price of millet/sorghum, lagged groundnut/millet price ratio, lagged cotton/millet ratio, lagged domestic production of millet/sorghum, technology and binary variables for drought and government policies.

Lagged Price of Millet/Sorghum (PM_{t-1})

This variable measures the effects of the expected future price on farmers' decisions to produce. Economic theory predicts that, under pure competition, price constitutes the major determinant of farmers' decisions as to what to produce and how much to produce. But farmers seldom know what prices will prevail at harvest when they are making planting decisions. In Mali, for example, millet is planted in June and official farm prices are announced in December. Hence, the latest information farmers have regarding the price level of millet for any marketing year, t, are the prices of the previous year, t-1. The expected price, as measured by last year's price, is hypothesized to be positively associated with domestic production of millet/sorghum.

Lagged Cotton/Millet Price Ratio ($PCOT_{t-1} \div PM_{t-1}$) and Lagged Groundnut Millet Price Ratio ($PGNT_{t-1} \div PM_{t-1}$)

In the short run, the most important cost involved in the production of millet/sorghum (or any crop) is the lost opportunity to produce other things. Two important alternative crops in the case of millet/sorghum are cotton and groundnuts. The lagged prices of these crops are normally used in supply response models but, due to the high correlation between price series, the lagged price ratios are used here. The two price ratios are hypothesized to be negatively related to domestic production of millet/sorghum.

Lagged Domestic Production of Millet/Sorghum (TPM_{t-1})

Current production is usually highly correlated with production in the previous year. The lagged domestic production is included as a "gross estimate" to measure any distributed lag effects in the response of production to the other independent variables. It may also carry the effects of changes over time not specifically measured by the other variables in the equation (for example, farm crop rotation practices, management habits, or amount of fixed assets in millet/sorghum production). Lagged domestic production is hypothesized to be positively related with the domestic production of millet/sorghum.

Technology (T)

The supply curves of most agricultural commodities have shifted because of technological changes. Such changes are embodied in an efficient combination of resources, or in the reduction of resource costs. As technology progresses it becomes possible to produce more cheaply with the same amount of inputs. Thus farmers are willing to produce at a lower price than formerly. Examples of technological changes in millet production include the introduction of new varieties of seeds and the adoption of improved production practices.

Because technical change is difficult to measure, but accumulates over time, a time trend is included as a "proxy" for technological change. Technological change is hypothesized to be positively related to millet production.

Government Policies (BVMIL)

Government policies are represented by a binary variable that takes values 0 before 1968, and 1 in 1968 and thereafter. Such policies include discontinuing collective agriculture and establishing new regional development programs ("programme de development rural integre" in French). This binary variable is introduced by itself in some equations. In others it is specified jointly with trend and an interaction term, BVMIL*TREND, to measure both the change in intercept and slope that occurred with the change in government. When introduced separately BVMIL is hypothesized to have a positive effect on production. When introduced jointly with trend and the interaction term, the coefficient on BVMIL is hypothesized to be negative. This is because the change in government during 1968 disrupted the harvest. The coefficient on the interaction term is hypothesized to be positive. That is, annual production is expected, other factors remaining constant, to increase more rapidly due to technological and institutional change after 1968.

Drought (BVDGT)

Yield and total production vary directly with rainfall. Ideally one would use average rainfall data to measure the impact of drought an production, but such data was not available for all years included in this study. Over the past years domestic production decreased largely because of drought. Thus a binary variable carrying values 1 during the years of drought (1969=1970=1973=1974=1978=1) and values 0 otherwise is included to capture the effects of the recent Sahelian droughts. A negative relationship is expected.

Equation two of the recursive system explains the quantity of millet/sorghum sold to the government (SM_t). One or more of the following exogenous factors may influence the sale of millet/sorghum: current official price of millet/sorghum, current production of millet/sorghum, the change in production, technology, the lagged sales of millet/sorghum and government policies.

Current Official Price of Millet/Sorghum (PM_t)

This variable measures how official prices affect a farmer's decision to sell millet to the national grain board. Usually millet prices are announced during harvest time in December. The current official price of millet is hypothesized to be positively related to sales to the government.

Current Production of Millet/Sorghum (TPM_t)

This endogenous variable is hypothesized to be positively related to sales to the government. As production increases, the open market prices usually fall towards and possibly below the government price. Hence, farmers tend to sell more to the government.

Change in Production of Millet/Sorghum ($\Delta TPM_t = TPM_t - TPM_{t-1}$)

This variable is hypothesized to be positively related to sales to the government. Farmers feel less pressure to hold safety stocks when production increases than when production is decreasing. This variable takes both positive and negative values, and is an alternative specification to TPM_t.

Technology (T)

This time trend represents the effect of technological changes on farmer sales to the government. Such changes include the reduction in marketing costs per unit of output sold due to improvement in storage facilities, in transports, in handling facilities, etc. Technology is expected to be positively related to sales to government.

Government Policies (BVMIL)

Since 1968, the government has attempted to increase its control over the millet market. These attempts include: the creation of regional development institutions in charge of millet collection and a ban on the free movement of grain. The same binary variable used in the previous equation carrying values 0 before 1968 and values 1 thereafter is included here to capture more rigorous enforcement of government policy. A positive relationship is expected between BVMIL and the sales of millet. This variable is also specified jointly in some tests of the model with an interaction term BVMIL*TREND and TREND to capture slope effects similar to those hypothesized in the first equation. In the joint specification the coefficient on BVMIL is hypothesized to be negative while the coefficient on the interaction term, BVMIL*TREND, is hypothesized to be positive. That is, annual sales to OPAM are expected, other factors remaining constant, to increase more rapidly due to technological and institutional change after 1968.

<u>Lagged Sales of Millet/Sorghum</u> (SM_{t-1})

This lagged dependent variable usually captures the effects of changes over time not explicitly measured by the other independent variables in the equation. Here it may measure change in farmers long-term expectations concerning official price policy. A positive relationship is expected between the lagged sales and the current sales to government.

Equations one and two, and the associated hypothesis are summarized below:

1) $TPM_t = \alpha_0 + \alpha_1 PM_{t-1} + \alpha_2(PCOT_{t-1} \div PM_{t-1}) + \alpha_3 BVDGT +$

$\alpha_1>0 \quad \alpha_2<0 \quad \alpha_3<0$

$\alpha_4(PGNT_{t-1} \div PM_{t-1}) + \alpha_5 T + \alpha_6 BVMIL + \alpha_7 T{*}BVMIL + \alpha_8 TPM_{t-1} + \varepsilon_{1t}$

$\alpha_4<0 \quad \alpha_5>0 \quad \alpha_6 \gtrless 0 \quad \alpha_7>0 \quad \alpha_8>0$

2) $SM_t = B_0 + B_1 PM_t + B_2 \Delta TPM_t + B_3 TPM_t + B_4 T + B_5 BVMIL + B_6 T{*}BVMIL +$

$B_1>0 \quad B_2>0 \quad B_3>0 \quad B_4>0 \quad B_5 \gtrless 0 \quad B_6>0$

$B_7 SM_{t-1} + \varepsilon_{2t}$

$B_7>0$

Where:

TPM_t = domestic production of millet/sorghum in thousands of tons (1000 tons)

SM_t = sales of millet/sorghum to OPAM in thousands of tons (1000 tons)

PM_{t-1} = lagged official producers' price per kilogram of millet/sorghum in Malian francs (MF/KG)

$PCOT_{t-1} \div PM_{t-1}$ = lagged cotton/millet price ratio

BVDGT = binary variable carrying values 1 when there is drought (1969=1970=1972=1973=1974=1978=1) or 0 otherwise

$PGNT_{t-1} \div PM_{t-1}$ = lagged groundnut/millet price ratio

T = time trend (T = 1, 2, 3, . . .)

BVMIL = binary variable carrying value 0 before 1968, and value 1 in 1968, and thereafter to capture the influence of government policies and to change the intercept

T*BVMIL = interaction term between T and BVMIL used to change the slope

TPM_{t-1} = lagged domestic production of millet/sorghum in thousands of tons (1000 tons)

PM_t = current official producers' price per kilogram of millet/sorghum in Malian francs (MF/KG)

ΔTPM_t = change in domestic production from its previous level in thousands of tons (1000 tons)

SM_{t-1} = lagged sales of millet/sorghum in thousands of tons (1000 tons)

$\alpha_i = B_i$ = where i = 0,1,2,3,... = regression parameters to be estimated

ε_{1t} = error term equation one $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) = \sigma^2$, $E(\varepsilon_t \varepsilon_{t-m}) = 0$ where $m \neq 0$ for all t

ε_{2t} = error term equation two $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) = \sigma^2$, $E(\varepsilon_t \varepsilon_{t-m}) = 0$ where $m \neq 0$ for all t

B. Rice

The rice model consists of two equations similar to those in the millet/sorghum model: 1) the domestic production equation and 2) the sales to OPAM equation. The domestic production of rice (TPR_t) is hypothesized to be significantly influenced by the lagged official price of rice, lagged domestic production of rice, technology and binary variables measuring drought, and changes in government policies.

Lagged Price of Rice (PR_{t-1})

This variable measures the influence of price on a farmer's decision to produce. Just as for millet, the official producers' price of rice is announced in December after planning which starts in June. Hence, the single most important determinant of the rice farmer's price expectation in any given marketing year t may be the price of the previous year, t-1. The lagged price of rice is hypothesized to be positively associated with domestic production of rice.

Technology (T)

Long run shifts in the supply schedule for many agricultural commodities are often caused by technological changes. As previously stated, such technological changes are embodied in a better combination of resources or a decrease in resource costs. Moreover, as technology improves it becomes possible to produce more rice with the same amount of inputs; thus farmers are willing to supply more rice at a given price. The most important technological changes are increased irrigation through projects such as the French "Markala dam" project, the regional development institutions ("Operation Riz") and the adoption of new varieties of seeds. Because of measurement problems involved, a time trend is used as a "proxy" for technology; it is hypothesized to be positively associated with current domestic production of rice.

Government Policies (BVMIL)

This is the same explanatory variable that was specified in the millet/sorghum equation. Here it is introduced separately and jointly with trend and interaction term, BVMIL*T, just as in the millet/sorghum annual production equation. The rationale and hypotheses are also the same.

Drought (BVDGT)

Nearly all of the rice in Mali is grown on the hydromorphic soils of the Niger and Bani rivers. However, the ferrugenous soils of the south also support small amounts of rainfed cultivation. During the Sahelian drought, rice production decreased. To capture this effect, a binary variable is included carrying values 1 in the presence of drought (1969=1970=1973=1974=1978=1) or 0 otherwise. Drought is hypothesized to be negatively associated with domestic production of rice.

Equation two of the recursive system relates the sales of rice to OPAM (SR_t) to the current official producers' price of rice, current domestic production of rice, change in domestic production of rice, lagged sales of rice to OPAM, technology and government policies.

Current Official Producers' Price of Rice (PR_t)

Unlike millet, rice is not considered to be a traditional cereal and is highly differentiated. The government offers three different prices for rice based on quality. The highest price is paid for white paddy, the lower for red and an intermediate price for the mixed red and white. Because all paddy produced in the government-sponsored rice projects is white, except for a small amount in Mopti, the white paddy price is the relevant price. The current official producer price of rice is hypothesized to be positively associated with the sales to government.

Current Domestic Production of Rice (TPR_t)

OPAM sales usually increase when domestic production expands. This is because open market prices are lowered, and more often fall in line with government guaranteed prices when production is high. Hence, farmers find selling to the grain agency relatively more attractive. The current domestic production is expected to be positively associated with the sales to OPAM.

Change in Domestic Production of Rice ($\Delta TPR_t = TPR_t - TPR_{t-1}$)

This variable is an alternative specification to TPR_t and is the change in annual production. It takes both positive and negative values. In years when production increases, farmers feel less pressure to hold safety stocks than in years when production decreases. Therefore the change in domestic production is hypothesized to be positively associated with the sales to OPAM.

Technology (T)

This variable measures the influence of the improvement in the distribution channels on farmers' decisions to sell. Such improvements are embodied in the net reduction of marketing cost per unit of output sold. The most important recent technological changes introduced are the construction or improvement of secondary roads and the construction of milling facilities. Technology is measured by a time trend and hypothesized to be positively associated with the sales of rice to OPAM.

Government Policies (BVMIL)

This is the same explanatory variable that was specified in the millet/sorghum equation. Here it is introduced separately and jointly with trend and an interaction term, BVMIL*T, just as in the millet/

sorghum annual production equation. The rationale and hypotheses are also the same.

Lagged Sales of Rice (SR_{t-1})

This lagged dependent variable is included to measure any distributed lag effects of farmers in the response of sales to the other independent variables. It also carries the effects of changes over time not specifically measured by the other independent variables (for instance, farmers' selling habits, or long-term expectations concerning government price policy). The lagged sale of rice is expected to be positively associated with current sales to OPAM.

Equations one and two and the associated hypotheses are summarized below:

1) $TPR_t = \alpha_0 + \alpha_1 PR_{t-1} + \alpha_2 BVDGT + \alpha_3 T + \alpha_4 BVMIL + \alpha_5 T{*}BVMIL +$

$\alpha_1 > 0 \quad \alpha_2 < 0 \quad \alpha_3 > 0 \quad \alpha_4 \gtrless 0 \quad \alpha_5 > 0$

$\alpha_6 TPR_{t-1} + \varepsilon_{1t}$

$\alpha_6 > 0$

2) $SR_t = B_0 + B_1 PR_t + B_2 \Delta TRP_t + B_3 TPR_t + B_4 T + B_5 BVMIL + B_6 T{*}BVMIL +$

$B_1 > 0 \quad B_2 > 0 \quad B_3 > 0 \quad B_4 > 0 \quad B_5 \gtrless 0 \quad B_6 > 0$

$B_7 SR_{t-1} + \varepsilon_{2t}$

$B_7 > 0$

Where:

TPR_t = domestic production of rice in thousands of tons (1000 tons)

SR_t = sales of rice to OPAM in thousands of tons (1000 tons)

PR_{t-1} = lagged official producers' price per kilogram of rice in Malian francs (MF/KG). The white paddy price is used.

BVDGT = binary variable carrying values 1 when there is drought (1969 = 1970 = 1973 = 1974 = 1978 = 1) or 0 otherwise

T = time trend (T = 1, 2, 3, ...)

BVMIL = binary variable carrying values 0 before 1968 and value 1 in 1968 and thereafter to capture the influence of government policies on the domestic production of rice and to change the intercept in 1968

T*BVMIL = interaction term between BVMIL and T used to test the change in slope after 1968

TPR_{t-1} = lagged domestic production of rice in thousands of tons (1000 tons)

PR_t = current official producers' price per kilogram of rice in Malian francs (MF/KG)

ΔTPR_t = change in domestic production of rice in thousands of tons (1000 tons)

SR_{t-1} = lagged sales of rice to OPAM in thousands of tons (1000 tons)

α_i = B_i = where i = 0,1,2,... regression parameters to be estimated

ε_{1t} = error term equation one $E(\varepsilon_t) = 0$, $E(\varepsilon_t{}^2) = \sigma^2$, $E(\varepsilon_t \varepsilon_{t-m}) = 0$ where $m \neq 0$ for all t

ε_{2t} = error term equation two $E(\varepsilon_t) = 0$, $E(\varepsilon_t{}^2) = \sigma^2$, $E(\varepsilon_t \varepsilon_{t-m}) = 0$ where $m \neq 0$ for all t

IV. EMPIRICAL RESULTS*

The models specified in the previous chapter were tested using annual data from 1960 to 1979. Table XII displays the basic descriptive statistics for the domestic production and sales of millet/sorghum and rice. On average, 192.05 thousand tons of rice were produced and 49.105 thousand tons were sold to the National Grain Agency. The coefficients of variation (C.V.) indicate that there is less variability about the mean for domestic production than for sales to OPAM. The reported domestic production of millet/sorghum averaged 765.5 thousand tons and the amount sold to OPAM averaged 29.05 thousand tons. The coefficients of variation are 16.1 and 57.6 percent, respectively, indicating more variability in sales to OPAM rather than in production.

The recursive feature of both the rice and millet/sorghum models permits one to apply ordinary least squares estimation procedure on each structural equation. The resulting coefficient estimates are consistent and assymptotically efficient.[24] Each estimated equation was tested for first order serial correlation. When serial correlation was significant, the Cochran-Orcutt iterative method was used to re-estimate the equation.[25] Only weighted results are reported for equations where serial correlation was a problem. In all of the

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[24]Kmenta, Elements of Econometrics, p. 586.

[25]The test was conducted using the durbin Watson Statistic (DW) at the 5 percent level of significance. This test was not applied to equations containing lagged values of the dependent variables.

*See Appendix I for the raw data used, and Appendix II for the simple correlation matrices.

Table XII. Descriptive Statistics of the Dependent Variables

	Dependent Variables	Units (tons)	Mean	Standard Deviation	Low Value	High Value	C.V.*
1a.	Domestic production of Rice (TPR_t)	1000	102.050	61.03	90	350	.318
1b.	Sales of Rice to OPAM (SR_t)	1000	49.105	20.439	26	93	.416
2a.	Domestic production of millet/sorghum (TPM_t)	1000	765.5	123.468	503	1050	.161
2b.	Sales of Millet/ Sorghum to OPAM (SM_t)	1000	29.05	16.72	8	71	.576

*Coefficient of variation = Standard Deviation ÷ mean.

following tables which report estimation results, t ratios are given in parentheses under coefficient estimates. Tests of statistical significance for individual coefficients are two tailed tests.

A. Millet/Sorghum Estimation Results

This section reports empirical results for millet/sorghum. Each model will be explained from the standpoint of statistical and economic theory.

Production

Equations 1 through 9 in Table XIII introduce alternative specifications to predict the domestic production of millet/sorghum. All reported equations are significant at the one percent level based on an F test. The $\overline{R}^2$ vary between .33 and .80.

Equation 1 is the weighted result of the regression of production on the lagged price of millet/sorghum (PM_{t-1}). The coefficient is positive as expected and is significant at the 10 percent level, which means that millet production is positively related to the lagged government price of millet.

Equation 2 introduces the binary variable for drought (BVDGT) to the model. The coefficient for BVDGT has a negative sign as hypothesized and is statistically significant at the 1 percent level. The Sahelian drought did in fact affect millet yield, causing production to fall. The lagged price of millet (PM_{t-1}) retains its positive sign and increases in significance to the 1 percent level.

Equation 3 introduces the lagged production of millet/sorghum (TPM_{t-1}) to the model. The previous year's production has a positive influence on current production, as expected, which indicates that

Table XIII. Regression Equations Predicting the Production of Millet/Sorghum (1960-1979)

	Dependent Variables	Intercept	Lagged Millet/Sorghum Price PM_{t-1}	Lagged Cotton/Millet Price Ratio $PCOT_{t-1} \div PM_{t-1}$	Drought BVDGT	Lagged Groundnut/Millet Price Ratio $PGNT_{t-1} \div PM_{t-1}$	Trend T	Government Policies & Shift in Intercept BVMIL	Interaction Term T*BVMIL	Lagged Production of Millet/Sorghum TPM_{t-1}	DW	$\bar{R}^2$	F Ratios
1. CORC	TPM (1000 tons)	603.804	8.269+ (1.906)								1.971	.330	10.228**
2. OLS	TPM (1000 tons)	670.066	7.664** (3.860)		-196.870** (4.937)						1.183	.635	17.486**
3. OLS	TPM (1000 tons)	404.270	6.348** (3.835)		-190.951** (5.922)					.381** (3.176)	2.242	.761	21.252**
4. OLS	TPM (1000 tons)	600.298	11.517** (4.624)	103.271* (2.296)	-146.151** (3.420)	-213.367* (2.267)					1.509	.699	11.982**
5. OLS	TPM (1000 tons)	436.858	8.559** (3.20)	51.955 (1.088)	-165.015** (4.146)	-114.094 (1.165)				.297* (2.063)	2.1	.752	12.519**
6. OLS	TPM (1000 tons)	595.563	12.281** (4.072)	82.629 (1.307)	-140.821** (3.111)	-163.145 (1.143)		-39.926 (.478)			1.612	.682	9.138**
7. OLS	TPM (1000 tons)	445.103	22.817** (3.770)	136.191 (2.133)	-119.587* (2.800)	-184.494 (1.412)	-21.364* (1.955)	63.007 (.680)			2.019	.735	9.786**
8. OLS	TPM (1000 tons)	717.697	6.104 (.613)	168.5** (2.821)	-154.472** (3.659)	-320.300* (2.359)	-32.573* (2.877)	-175.346 (1.208)	46.340* (2.01)		2.09	.785	10.914**
9. OLS	TPM (1000 tons)	652.743	.220 (.021)	135.999* (2.201)	-179.344** (4.058)	-291.035* (2.250)	-26.376* (2.250)	-165.577 (1.486)	46.222* (2.083)	.214 (1.416)	2.372	.801	10.601**

Key:

**Significant at 1 percent level.
*Significant at 5 percent level.
+Significant at 10 percent level.

CORC - Cochran-orcutt weighted least squares
OLS - Ordinary least squares

farmers' decisions to produce are also based on their past year's production levels. Years of high production are followed by more production the following year. This relationship is significant at the 1 percent level. The coefficients on lagged millet/sorghum price and drought retain their respective signs and remain statistically significant at the 1 percent level.

Equation 4 deletes the lagged production and includes the two lagged price ratios to the model. The coefficient for lagged cotton/millet price ratio ($PCOT_{t-1} \div PM_{t-1}$) does not have the hypothesized negative sign; but it is statistically significant at the 5 percent level. This means that more millet is produced when cotton profitability increases. The positive sign may be caused by inaccurate data, or possibly by some economic forces that are not accurately modeled in this relatively simple model.[26] The lagged groundnut/millet price ratio ($PGNT_{t-1} \div PM_{t-1}$) is negatively related to production as expected, and it's coefficient is statistically significant at the 5 percent level. This suggests that when groundnut price increases, farm resources used for producing millet are diverted into groundnut production, causing the supply of millet to decrease. The coefficients for lagged price of millet/sorghum and drought retain their respective signs and remain statistically significant at the 1 percent level.

Equation 5 introduces the lagged production of millet/sorghum (TPM_{t-1}) to the model. The coefficient on TPM_{t-1} retains its positive

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[26]This positive relationship can also be expected, since millet follows cotton in rotation and hence capitalizes on residual nutrients from cotton fertilizers.

signs but decreases in statistical significance. The t test indicates a 5 percent significance level which is below the previous level. The coefficient for the two price ratios retain their respective signs but become statistically insignificant despite their very low correlation with TPM_{t-1}. The simple correlation between TPM_{t-1} and $PGNT_{t-1} \div PM_{t-1}$ is -.08; between TPM_{t-1} and $PCOT_{t-1} \div PM_{t-1}$ it is .058. The lagged price of millet/sorghum (PM_{t-1}) and drought (BVDGT) continue to perform as expected and their coefficients remain statistically significant at the 1 percent level.

Equation 6 introduces the binary variable for government policies (BVMIL) to the model, and deletes lagged production. The coefficient for BVMIL does not have the hypothesized positive sign, and it is not statistically significant. When specified in this form (intercept shifts only) government policies appear to have no impact upon millet/sorghum production. The two price ratios retain their respective signs and remain insignificant. The lagged millet price (PM_{t-1}) and drought (BVDGT) continue to perform as predicted and remain significant at the 1 percent level.

Equation 7 introduces the trend variable (T) to the model. T does not have the predicted positive sign but is significant at the 10 percent level. This implies that production actually decreased over time. Perhaps the time trend is not a suitable proxy for improvements in technology or perhaps greater gains actually occurred during earlier years. The coefficient for the binary variable for the shift in supply in 1968 (BVMIL) does not have the hypothesized negative sign and is not significant. Thus the change in government in 1968 had no influence on harvest. The coefficient for the lagged millet/sorghum price (PM_{t-1}) continues to be positive and significant; the lagged cotton/millet price ratio ($PCOT_{t-1} \div PM_{t-1}$) coefficient continues to be positive and regains statistical significance at the 5 percent level. Drought (BVDGT) continues to be negatively related to production and decreases in significance to the 5 percent level. The coefficient for lagged groundnut/millet price ratio ($PGNT_{t-1} \div PM_{t-1}$) is negative and remains statistically insignificant.

Equation 8 introduces the interaction term (T*BVMIL) jointly with Trend (T) and BVMIL to the model. The coefficient for T*BVMIL has the predicted positive sign and is significant at the 5 percent level. The coefficient for trend does not have the expected positive sign but is significant at the 5 percent level. BVMIL is negatively related to production as predicted but is not significant.

The lagged price of millet/sorghum (PM_{t-1}) in equation 8 continues to perform as predicted but becomes insignificant. Multicollinearity with T, BVMIL, and T*BVMIL reduces the magnitude of the significance of the relationship between PM_{t-1} and TPM_t. The simple correlation between these four variables varies between .7 and .9. The lagged cotton/millet price ratio ($PCOT_{t-1} \div PM_{t-1}$) retains its positive sign and remains significant at the 5 percent level. Drought (BVDGT) continues to have a negative impact and becomes significant at the 1 percent level. The lagged groundnut/millet price ratio ($PGNT_{t-1} \div PM_{t-1}$) increases in significance to the 5 percent level.

Equation 9 introduces lagged production (TPM_{t-1}) to the model. The coefficient for TPM_{t-1} retains its positive sign but become insignificant. The lagged price of millet/sorghum (PM_{t-1}) is positively related to production but remains insignificant, due to the multicollinearity problems explained above. The coefficient for the lagged cotton/millet price ratio ($PCOT_{t-1} \div PM_{t-1}$) continues to be positive and remains significant at the 5 percent level. Drought (BVDGT) remains negatively and significantly related to production. The lagged groundnut/millet price ratio ($PGNT_{t-1} \div PM_{t-1}$) continues to perform as predicted, and is significant at the 5 percent level. The coefficient for Trend (T) retains its negative sign and remains significant at the 5 percent level. BVMIL remains insignificant. The interaction term (T*BVMIL) continues to perform as predicted, and remains significant at the 5 percent level.

<u>Sales to OPAM</u>

Table XIV reports the estimated results for equations predicting the sales of millet/sorghum to the National Grain Agency. None of the reported equations are statistically significant at the 10 percent level. The models $\overline{R}^2$ are all extremely low, varying between .01 and .274. Thus, they explain very little of the variance in sales to OPAM.

Equations 1 through 8 introduce alternative specifications to predict SM_t. Equation 1 is the simple linear regression of SM_t on current price of millet/sorghum (PM_t). The coefficient is positive, as predicted, but is not statistically significant. This suggests that sales of millet/sorghum are not influenced by official prices.

Equation 2 introduces the current production of millet/sorghum (TPM_t) to the model. The coefficient for TPM_t has the hypothesized positive sign and is significant at the 10 percent level. Hence, in years when high production depresses private market prices, farmers tend to sell more of their production to government for the sake of income support. The coefficient for current price of millet/sorghum

Table XIV. Regression Equations Predicting the Sales of Millet/Sorghum to OPAM (1960-1979)

	Dependent	Independent Variables										
		Intercept	Current Price of Millet/Sorghum	Change in Production of Millet/Sorghum	Current Production of Millet/Sorghum	Trend	Government Policies & Shift in Intercept	Interaction Term	Lagged Sales to OPAM			
			PM_t	ΔTPM_t	TPM_t	T	BVMIL	T*BVMIL	SM_{t-1}	DW	$\bar{R}^2$	F Ratios
1. OLS	SM_t (1000 tons)	12.779	.512 (1.334)							1.676	.039	1.78
2. OLS	SM_t (1000 tons)	-17.702	.286 (.741)		.054+ (1.751)					1.894	.138	2.524
3. OLS	SM_t (1000 tons)	19.804	.450 (1.151)	.029 (.930)						1.771	.032	1.316
4. OLS	SM_t (1000 tons)	15.073	.455 (1.149)						.169 (.727)	1.920	.014	1.131
5. OLS	SM_t (1000 tons)	17.664	.801 (1.383)				-7.823 (.675)			1.736	.01	1.091
6. OLS	SM_t (1000 tons)	-7.211	2.651 (1.538)			1.194 (.433)	35.680 (1.048)	-6.137 (1.407)		1.970	.008	1.042
7. OLS	SM_t (1000 tons)	-81.188	2.333 (1.576)		.091* (2.549)	3.057 (1.238)	74.664* (2.269)	-9.917* (2.470)		2.765	.274	2.438
8. OLS	SM_t (1000 tons)	-86.009	2.246 (1.451)		.101* (2.205)	3.221 (1.242)	78.530* (2.198)	-10.150* (2.417)	-.092 (.351)	2.690	.225	1.925

*Significant at 5 percent level.
+Significant at 10 percent level.

(PM_t) retains its positive sign and remains insignificant.

Equation 3 introduces change in production ΔTPM_t to the model and deletes current production. ΔTPM_t has the predicted positive impact but is not statistically significant. Thus, changes in production do not seem to have a major impact on farmers' sales of millet/sorghum. The coefficient for current price continues to perform as expected but is not significant statistically.

Equation 4 introduces lagged sales (SM_{t-1}) to the model and deletes change in production (ΔTPM_t). The coefficient for SM_{t-1} has the predicted positive sign but is not statistically significant. The coefficient for current price (PM_t) retains its positive sign but is not significant.

Equation 5 introduces the binary variable for government policies (BVMIL) to the model. The coefficient does not have the predicted positive sign, and it is not statistically significant. Current price of millet (PM_t) continues to perform as expected, and its coefficient remains insignificant.

Equation 6 introduces Trend (T) jointly with BVMIL and the interaction term (T*BVMIL) to the model. The coefficient for T is positive as predicted but is not significant. BVMIL and T*BVMIL do not have the expected influence and are not significant. The change in government and time related factors seem to have had no impact on farmers' sales to the government. Current price of millet/sorghum (PM_t) continues to perform as predicted. Its coefficient remains statistically insignificant.

Equation 7 reintroduces current production (TPM_t) to the model. Its coefficient continues to be positive and increases in statistical significance to the 5 percent level. Similarly the coefficient for current price of millet/sorghum (PM_t) is positive but is not statistically significant. Trend (T) retains its sign and is still not significant. BVMIL and T*BVMIL both keep their respective signs and increase in significance. They become significant at the 5 percent level.

Equation 8 reintroduces lagged sales (SM_{t-1}) to the model. The coefficient does not have the predicted positive sign and is not significant. All the other variables retain their respective signs and remain at their previous levels of significance.

B. Rice Estimation Results

As for millet/sorghum, several alternative specifications were estimated for both the production and sales of rice. The results are analyzed in the following section.

Production

Table XV displays the estimated coefficients and accompanying statistics for models predicting annual rice production in Mali. Each equation is significant at the 1 percent level based on an F test. The lowest $\overline{R}^2$ value is .305, and the highest value is .709.

Equation 1 is the simple regression of TPR_t on lagged price of rice (PR_{t-1}). The coefficient is positive as hypothesized and is significant at the 1 percent level. Thus, last year's government price has a positive influence on this year's rice production.

Equation 2 introduces the binary variable for drought (BVDGT) to the model. The coefficient for BVDGT is negative as predicted and is significant at the 1 percent level. The coefficient for lagged price of rice (PR_{t-1}) retains its positive sign and remains significant at the 1 percent level.

Table XV. Regression Equations Predicting the Production of Rice (1960-1979)

	Dependent Variables	Intercept	Lagged Price of Rice PR_{t-1}	Drought BVDGT	Trend T	Government Policies & Shift in Intercept BVMIL	Interaction Term T*BVMIL	Lagged Production of Rice TPR_{t-1}	DW	$\bar{R}^2$	F Ratios
1. OLS	TPR_t (1000 tons)	123.229	3.158** (3.056)						1.250	.305	9.338**
2. OLS	TPR_t (1000 tons)	132.181	3.762** (5.133)	-85.593** (4.478)					1.377	.662	19.635**
3. OLS	TPR_t (1000 tons)	93.828	2.933** (3.650)	-82.698** (4.646)				.296+ (1.935)	1.758	.709	16.453**
4. OLS	TPR_t (1000 tons)	128.792	4.485** (3.918)	-76.084** (3.388)		-24.335 (.827)			1.494	.656	13.075**
5. OLS	TPR_t (1000 tons)	89.949	2.441 (1.510)	-27.155** (3.925)		12.490 (.355)		.339 (1.703)	1.765	.692	11.697**
6. OLS	TPR_t (1000 tons)	158.447	3.563 (1.07)	-77.964** (3.230)	-5.509 (.939)	-64.462 (.869)	8.289 (.796)		1.479	.634	7.572**
7. OLS	TPR_t (1000 tons)	134.379	-2.509 (.590)	-100.225** (4.10)	-3.272 (.603)	-75.182 (1.117)	15.563 (1.543)	.464* (2.026)	1.684	.700	8.393**

**Significant at 1 percent level.
*Significant at 5 percent level.
+Significant at 10 percent level.

Equation 3 introduces lagged production of rice (TPR_{t-1}) to the model. The coefficient for TPR_{t-1} has the predicted positive sign and is significant at the 10 percent level. Thus, current production of rice is positively related to previous levels of production. Lagged price of rice (PR_{t-1}) and drought (BVDGT) continue to perform as hypothesized and remain significant at the 1 percent level.

Equation 4 introduces the binary for government policies (BVMIL) to the model and deletes lagged production. BVMIL does not have the predicted positive sign, and is not significant. Lagged price of rice (PR_{t-1}) and drought (BVDGT) retain their respective signs and remain strongly related to current production.

Equation 5 reintroduces lagged production of rice (TPR_{t-1}) to the model. TPR_{t-1} continues to perform as predicted but its coefficient becomes insignificant. Lagged price of rice (PR_{t-1}) remains positively related to current production and also becomes insignificant. Multicollinearity is fairly high for this specification. The simple correlation between PR_{t-1} and BVMIL is .747, and between PR_{t-1} and TPR_{t-1} is .529. Drought (BVDGT) remains strongly related to production. BVMIL becomes positively related to production, as expected, but remains insignificant.

Equation 6 introduces BVMIL jointly with Trend (T) and the interaction term (T*BVMIL) to the model. Trend does not have the predicted positive sign and significance. The coefficients for the interaction term and BVMIL are positive as hypothesized but neither is significant. The change in governments, the associated changes in agricultural development policy, and other time related factors appear to have little influence on rice production. The drought variable continues to perform as expected and its coefficient remains significant at the 1 percent level.

Equation 7 reintroduces lagged production of rice (TPR_{t-1}) to the model. The coefficient remains positive and increases to the 5 percent level in significance. Lagged price of rice (PR_{t-1}) becomes negatively related to production, but its coefficient is not statistically significant. Drought (BVDGT), however, continues to have a negative impact and remains significant at the 1 percent level. The coefficient for T, BVMIL, and T*BVMIL retain their respective signs and remain insignificant.

Sales to OPAM

Equations 1 through 9 in Table XVI introduce alternative specifications to predict sales of rice to the government. All reported equations are significant at the 1 percent level, based on an F test. The models $\bar{R}^2$ are all high but not extremely high for time series data. They vary between .685 and .856, indicating that the estimated equations provide adequate predictions of rice sales (SR_t).

Equation 1 is the weighted regression of SR_t on current price of rice (PR_t). The coefficient has the predicted positive sign and is significant at the 1 percent level. Thus current government prices have a positive influence on current sales.

Equation 2 introduces current production of rice (TPR_t) to the model. TPR_t is positively related to sales of rice, as expected, and its coefficient is significant at the 1 percent level. Farmers sell more of their production to the government when harvests are good. High production may depress private market prices for rice, making

Table XVI. Regression Equations Predicting the Sales of Rice to OPAM (1960-1979)

	Dependent Variables	Independent Variables									
		Intercept	Current Price of Rice PR_t	Change in Production of Rice ΔTPR_t	Current Production of Rice TPR_t	Trend T	Government Policies & Shift in Intercept BVMIL	Interaction Term T*BVMIL	Lagged Sales of Rice SR_{t-1}	DW	$\bar{R}^2$	F Ratios
1. CORC	SR_t (1000 tons)	20.238	1.186** (3.592)							1.560	.766	60.07**
2. CORC	SR_t (1000 tons)	15.653	.382 (.866)		.132** (3.167)					1.780	.839	47.767**
3. OLS	SR_t (1000 tons)	10.457	.790* (2.222)						.423+ (1.937)	1.474	.753	29.876**
4. OLS	SR_t (1000 tons)	18.208	1.301** (6.860)	.08+ (1.892)						1.165	.751	29.555**
5. OLS	SR_t (1000 tons)	9.331	.344 (1.156)	.126** (3.645)					.656** (3.679)	1.973	.856	38.746**
6. OLS	SR_t (1000 tons)	18.327	1.266** (4.214)	.081+ (1.843)			1.187 (.156)			1.159	.735	18.581**
7. OLS	SR_t (1000 tons)	27.611	.854 (.910)			-1.348 (.701)	-19.226 (.867)	3.184 (1.091)		1.125	.685	11.324**
8. OLS	SR_t (1000 tons)	36.026	-.095 (.104)	.107* (2.328)		-.490 (.283)	-33.443 (1.637)	4.884+ (1.831)		1.416	.757	12.811**
9. OLS	SR_t (1000 tons)	16.116	-.318 (.420)	.138** (3.515)		.325 (.225)	-8.505 (.450)	1.551 (.626)	.617* (2.824)	2.279	.838	17.326**

**Significant at 1 percent level.
*Significant at 5 percent level.
+Significant at 10 percent level.

the official government price more attractive. Current price of rice (PR_t) retains its positive sign but is not statistically significant. Multicollinearity with TPR_t reduces the magnitude of the significance level of the relationship between PR_t and SR_t. The simple correlation between these two variables is .588.

Equation 3 introduces lagged sales (SR_{t-1}) to the model and deletes current production. The coefficient for SR_{t-1} is positive as hypothesized and is statistically significant at the 10 percent level. Farmers long-term expectations surrounding government policies, as measured by the current official price and lagged sales, seem to influence their decisions to sell rice to the government. This specification, however, is plausible only to the extent that farmers feel that past government prices are a good indicator of future prices. The coefficient for current price (PR_t) remains positive and increases to the 5 percent level in significance.

Equation 4 introduces change in production (ΔTPR_t) to the model. Its coefficient is positive as predicted and significant at the 10 percent level. Thus, farmers sell more to the government when production has increased from the level of the previous year. Current price of rice (PR_t) increases in significance to the 1 percent level.

Equation 5 reintroduces lagged sales (SR_{t-1}) to the model. Its coefficient retains its positive sign, and is significant at the 1 percent level. Current price (PR_t) has the predicted positive sign but loses significance. Multicollinearity between PR_t and SR_t is high. The simple correlation between these two variables is .855. The coefficient for change in production (ΔTPR_t) retains its positive sign and becomes strongly significant at the 1 percent level.

Equation 6 adds the binary variable for government (BVMIL) to the model, and deletes lagged sales (SR_{t-1}). BVMIL is positively related to sales as predicted but is not significant. Current price of rice (PR_t) retains its positive sign and increases in significance to the 1 percent level. Change in production (ΔTPR_t) continues to perform as hypothesized but decreases in significance to the 10 percent level.

Equation 7 introduces BVMIL jointly with Trend (T) and the interaction term (T*BVMIL). BVMIL has the predicted negative sign but is not statistically significant. This implies that the intercept is unchanged. No simple shift in sales to the government occurred after 1968. The coefficient for Trend (T) has a negative sign, contrary to hypothesis, but is not significant. The coefficient for T*BVMIL is positive as predicted but is not significant. This result, in conjunction with the previous results for trend and BVMIL, means that time related factors such as technological advances, changes in government, and changes in government policies have no significant influence on sales to OPAM. Current price (PR_t) continues to perform as hypothesized, but multicollinearity with the three previous variables reduces its coefficient to statistical insignificance. The simple correlation between each of these four explanatory variables is greater than .7. Further evidence of this multicollinearity is indicated by the large $\bar{R}^2$ (.685).

Equation 8 reintroduces ΔTPR_t to the model. The coefficient for TPR_t retains its positive sign and increases in significance to the 5 percent level. The current price of rice (PR_t) becomes negatively related to sales but its coefficient is not statistically significant.

The coefficient for Trend (T) retains its negative sign, but is not statistically significant. BVMIL also continues to be negatively related to sales and its coefficient remains insignificant. The coefficient for the interaction term (T*BVMIL) continues to have the hypothesized positive sign, and increases in significance to the 10 percent level.

Equation 9 reintroduces lagged sales (SR_{t-1}) to the model. SR_{t-1} remains strongly related to current sales of rice. Its coefficient retains its positive sign but decreases in significance to the 5 percent level. Current price of rice (PR_t) continues to have a negative, insignificant relationship with sales. Change in production (ΔTPR_t) is positively related to sales, and significant at the 1 percent level. Trend (T) becomes positively related to sales as predicted but is not significant. BVMIL and T*BVMIL continue to perform as hypothesized but their coefficients are statistically insignificant.

C. Elasticities

The concept of the elasticity of supply is very important and useful in applied economics and policy analysis. It enables us to understand the behavior of economic participants toward price incentives and to analyze the impact of specific policies on supply.

By definition the price elasticity is the ratio of the percentage change in quantity supplied to the percentage change in price, other factors being held constant. For a linear relationship, $y_t = b_0 + b_1 x_{t-1}$, the supply elasticity is derived as the following: $\frac{dy_t}{dx_{t-1}} \cdot \frac{\bar{x}}{\bar{y}} = b_1 \frac{\bar{x}}{\bar{y}}$ Where y_t is production in year t and x_{t-1} is price in the previous time period. $\bar{x}$ and $\bar{y}$ are the mean values of the respective variables. The numerical value of the elasticity increases when the numerator increases and decreases when the denominator increases.

Table XVII displays the elasticity estimates for the millet/sorghum production to its own lagged price, and to lagged relative price ratios of groundnuts and cotton. The own price elasticities are positive as expected and vary between .006 and .563. This implies that a 10 percent increase in price would result in an increase in production by between .06 and 5.63 percent, *ceteris paribus*. Despite the unavailability of a previous time series study on millet/sorghum in Mali, these supply elasticities are modest magnitudes in comparison to supply elasticities obtained elsewhere for the same crop. For instance, in Senegal, Niane found a short run elasticity of 2.5 for millet/sorghum using time series data from 1960 to 1976.[27] In Syria, Harik found a short run elasticity of 1.21 using time series data between 1957 and 1972.[28]

The cross price elasticities for changes in the price of groundnuts are negative as expected and vary between -.228 and -.641. Groundnuts are substitutes for millet/sorghum. As the price of groundnuts increases, productive factors are diverted from millet/sorghum production into groundnuts production, causing the supply curve for millet/sorghum to shift to the left.

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[27]Niane, "Supply and Demand of Millet and Sorghum in Senegal," p. 37.

[28]Ibid., p. 37.

Table XVII. Estimated Elasticities of Supply for Millet/Sorghum Production (1960-1979)*

Equations	Elasticities to own lagged price	Elasticities to cotton/millet price ratio	Elasticities to lagged groundnuts/ millet price ratio
1. CORC	.206	--	--
2. OLS	.192	--	--
3. OLS	.159	--	--
4. OLS	.288	.301	-.427
5. OLS	.214	.156	-.228
6. OLS	.307	.248	-.326
7. OLS	.563	.311	-.253
8. OLS	.153	.506	-.641
9. OLS	.006	.408	-.582

*All elasticities are derived from equations displayed in Table XIII.

The cross price elasticities for cotton seem to be positive, contrary to hypothesis. These estimates vary between .156 and .506, and they suggest that cotton is not a substitute for millet/sorghum. This may be due to inaccurate data or inappropriate specification of the complex economic relationships at work in the cotton sector.

Table XVIII displays the supply elasticity estimates for sales of millet/sorghum to OPAM. These elasticities are larger than production supply elasticities, but little confidence can be placed in them given the low statistical significance of most underlying estimated coefficients.

As for millet/sorghum, elasticities were also derived for rice production and sales to OPAM. Estimates for rice production are presented in Table XIX. Elasticities to own lagged price vary between .273 and .502. Comparison with estimates from other studies in underdeveloped areas confirm that these estimates are modest. In Senegal, Niane found a short run elasticity of 2.7 for rice using time series data from 1960 and 1976.[29]

Table XX displays elasticity estimates for sales of rice to current government price. These estimates are positive as expected and vary between .164 and .622.

The findings from this study strongly suggest that farmers in Mali respond to price in a fashion predicted by neoclassical economic theory. All the elasticities computed for millet/sorghum and rice conform to theoretical expectations except the cross elasticities of millet/sorghum to changes in cotton prices.

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[29]Ibid., p. 37.

Table XVIII. Estimated Elasticities of Supply for Millet Sales (1960-1979)*

Equations	Elasticities to Own Current Price
1. OLS	.354
2. OLS	.198
3. OLS	.311
4. OLS	.314
5. OLS	.553
6. OLS	1.832
7. OLS	1.612
8. OLS	1.074

*All elasticities are derived from equations displayed in Table XIV.

Table XIX. Estimated Elasticities of Supply for Rice Production (1960-1979)*

No. Equations	Elasticities to Own Lagged Price
1. OLS	.355
2. OLS	.421
3. OLS	.328
4. OLS	.502
5. OLS	.273
6. OLS	.399

*All elasticities are derived from equations displayed in Table XV.

Table XX. Estimated Elasticities of Supply for Rice Sales (1960-1979)*

No. Equations	Elasticities to Own Current Price
1. CORC	.573
2. CORC	.185
3. OLS	.378
4. OLS	.622
5. OLS	.164
6. OLS	.605
7. OLS	.408

*All elasticities are derived from equations displayed in Table XVI.

V. POLICY ANALYSIS

A. Basic Theory

During several recent years the government of Mali subsidized consumption of cereals by maintaining consumer and producer prices below world market prices.[30] All of the consequences of such policies on consumers, producers, and government are difficult to quantify but it is possible to identify in a general fashion the transfers and costs involved. The framework for this analysis is illustrated in Figure 2. The demand and supply of cereals (e.g. rice) are drawn to reflect Malian conditions.

In the absence of any international trade, domestic price is set at P_E, the intersection of the domestic supply and demand curves. However, with trade, no government intervention, and no transport costs, the domestic price P_E cannot differ from the world market price, P_W. At P_W domestic production and demand are q_1 and q_2, respectively, resulting in net imports of $q_2 - q_1$. A third and more realistic case recognizes that the Malian government often intervenes in the market to set domestic prices of cereals below the world price levels, resulting in a nominal protection coefficient smaller than unity. As prices fall to P_0 due to government subsidies, domestic production decreases to q_3 and consumption is increased to q_4. Imports increase to $q_4 - q_3$.

This policy of maintaining domestic prices below the world market price level has four effects:

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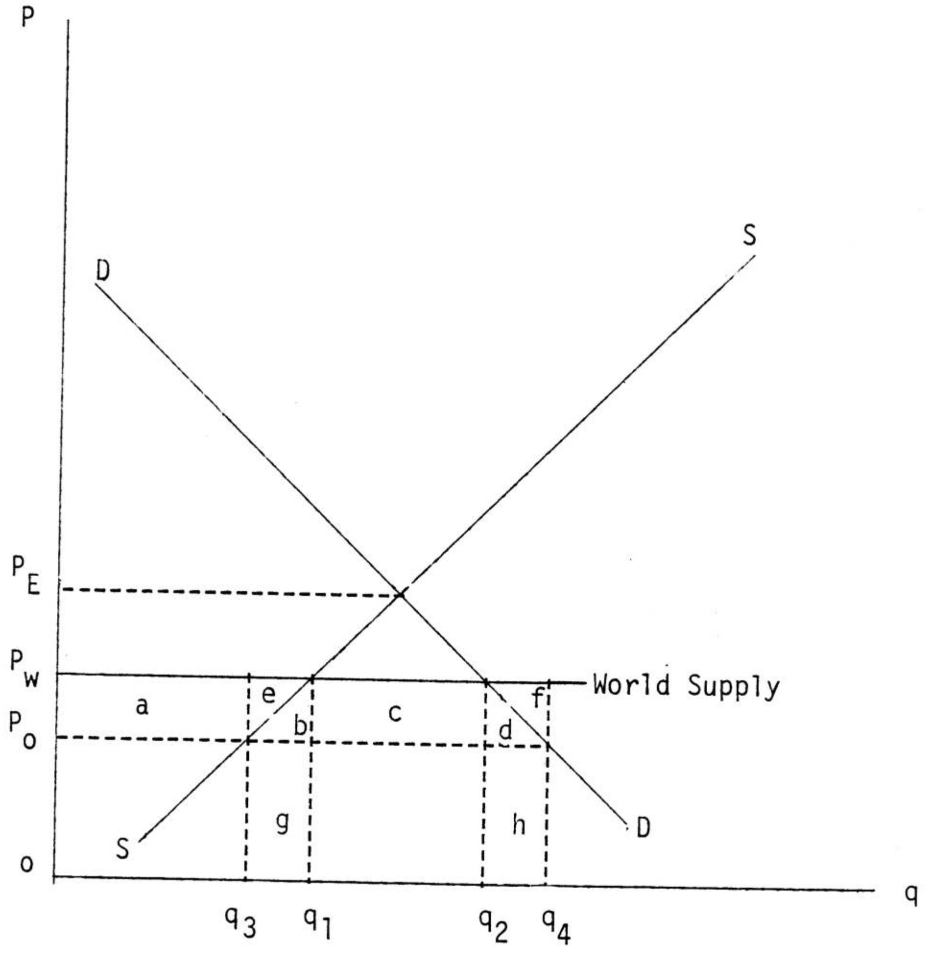
[30]See Table XI on page 28.

Figure 2. Economic and Welfare Effects of the Government Pricing Policy on Cereals



1. It transfers welfare from producers to consumers;
2. Government pays out large amounts in subsidies to importers;
3. Resources are withdrawn from cereal production;
4. It detracts from the country's balance of payments.

Referring to Figure 2, the welfare gain accruing to consumers due to government policy is equal to the area a + b + c + d + e. The area a + e is the transfer of welfare from producers to consumers in the form of lower prices, i.e., it is the loss in producer's surplus. The area (e + b + c + d + f) indicates the total value of the government subsidy on imported grain. According to Berg, estimates of this area for rice alone were 25 percent of the country's budget in 1974 (Berg, 1975, p. 76).

The net loss to society due to pricing inefficiency is area (e + f). One can derive this by subtracting the area of consumer gains from the areas of producers and government losses as follows:

$$(a + e) + (e + b + c + d + f) - (a + b + c + d + e) = e + f$$

(loss to producers) + (loss to government) - (gain to consumers) = net welfare loss

Finally, there is a balance of payments effect associated with the lower prices. The lower prices increase spending on imports equivalent to area (e + b + g) + (d + f + h). This directly worsens the current account of the balance of payments.

B. Empirical Estimates of the Welfare Effects of Policies on the Demand and Supply of Rice and Millet/Sorghum

The supply models of the previous chapter can be used to estimate the efficiency and welfare effects of government policies in

Malian grain markets. Ideally one would also employ empirical measures of demand elasticity; however, none are available. The following analyses assume the price elasticities of demand for millet/sorghum and rice to be -.1.[31] Some of the numerical estimates depend upon this assumption. As will be seen below, the results for rice are more sensitive to demand elasticity than are those for millet/sorghum.

Millet/Sorghum

The welfare implications of government policies for the millet/sorghum demand and supply are presented in Figure 3. The supply curve is based upon equation 7 of Table XIV. All explanatory variables other than price are collapsed to their mean value. This illustrative example is for the 1971/72 crop year. The world market price is approximated by the Bamako C.I.F. price, 48.3 MF/KG. This price is substantially higher than the official domestic producer price in 1971/72, 20 MF/KG.

The gains and losses from the government subsidy program are represented by appropriate areas in Figure 3. The loss of producer surplus is represented by area P_W P_O BG. This area amounts to 1,755 million Malian francs. The gain to consumers is measured by area P_W P_O DE, which equals 1,500 million Malian francs. The government subsidy is represented by area ABDF, and sums to 792.4 million Malian francs. The net welfare loss to Mali, which flows to suppliers of imported grain, is the sum of areas ABG and EDF. This area equalled 1,047 million Malian francs in 1971/72.

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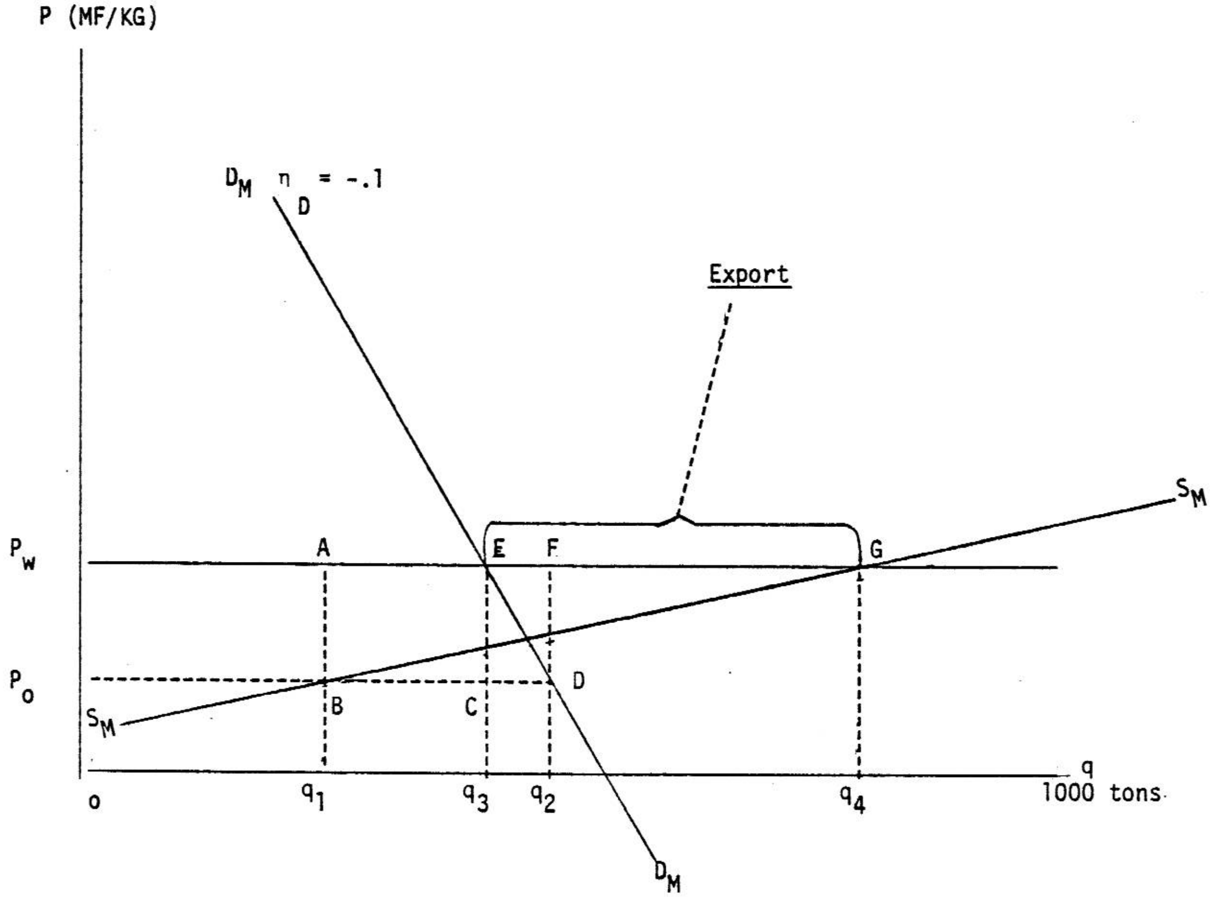
[31] According to the CILSS estimates the demand for cereals is inelastic in the Sahel. Therefore a demand elasticity of -.1 is used (see CILSS, op. cit., Vol. 1, French version, p. 233).

Figure 3. Welfare Analysis of Supply Responsiveness for Millet/Sorghum (1971-1972)*



KEY:

The supply curve is derived from equation 7 in Table XIV. This choice was made by selecting the equation with the highest R^2 and F-Ratio combination. All explanatory variables other than price are collapsed to their mean value giving the following equation: S = 94,556.316 + 2.333P. There are other derived supply curves that the interested reader may wish to use in this analysis. Most notably one could derive the long run supply curve by recognizing that current production in the sales to OPAM model is itself a function of price. Substituting any equation from Table XIII into equation 7 of Table XIV would result in a more steeply sloped long run supply curve. Also zero transport costs are assumed in this example.

P_w = 48.3 MF/KG	q_1 = 29,000 tons	q_3 = 49,000 tons
P_o = 20 MF/KG	q_2 = 57,000 tons	q_4 = 95,000 tons

If the government discontinued the subsidy program in long run equilibrium, Mali would be a net exporter of millet/sorghum. Rather than paying 1,352 million Malian francs for imports, the nation would receive export revenues totaling 2,222 million Malian francs. Moreover, if the transfer could be arranged, millet/sorghum producers could compensate consumers for their loss in consumer surplus and still have a net gain of (1755 - 1500 = 255 million Malian francs). This is a classic example of a Pareto efficiency gain. Several persons gain while no one loses welfare.

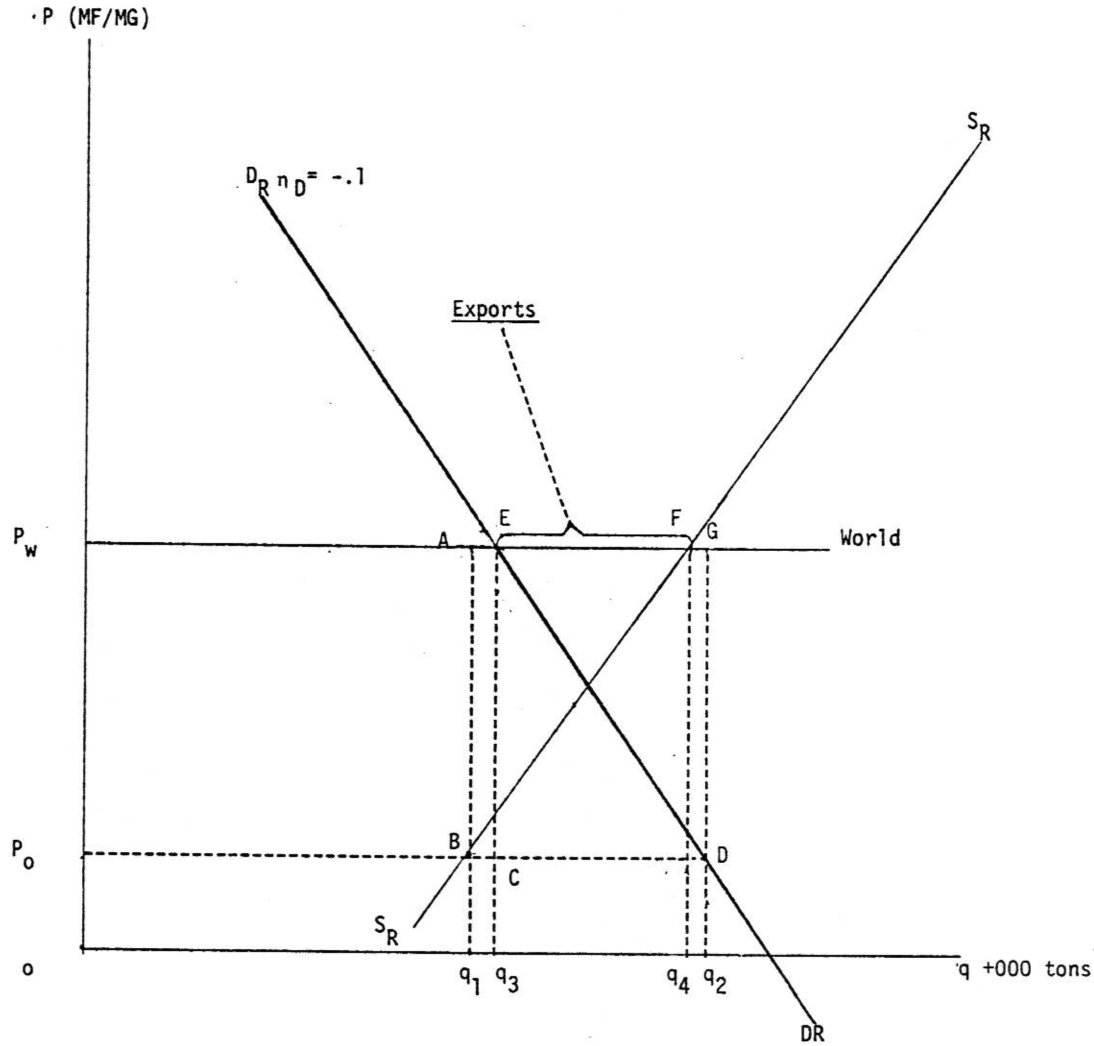
Rice

Figure 4 is a similar illustration for rice. The supply curve is derived from equation 5 of Table XVI by collapsing all explanatory variables other than price to their mean values. As for millet/sorghum, the demand curve was drawn as fairly inelastic ($n_1 = -.1$). The 1972 C.I.F. and the official producers' prices are equal to 114.3 and 25 Malian francs, respectively. The loss to producers from the subsidized imports is measured by the area $P_W P_O$ BF, which equals 6,028 million Malian francs. Consumers surplus equals area $P_W P_O$ DE, and is 6,027 million Malian francs.

The government subsidy is measured by area ABDG and equals 2,768 million Malian francs. The net welfare loss is identified as the sum of areas ABF and of EGD. Its value equals 2,590 million Malian francs.

If the government discontinued the subsidy program, in long run equilibrium Mali would be a net exporter of rice. Rather than paying 3,543 million Malian francs for imported rice, the nation would receive export revenues totaling 3,086 million Malian francs.

Figure 4. Welfare Analysis of Supply Responsiveness for Rice in Mali (1971-1972)*



KEY:

The supply curve is derived from equation 5 in Table XVI. This choice was made by selecting the equation with the highest R^2 and F-Ratio combination. All explanatory variables other than price are collapsed to their mean value giving the following equation: S = 80,304.681 + .344P. There are other derived supply curves that the interested reader may wish to use in this analysis. Most notably one could derive the long run supply curve by recognizing that change in production in the sales to OPAM model is itself a function of price. Substituting any equation from Table XV would produce a different long run supply curve. Also zero transport costs are assumed in this example.

P_w = 114.3 MG/KG	q_1 = 58,000 tons	q_3 = 53,000 tons
P_o = 25 MF/KG	q_2 = 82,000 tons	q_4 = 80,000 tons

The impact on the current account of the balance of payments would be a positive amount equal to 6,629 million Malian francs. Moreover, as with millet/sorghum, producers would compensate consumers for their loss and still experience a net gain of 1 million Malian francs.

VI. SUMMARY, RECOMMENDATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

A. Summary

One of the most pressing concerns of the present age is the "world food problem." While this is a very complex and multi-dimensional problem, it very simply means that there is not enough food available at reasonable prices in less developed countries, especially in the Sahel. During recent years, food self-sufficiency has become an important policy issue for Mali's policy planners. Although self-sufficiency has always been a goal of the Malian government, the Sahelian drought made it an even more important policy consideration. Today the long-term goal is to re-establish Mali as a net exporter of food stuffs to neighboring states. In the intermediate run, the government hopes to increase food self-sufficiency and export capability in staples by transferring hectarage from cash crops to grains, by opening up new lands and by increasing yield per hectarage. But despite many efforts made to achieve self-sufficiency, the import gap continues to widen.

The specific objectives of this study were to:

- review recent grain marketing policies in Mali;
- predict domestic production of millet/sorghum and rice and their respective amounts sold to the "office des produits agricoles du Mali" (OPAM); and
- evaluate the impacts of government policy on rice and millet/sorghum economies.

Several economic factors that influence the amount of millet/sorghum and rice produced and the amount officially marketed were identified. Models were specified and tested using time series data from secondary sources for the period from 1960 to 1979. The selection of explanatory factors was based on economic theory, knowledge of the Malian grain industry, and data availability.

The major findings of this study strongly suggest that:

1. Millet/sorghum production and sales are both positively responsive to government determined prices. The price elasticities at the mean for millet/sorghum production vary between .006 and .563. These estimates are modest when compared with estimates from other countries. Higher elasticities were obtained for millet/sorghum sales and they vary between .198 and 1.832. The cross price elasticities for changes in groundnut prices were negative as expected and vary between -.228 and -.641. However, the cross price elasticities for changes in cotton prices are positive, contrary to hypothesis, and their numerical values vary between .156 and .506.

2. Rice production and sales are positively related to official producers prices. The elasticities at the mean for rice production were positive and they varied between .272 and .502, which indicates a significant response. The computed elasticities for rice sales were also positive, and their numerical values ranged from .164 to .622.

3. The government program of subsidized imports has a definite adverse effect on producers. Subsidized imports have four effects:

    - they transfer welfare from producers to consumers;
    - government loses tax revenues;
    - resources are pulled out of production; and
    - the balance of payments is adversely affected.

B. Recommendations

This analysis of supply responsiveness for millet/sorghum and rice farmers in Mali provides insights into agricultural production in a subsistence economy. In particular, it gives one answer to an important question: what is the potential for breaking bottlenecks in agriculture via increased reliance upon the price mechanism? The results of this study do not provide a definitive answer because the lack of data limited the analysis to relatively simple model specifications. Moreover, much of the available data is of questionable accuracy; hence, the resulting estimates may best be regarded as indicative rather than definitive. Nonetheless these indicative estimates confirm (fail to reject) the basic supply response hypothesis. They suggest that it is possible to increase crop production in Mali by raising farm level prices.

Uncertainty, a factor in farm planning, is not analyzed in this study. Price responses would likely be higher if producers could be assured guaranteed prices. OPAM should consider setting its official price in advance of planting rather than at harvest. An improved storage system would also help to stabilize price seasonally. Moreover, higher prices alone can have little effect on increasing yields per hectare unless there is a thorough improvement in the other services made available to farmers (e.g. transportation, credit, fertilizer, technological knowledge, etc...). Finally, government should consider eliminating the subsidies on imports. If it wishes to preserve the purchasing power of urban consumers it could allow wages to rise by a corresponding amount. This might temporarily stimulate inflation, but it eliminates a drain on the treasury (import subsidies). In fact, if properly managed, this treasury savings is more than enough to offset inflationary pressures because the subsidy contains a social cost that would no longer be incurred (areas e and f in Figure 2). Moreover, in the long run the increase in supply by domestic producers may accelerate agricultural development with the result that supply increases, not only by a movement upward on the supply curve in Figure 2, but also by a steady outward shift in the supply curve over time.

C. Suggestions for Further Research

This study analyzed production and marketed supplies of millet/ sorghum and rice. It provided us with some insights on producers' behavior toward economic incentives. However, knowledge about factors affecting consumer demand would also be necessary for an effective and successful planned development program for the agricultural sector. Price elasticities of demand would be particularly helpful for analyzing the effects of specific policies on the food system and agricultural development in Mali. This was recognized at least as early as 1915 when Henry A. Wallace wrote "The demand laws . . . indicate to me that the farming class as a whole is penalized for overproduction and rewarded for underproduction" (as quoted in Tomek and Robinson, 1981, p. 47).

Also, a trade-off exists between cash crops and food crops in any policy formulation or strategy intended to promote the production of food crops. Groundnuts and cotton are alternative crops for millet/ sorghum farms. Similarly, sugar cane and wheat are alternative crops for rice growers. At this time, cash crops provide more than half of the country's export revenues. Hence, future studies might analyze the empirical estimation of the supply models for these crops that are very important to the country's economy.

APPENDIX I: RAW DATA USED IN THE STUDY

Table I-1. Domestic Production of Millet/Sorghum and Rice[a]

Year	Millet/Sorghum	Paddy
1959	760	182
1960	800	188
1961	850	185
1962	800	188
1963	870	200
1964	755	195
1965	710	158
1966	700	162
1967	737	158
1968	830	172
1969	556	135
1970	503	162
1971	715	163
1972	705	195
1973	624	100
1974	660	90
1975	850	250
1976	865	300
1977	1,050	350
1978	820	220
1979	910	270

SOURCES:

1959: Samir, Amin. Trois Experiences de Developement, p. 23.

1960, 1962 and 1964-1979: Marches Tropicaux et Mediteraneens, pp. 3560 and 3561.

1961 and 1963: WARDA, op. cit., p. 3c.

[a]All productions are in 1000 of tons and all years are the second years of the crop season, i.e., 1978/79 is written as 1979.

Table I-2. Sales of Millet/Sorghum and Rice to OPAM[a]

Year	Millet/Sorghum[b]	Paddy[c]
1960	28*	35*
1961	20	45
1962	20	26
1963	29	33
1964	17	31
1965	17	27
1966	26	29
1967	56	37
1968	60	40
1969	8	32
1970	26	49
1971	12	42
1972	29	51
1973	11	50
1974	9	57
1975	40	83
1976	71	93
1977	31	93
1978	37	66.4
1979	34*	62.7

*Estimates.

[a]All sales are in 1000 tons.

[b]Source: 1961-1976. C.I.L.S.S., op. cit., vol. I, table 9.
1977-1978: Marches Tropicaux et Mediteraneens, p. 3563.

[c]Source: 1961-1977: WARDA, op. cit., p. 8a.
1978 and 1979: Marches Tropicaux et Mediteraneens, p. 3564.

Table I-3. Producer Prices[a]

Year	Millet/Sorghum[b]	Paddy[c]	Groundnuts[d]	Cotton[e]
1959	16	12.5	14.8	34
1960	11.5	12	15.6	34
1961	10	9	14	34
1962	10	9	14	34
1963	10	11	14	34
1964	10	11.5	14	34
1965	11	12.5	13	34
1966	11	12.5	13	34
1967	16	16	16	34
1968	16	18	24	40
1969	16	18	24	40
1970	18	25	30	45
1971	18	25	30	50
1972	20	25	30	50
1973	20	25	30	50
1974	32	25	30	50
1975	32	40	40	50
1976	32	40	40	75
1977	32	40	45	75
1978	36	45	50	90
1979	40	50	60	95

[a]All prices are in Malian francs/kilogram. The Malian franc was devalued by 50 percent in 1967. All years are the second year of the season.

[b]Mali has never established separate prices for millet and sorghum. Before 1967 there were separate prices by surplus or deficit region.

Source: 1959-1977: WARDA, op. cit., p. 3c.

1978 and 1979: Marches Tropicaux et Mediteraneens, p. 3563.

[c]Paddy quality is white paddy, the most expensive brand.

Source: 1959-1977: WARDA, op. cit., p. 11a.

1978-1979: Unpublished Document, Ministere du developement rural, Bamako 1980-

[d]Groundnuts in the shell.

Source: 1959-1977: Ibid, p. 11a.

1978: Assises du Commerce, Tome II, p. 3.

1979: Marches Tropicaux et Mediteraneens, p. 3568.

[e]First quality seed cotton.

Source: 1959-1977: WARDA, op. cit., p. 11a.

1978 and 1979: Marches Tropicaux et Mediteraneens, p. 3566.

APPENDIX II: SIMPLE CORRELATION MATRIX

Table II-1. Correlation Matrix for Regression Equations Displayed in Table XIII

	TPM_t	TPM_{t-1}	PM_{t-1}	$PGNT_{t-1}$	$PCOT_{t-1}$	$PGNT_{t-1} \div PM_{t-1}$	$PCOT_{t-1} \div PM_{t-1}$	BVDGT	BVMIL	T	T*BVMIL
TPM_t	1										
TPM_{t-1}	.493	1									
PM_{t-1}	.452	.245	1								
$PGNT_{t-1}$	.287	.218	.930	1							
$PCOT_{t-1}$	.423	.329	.879	.934	1						
$PGNT_{t-1} \div PM_{t-1}$	-.298	-.081	-.033	.256	.187	1					
$PCOT_{t-1} \div PM_{t-1}$	-.156	.058	-.477	-.283	-.175	.744	1				
BVDGT	-.621	-.024	.128	.278	.180	.309	-.04	1			
BVMIL	-.081	-.155	.722	.783	.618	.303	-.331	.471	1		
T	.167	.067	.888	.929	.852	.317	-.196	.330	.850	1	
T*BVMIL	.161	.049	.906	.946	.837	.254	-.337	.380	.927	.961	1

Table II-2. Correlation Matrix for Regression Equations Displayed in Table XIV

	SM_t	PM_t	ΔTPM_t	TPM_t	BVMIL	T	T*BVMIL	SM_{t-1}
SM_t	1							
PM_t	.300	1						
ΔTPM_t	.258	.171	1					
TPM_t	.452	.335	.531	1				
BVMIL	.118	.740	.069	-.081	1			
T	.241	.938	.104	.167	.850	1		
T*BVMIL	.180	.922	.115	.161	.927	.961	1	
SM_{t-1}	.221	.196	-.034	.401	.286	.234	.268	1

Table II-3. Correlation Matrix for Regression Equations Displayed in Table XV

	TPR_t	PR_{t-1}	TPR_{t-1}	BVDGT	BVMIL	T	T*BVMIL
TPR_t	1						
PR_{t-1}	.584	1					
TPR_{t-1}	.554	.529	1				
BVDGT	-.479	.184	.027	1			
BVMIL	.171	.748	.076	.471	1		
T	.400	.927	.311	.330	.850	1	
T*BVMIL	.388	.925	.284	.380	.927	.961	1

Table II-4. Correlation Matrix for Regression Equations Displayed in Table XVI

	SR_1	PR_t	ΔTPR_t	TPR_t	BVMIL	T	T*BVMIL	SR_{t-1}
SR_t	1							
PR_t	.854	1						
ΔTPR_t	.398	.218	1					
TPR_t	.699	.588	.508	1				
BVMIL	.648	.760	.107	.171	1			
T	.797	.246	.111	.400	.850	1		
T*BVMIL	.811	.932	.126	.388	.927	.961	1	
SR_{t-1}	.845	.855	.005	.658	.613	.807	.814	1

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