SUPPLY AND DEMAND OF MILLET AND SORGHUM IN SENEGAL

by

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INTRODUCTION

A. The International and Historical Context of Food Grain Shortages

The history of starvation in the world is very tightly linked with the history of humanity. The problem of starvation was discussed in 1945 at the Worldwide Constitutional Conference of Food and Agriculture Organization of the United Nations (FAO). The main goal of the organization was and remains a food policy for the benefit of all, in order to liberate all people from starvation.

Since 1950, there has been a notable decrease in agricultural production per capita in the developing countries in comparison to the needs [10]. In 1972 and 1973, poor harvests created a dramatic situation in many regions of the world and once again it was in the developing countries where people suffered the most. In the Sahel countries, many thousands of lives would have been lost if the international community and the United Nations had not helped.

In 1973, during their Alger Conference, the Non-Aligned Countries requested a World Food Conference. In November 1975 that conference took place in Rome with

the sponsorship of the United Nations. Among the resolutions, three of the more important are noted:

(1) Intensification of agricultural development programs

(2) Extension of research and training programs in food and agriculture

(3) Food and nutrition policies for the improvement of consumption patterns

Furthermore, the conference adopted a declaration for the definite elimination of starvation and malnutrition in the world. Solutions to food problems rely on an international cooperation on the one hand, and the orientation of agricultural policy in developing countries for the increase in food-crop production, on the other hand.

B. The Senegalese Case of Food Grain Production and Deficit

Senegal is among the developing countries which are not self-sufficient in food grain. Since independence was achieved in 1960, the necessity of improving food-crop production has been emphasized in the different National Development Plans. The first four-year Economic Plan (1961-1964) fixed these objectives:

(1) increasing the volume of food-crop production by increasing yield and expanding hectarage

(2) diversifying production

(3) improving the quality of production

These objectives have been repeatedly mentioned in all subsequent plans. Nevertheless, neither the structure of the agricultural sector nor the level of self-sufficiency with respect to food-crop supply has noticeably changed. Perhaps the main reason is that the government has maintained an export-oriented agricultural policy inherited from the colonial administration. This policy emphasizes export of groundnut production and the import of food grain. This contradiction between goals and policy has allowed the import of cereals to increase during the plan period (1961-1964).

The cereal balance for the period 1969-70 to 1976-77, and the percentage of consumption satisfied by local production, imports, and food aid, are given in Tables I and II. These tables demonstrate that the export-oriented agriculture still prevails in Senegal. Table III shows the increase in the cost of cereal imports during the period 1961-1974. On the other hand, income from the export of groundnuts averaged 42,500 CFA per metric ton during the period 1961-1964, and about 36,000 CFA per ton in 1974. Price fluctuations have increased the risk and uncertainty of export-oriented agriculture.

The traditional theory of comparative advantage demonstrates that if every country specialized in production

TABLE I

CEREAL BALANCE

(1000 metric tons)

YEAR	Millet/Sorghum				Rice				Maize				Wheat				Total			
	DP	CI	FA	T	DP	CI	FA	T	DP	CI	FA	T	DP	CI	FA	T	DP	CI	FA	T
1969-70	635	0.2	-0-	635.2	91.65	110.6	8.6	210.85	49	-0-	9.6	58.6	-0-	108.4	4.0	112.4	775.65	219.2	22.2	1017.52
1970-71	401	28.9	0.7	430.6	64.35	187.5	-0-	251.85	39	-0-	2.1	41.1	-0-	112.0	-0-	112.0	504.35	328.4	2.8	835.55
1971-72	583	10.4	-0-	593.4	70.2	169.9	-0-	240.1	39	-0-	1.0	40.0	-0-	95.4	-0-	95.4	692.2	275.7	1.0	968.9
1972-73	323	26.4	15.0	364.4	28.6	188.5	3.5	220.6	20	-0-	46.6	66.6	-0-	62.1	43.4	105.5	371.6	277.0	108.5	757.1
1973-74	511	34.0	21.5	566.5	41.6	141.3	2.2	185.1	34	-0-	28.0	62.0	-0-	81.3	5.4	86.5	371.6	256.6	57.1	900.3
1974-75	777	5.0	-0-	782.0	76.1	124.0	-0-	200.1	43	-0-	5.5	48.5	-0-	94.0	6.2	100.2	896.1	223.0	11.7	1130.8
1975-76	715	43.0	NA	758.0	91.0	130.0	-0-	221.0	45	-0-	NA	47.4	-0-	105.0	-0-	105.0	851.0	278.0	30.0	1159.0
1976-77	554	70.0	NA	624.0	72.8	130.0	NA	202.8	47	-0-	NA	47.0	NA	NA	NA	NA	673.8	200.0	53.8	727.6

KEY

DP = Domestic Production

CI = Commercial Import

FA = Food Aid

T = Total

NA = Not Available

SOURCES

ONCAD; CILLS: Marketing, price policy, storage of food grains in the Sabel.

TABLE II

PERCENT OF CONSUMPTION SATISFIED BY PRODUCTION, IMPORTING AND FOOD AID

YEAR	PRODUCTION	IMPORTS	FOOD AID	TOTAL	CEREALS (1000s tons)
1969-70	76%	22%	2%	100%	1017.05
	60%	39%	1%	100%	835.55
	72%	28%	<1%	100%	968.0
	49%	37%	14%	100%	757.1
	65%	29%	6%	100%	900.3
	79%	20%	1%	100%	1130.8
	74%	24%	2%	100%	1159.0
	56%	NA	NA	100%	1200.0[e]

SOURCE: ONCAD/CILLS

[e]estimation

and export of goods in which it is the relatively least-cost producer in exchange for goods in which another country is a relatively lower-cost producer, both global welfare and the welfare of each trading country would be maximized. This implies that free, undistorted international trade is the very best policy for all countries to follow. This implication is derived under the assumptions of (1) perfect certainty and (2) small countries' inability to influence the world market price by their individual actions.

However, agricultural trade is characterized by two major forms of uncertainty: the weather, which is stochastic and not under the farmers' control, and the future international prices, which are uncertain and known at best in a probabilistic sense. It is not possible to predict exactly what future international prices will be. Since its independence in 1960, Senegal has experienced a decline in its earnings from export of agricultural products.

Because of these uncertainties, many countries, especially less-developed countries, have become increasingly reluctant to accept the logic of comparative advantage. Many countries have adopted policies to distort internal price away from the international term of trade to achieve self-sufficiency in food production.

Recently, some theoretical and empirical contributions in the international trade literature have examined the validity of the basic theorems of international trade, under both international price and production technology uncertainties.

Senegal is a small country with an open economy. A number of observers have argued that the policy of exporting groundnuts and the derived products, oil and meal, in exchange for cereal, rice, and millet/sorghum is consistent with Senegal's comparative advantage [e.g., CILSS, Vol. II, pp. 56, 66]. However, Jabora and Thompson [24, p. 22], in their study, "Agricultural Comparative

Advantage under International Price Uncertainty: The Case of Senegal," have found that in the presence of international price uncertainty, Senegal is better off producing more cereals at the expense of peanuts. They state that "government policies which distort internal price away from international prices to reflect the cost of risk to the economy may be optimal from the economic point of view." (p. 22)

The unfavorable position of the Senegalese agricultural sector with respect to world price would put the national economy in a very serious balance of trade problem if there weren't a substantial increase in the mining industry with a favorable world price of phosphates, and continuing development of the fishing sector. Nevertheless, the Senegalese balance of trade remains in deficit, due mainly to the import of foodstuffs.

The current agricultural policy emphasizes food grain self-sufficiency and has fixed for 1981 the objectives of production and the percentage of satisfied national consumption compared to the situation in 1976, as shown in Table IV.

The purpose of this study is to attempt to investigate (1) the most important determinants of millet/sorghum supply and demand, (2) supply and demand projections of millet/sorghum under a set of assumptions, and (3) some of the implications with respect to the stated goal of

TABLE III

CHANGE IN THE COST OF IMPORT OF CEREALS

YEAR	WHEAT			RICE			MILLET/SORGHUM		
	Q	V	CFA/ton	Q	V	CFA/ton	Q	V	CFA/ton
1961	74.16	1,487	20.050	109.78	2,697	24.566	2.953	47	15,916
1964	63.24	1,210	20.050	184.49	4,920	25.668	20.32	333	16,384
1970	112.4	2,363	21.023	119.20	3,335	27.978	0.184	3	16,304
1971	. . .	. . .	. . .	. . .	. . .	. . .	30.260	671	22,745
1974	86.7	2,853	33.079	207.0	18,032	87.111	7.260	201	27,800

Q = quantity in 1000s of metric tons

V = value in millions of CFA ($1 U. S. ≃ 240 CFA)

SOURCE: l'Economie Senegalaise 1965 (Chambre de Commerce de Dakar), Evaluation et perspectives du Secteur Rural dans le cadre de la preparation du plan--Note technique sur le S/S Argiculture (p. 14), Ministere du plan and de Cooperation--1977.

TABLE IV

OBJECTIVE OF PRODUCTION OF CEREALS FOR 1981 AND PERCENTAGE OF SATISFACTION OF THE NATIONAL CONSUMPTION

Cereal	Production 1976	Objective 1981	Pct. of Consumption 1976	Pct. of Consumption 1981
Rice	72,800	300,000 tons	36	56
Millet/sorghum	554,000	750,000 tons	88	111
Maize	47,000	148,000 tons	100	144
Wheat	NA	29,000 tons	... (20)	20
Total Cereal		1,227,000 tons		83

SOURCE: V[e] Development Plan, Tome II, pp. 22-23, Table I.

food crop self-sufficiency, and what recommendations might be made to decision makers.

Three factors make millet/sorghum an attractive choice for analysis:

(1) Rural people represent the largest component in the total population and therefore are the most important consumers of millet and sorghum

(2) The decision of the government to put into operation a new method of producing an instant millet "couscous"* and bread from a blend of millet and wheat developed by ITA** (but not yet exploited)

(3) The decision of the government to favor the development of food crop self-sufficiency

All of these factors suggest an increase in the production of millet and sorghum. But what are the main supply shifters of millet and sorghum? How important are they? What are the policy implications of the empirical findings? An attempt to answer these questions will be made in the remaining chapters of this study.

C. Plan of the Remaining Chapters

Chapter II contains a brief review of the millet/-sorghum industry in Senegal. Chapter III sets the theoretical framework for the empirical analysis--the economic

*Couscous is a brand of cooked millet/sorghum flour which is the most common form of meal from millet/sorghum.

**Institut de Technologie Alimentaire.

and statistical models. In Chapter IV, the data, the estimated relationships, and the interpretation of the statistical findings and corresponding forecasts are presented. The last chapter, Chapter V, will contain a summary, recommendations, conclusions, and suggestions for further research.

For those who are interested in groundnut and rice, the major substitutes for millet in production and consumption, respectively, two appendices are given. They briefly describe the two industries. In Appendix I, the supply of domestic rice is estimated and in Appendix II the supply and demand for groundnuts are statistically estimated by means of ordinary least squares. These appendices will help to show the importance of the relative price as a means for increasing agricultural production.

The raw data used in this study are presented in Appendix III.

CHAPTER II

THE MILLET/SORGHUM INDUSTRY IN SENEGAL

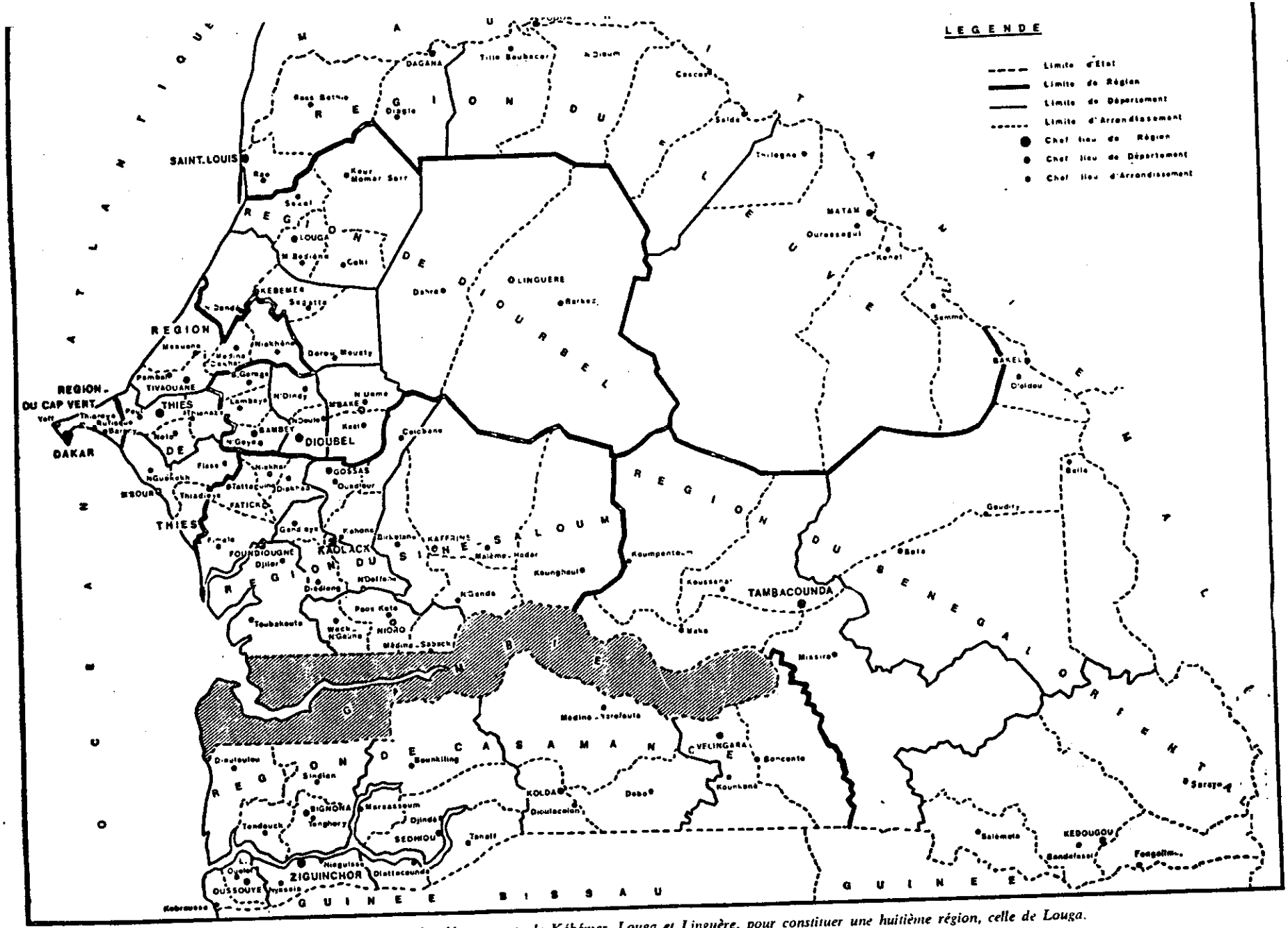
In Senegal, about 75 percent of the total work force is in agriculture, and about 95 percent of the production comes from farm-family units [6, p. 22]. Food supply in the rural areas is essentially provided by home-produced products (millet/sorghum, rice, maize, and beans). The urban areas are supplied mainly by import of cereals (rice, wheat) and domestic products like fish, peanut oil, and vegetables.

A. Production

Millet/sorghum and groundnut together occupy more than 75 percent of the all-cultivated land. In areas where extension activities have encouraged the production of cash crops such as groundnuts and cotton, their relative price vis-à-vis those of millet and sorghum, or relative net return from a hectare of land in alternative production, will be considered by the farmer. This is especially true if the farmer considers himself to have a comparative advantage in cash-crop production through the availability of improved technical inputs such as ox or horse plow. Expected availability of millet and sorghum for purchase must be considered, as some regions are consistently deficient producers while others produce surpluses.

Millet and sorghum production was estimated at 25.1 percent of the total agricultural output in 1976 or about 82 percent of the production of all cereals for the same year. The predominant inputs used in millet and sorghum production are land and labor. In the areas where millet and sorghum compete with groundnuts for land, the same technical inputs, such as seeder or ox plow, are also used for millet and sorghum as well. In the Central Basin, the primary substitute for millet and sorghum is groundnuts. In the Eastern Senegal region, the competing crops are groundnuts and cotton, with which the competition is more for labor than for land. In the southern part of the country, the substitutes for millet and sorghum are rice and groundnuts, with which the competition is for land and labor. In the northern region, along the Senegalese River, there is no cash crop competing or food crop substituting for millet and sorghum for the rain-fed crop, but the land has a low level of fertility and the rainfall is insufficient and irregular. The different economic regions are shown on the map (Figure 1).

Other important reasons for the low yield in the millet and sorghum production are lack of research on high-yielding millet/sorghum varieties and the low level of fertilizer usage--about 30.56 kg per hectare on the average. Agricultural research has focused on groundnuts and only in recent years has the government begun to



N.B. — La région de Diourbel a été amputée en 1976 *des départements de Kébémer, Louga et Linguère, pour constituer une huitième région, celle de Louga.*

The groundnut basin encompasses the regions of Thies, Diourbel, Sine Solum, a part of eastern Senegal. It is also the major area of millet/sorghum production.

Rice production areas are the Fleuve region and Casamance region.

encourage research on millet/sorghum. Another factor which has an important influence on the production pattern is the fact that the extension services are quite modest and services such as the delivery of input which strongly influence farm decisions are poorly organized [4].

B. Marketing

Since 1975, the government marketing board, ONCAD, has had a legal monopoly on the primary collection and marketing of millet/sorghum. Prior to this, legal private trade characterized the market. ONCAD collects the production from cooperatives, stores a security stock, and sells the rest to deficit producers and consumer cooperatives. But, in addition to the official ONCAD circuit, a parallel millet/sorghum market exists. Peasants sell to local traders, who in turn either sell to wholesalers or directly to consumers. In theory, ONCAD purchases from producers at 35 CFA per kilo (1976), while in the parallel market, the producer can sell directly to a trader at 40 CFA per kilo and both producer and trader receive a better price. The structure of the marketing organization is shown in Figure 3. In fact, ONCAD resells about 70 percent of its millet to cooperatives in the deficit area. But, as mentioned earlier, production of millet and sorghum is largely for subsistance purposes, and the percentage

FIGURE 2

ECONOMIC RELATIONSHIPS AND VARIABLES INVOLVED
IN MILLET INDUSTRY IN SENEGAL

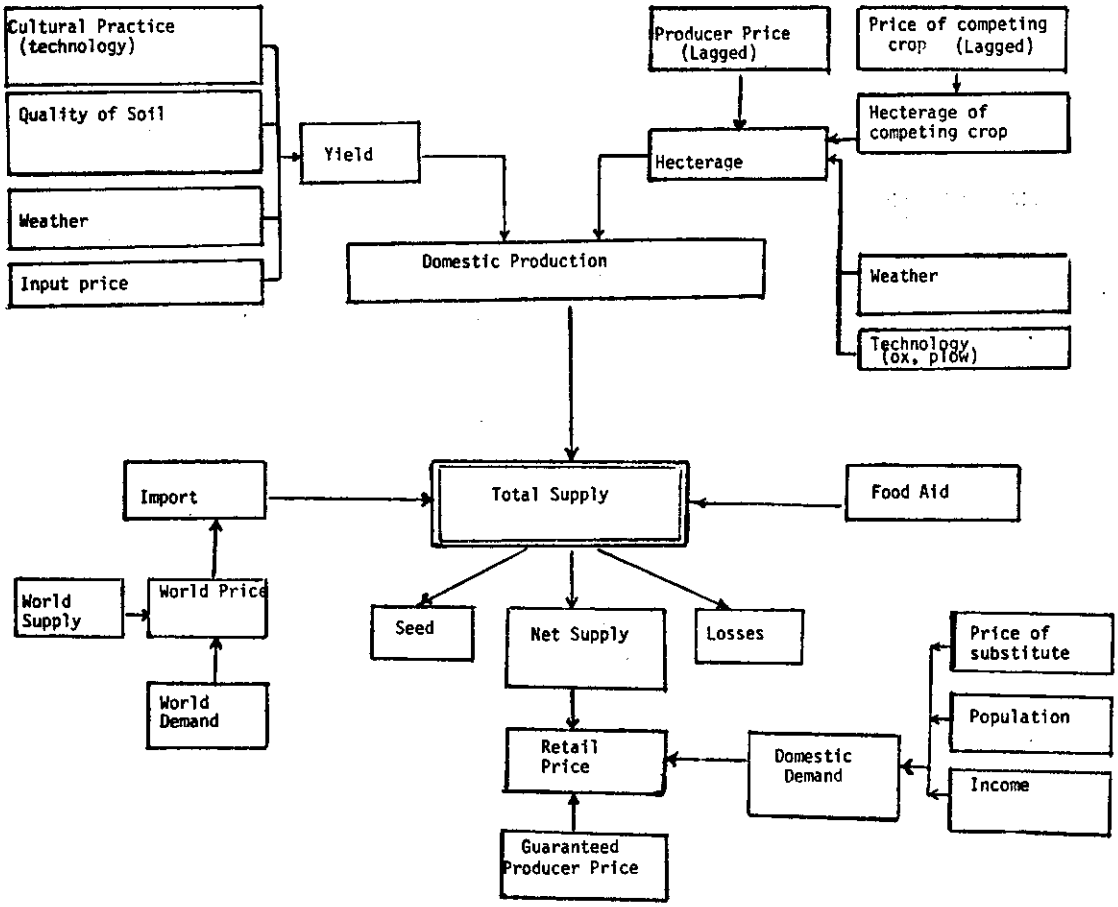
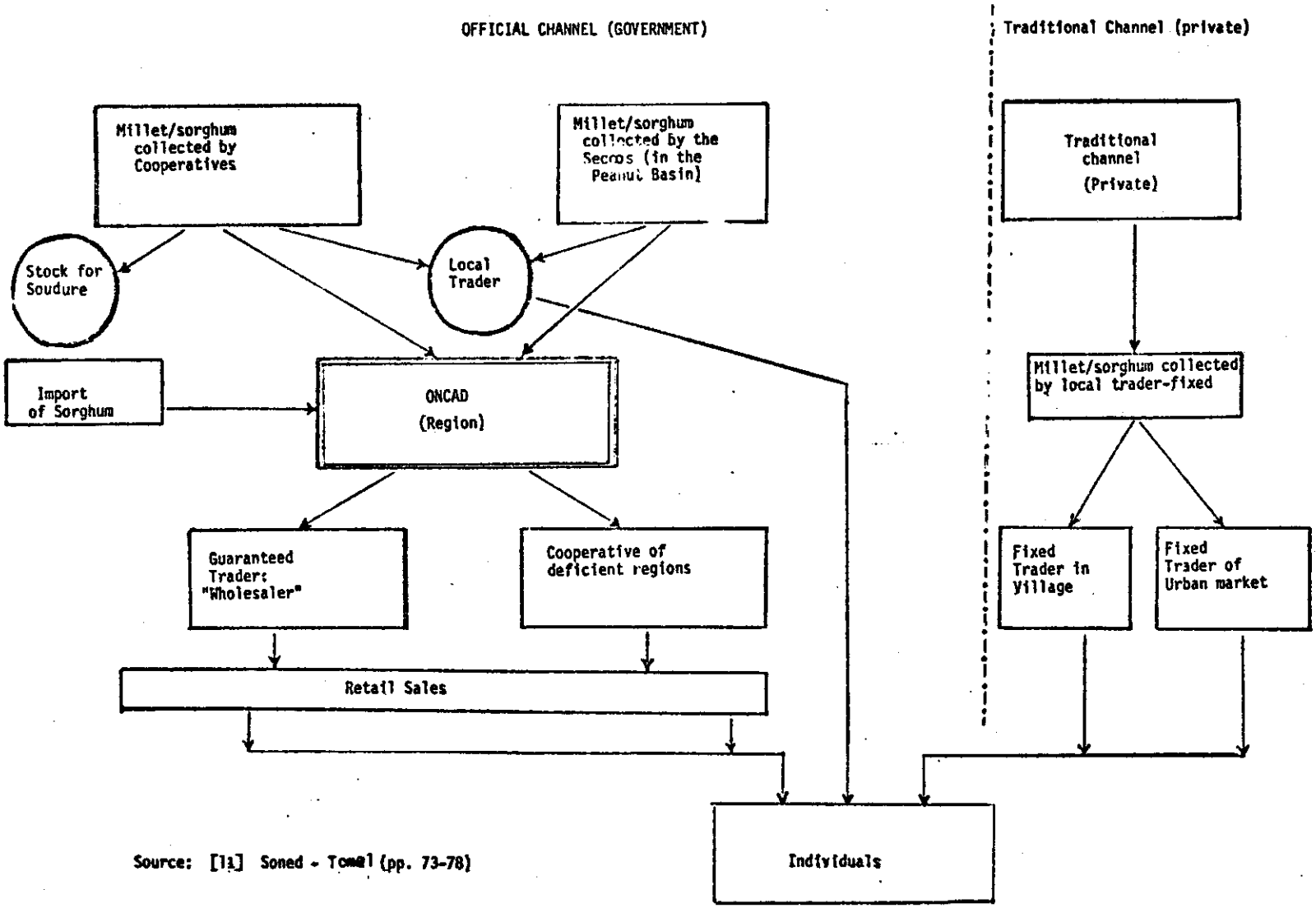


FIGURE 3

MILLET/SORGHUM MARKETING CHANNEL



Source: [1] Soned - Tomal (pp. 73-78)

of marketed production is very small (Table V): 3 percent in 1961-62, 0 percent in the drought years (1971-73), 6 percent in 1974 (the highest production ever obtained and the year when price rose from 18 CFA per kilo to 25 CFA per kilo), and only 2 percent in 1976 despite the official price of 35 CFA per kilo.

This decline in marketed production, from 6 percent to 2 percent, is due to a decline in the production, partially, but it is mainly a result of the rise of the price of rice to consumers. In fact, since 1972 the retail price of the imported rice rose from 40F per kilo to 60 CFA (1973), then to 100 CFA (1974) and 80 CFA per kilo (1975). Rice is the primary substitute for millet in the rural everyday meal; therefore, the peasants prefer to keep their millet and sorghum for their own consumption and consume less rice (except the rice producers). The price which the farmer uses in comparing cash-crop and food-crop prices could be expected to be the lagged official price of cash crop, since for these crops there does not exist a market price. Prices are exclusively controlled by the government.

The cereal balance for the years 1969-70 to 1975-76 (Table II) shows an average share of 28.43 percent for import in the total cereal consumption satisfied and 3.8 percent for food aid. But in a normal rainfall year, Senegal may be self-sufficient in millet and sorghum--

TABLE V

MILLET/SORGHUM MARKETED BY ONCAD

YEARS	PRODUCER PRICE (CFA/kilo)	QUANTITY MARKETED (tons)	PERCENT OF TOTAL PRODUCTION
1970-71	18	396	0
1971-72	18	2,866	0
1972-73	18	21	0
1973-74	25	29,969	6
1974-75	30	30,969	5
1975-76	30	12,125	2
1976-77	30	10,000	2

SOURCE: CILSS, Marketing, Price and Storage of Food Grains in the Sahel, August 1977, Vol. II.

for direct consumption by the population.

CHAPTER III

THE THEORETICAL FRAMEWORK

A. The Economic Model

The structure of supply-demand for millet and sorghum in Senegal is complex. Prices and uses are not always determined simultaneously by the supply and demand for millet/sorghum, but are sometimes determined by other factors outside of the millet/sorghum market.

Economic relationships in the millet/sorghum industry are shown in Figure 2. This figure can be divided into two major parts. The upper part illustrates factors involved in the domestic production and the lower part shows factors involved in the net supply and the retail price.

Assuming that last year's producer prices will prevail in the current year (the guaranteed producer prices are usually announced after planting), the important determinants of the hectarage and the yield would be:

For yield: the weather, the quality of the soil, the cultural practices (techniques) and the input prices

For hectarage: the weather, the technique used (traditional instruments or ox-drawn plow), the past year's price of millet and the price of competing crops

The total supply of millet/sorghum includes

local production plus the quantity imported and food aid from other nations or international agencies. After eliminating the quantity for seed, the percentage of losses, we come up to the net supply of millet/sorghum for population consumption (and in the near future, for the food-processing industry). The factors affecting domestic demand of millet are: population, income, consumption pattern, and the price of substitutes. There is an interaction between domestic demand, retail price, consumption pattern, income, and price of substitutes. The main substitute for millet/sorghum in the daily meals in urban as well as rural areas is rice. The net supply, together with the domestic demand and the government-guaranteed price, determines the retail price.

B. The Statistical Model

The statistical model is a functional representation of economic relationships. These relationships provide the basis for the selection of the variables and the construction of the model. It will be assumed that demand and supply are independent of each other and will be estimated separately by a single equation regression technique.

Short-run change in output is often influenced by weather variables and other unpredictable natural

hazards. Long-run changes in supply are mostly attributable to such factors as technology, price of inputs, etc.

The factors which affect demand, or the customer's decision with respect to the quantity of a commodity that he purchases, are many. Some of these factors are not precisely measurable statistically, such as changes in taste, psychological factors, and the like. The most important determinants appear to be: population, income, and the relative price of the commodity and the price of close substitutes in demand.

In most empirical econometric studies, data limitations exist. In this study, annual data for the period 1960-76 are used. Only variables for which data are available will be used; however, in some cases, proxy variables are necessary. Appendix III gives the available raw data which have been used in this study.

The following supply and demand relationships are specified respectively:

Supply

(1) $QMS_t = \alpha+\beta_1 PM_{t-1}+\beta_2 PGN_{t-1}+\beta_3 PR_{t-1}+\beta_4 PF_t+\beta_6 DV+\beta_7 T+e_t$

where:

QMS_t = Quantity of millet/sorghum production in year t in 1000s of metric tons

PMS_{t-1} = the last year official producer price of millet/sorghum expressed in francs CFA/kilo

PGN_{t-1} = the official producer price of groundnuts lagged one year expressed in FCFA/kilo

PR_{t-1} = one year lagged rice producer price, expressed in francs CFA/kilo

PF_t = price of fertilizer in current year, expressed in francs CFA/kilo; the data used here are the prices paid by the producer (not by the government) to the firms

RF_t = amount of rainfall during current year expressed in millimeters

DV = dummy variable, equal to 1 for the years 1973-1976, and 0 elsewhere; this variable is defined as the government pricing policy with higher prices during the last four years of the study period

T = time trend

α = a constant term

β_i = regression coefficient to be estimated

e_t = error term

Demand

(2) $$TDMS_t = \alpha+\beta_1 PM_t+\beta_2 PRIR_t+\beta_3 PR_t+\beta_4 PY_t+\beta_5 DV+\beta_6 T+e_t$$

where:

$TDMS_t$ = per-capita consumption of millet/sorghum in kilograms/year

PM_t = price of millet/sorghum in the current year, franc CFA/kilo

$PRIR_t$ = price of the imported rice in current year, in FCFA/kilo

PY_t = per-capita income in the current year, in FCFA/kilo

T = time trend

e_t = error term

β_i = regression coefficient to be estimated

α = constant term

Both supply and demand function will be estimated by means of ordinary least squares (OLS). For both supply and demand it is assumed that the errors are normally distributed with zero mean and finite and constant variances. The estimated coefficients will be then consistent, asymptotically efficient and have approximately a normal distribution. This will make it possible to use t-test for approximate statistical inferences.

CHAPTER IV

THE EMPIRICAL RESULTS

In this section, the focus will be on the estimated coefficients. In interpreting the estimates, attempts will be made to assess the validity of the estimates in relation to economic theory. The extent to which signs and relative magnitudes of the estimated parameters agree with expectations will be noted, and an explanation will be given for those that deviate from expectations.

A. Supply

Several different models were specified for the domestic supply relation. In each case, evidence of multicollinearity among the exogenous variables was found. For instance, when the equation was estimated using all seven exogenous variables, the individual t-tests on the coefficients for the prices of millet/sorghum, the competing crop, and fertilizer, and the amount of rainfall, indicated that the null hypothesis (that each coefficient is equal to zero) could not be rejected. Although the value of the $\bar{R}^2$ indicated a very good fit, the coefficients are very sensitive to slight modifications of the model. The value of $\bar{R}^2$ is interpreted as the proportion of the variation in the

endogenous variable explained by the regression equation. A high value of $\bar{R}^2$ such as .89 indicates a very good fit, a high degree of explanatory power of the model.

The value of the Durbin-Watson statistic can be used to test for the existence of serial correlation. Serial correlation is a common problem in applied econometrics. Its existence means that the stochastic disturbance terms are not independent of one another; that is, the covariance of e_t and $e_{t'}$ is not equal to zero, i.e., $Cov(e_t, e_{t'}) \neq 0$, for $t \neq t'$. The problem of serial correlation is often present when using time-series data, since in that case stochastic disturbance terms in part reflect variables not included explicitly in the model [18, p. 159]. The stochastic disturbance at one observation will be related to the stochastic disturbance at nearby observations. Typically, the most important type of serial correlation is first-order linear serial correlation, namely, the linear relationship between successive stochastic disturbance terms. If the value of the Durbin-Watson statistic is much less than 2, then a positive first-order serial correlation is generally indicated, while, when $\hat{d} > 2$, a negative first-order serial correlation is indicated. The supply equation (1), defined in Chapter III, has been estimated by means of OLS, and the value of $\hat{d}$ is equal to 3.07. This indicates the presence of a negative

first-order serial correlation. To treat this serial correlation, the Cochrane-Orcutt technique* has been used. The estimated coefficients of the exogenous variable did not change very much, but the $\bar{R}^2$ became much higher, indicating a higher explanatory power of the model. The Durbin-Watson statistic d is reduced to the value of 2.2550 after correlation. The t-ratios are indicated in parentheses.

(a) OLS:

$$(3) \quad QMST = \underset{(.41)}{99} + \underset{(4.)}{63.58PM_{t-1}} - \underset{(-2.69)}{12.PGN_{t-1}} - \underset{(-4.91)}{39.49PR_{t-1}} + \underset{(.47)}{4.17PF_t} +$$

---

*This method consists of the following steps to be applied on the equation:

$$(Y_t - \rho Y_{t-1}) = a(1-\rho) + b(X_t - \rho X_{t-1}) + (e_t - \rho e_{t-1})$$

(a) Obtaining OLS of $Y_t = a + bX_t + e_t$

(b) Calculate the estimated residuals $\hat{e}_1, \hat{e}_2, \ldots$. Use these to obtain a "first-round" estimate of $\rho = \hat{\rho}$ where $\hat{\rho} = \Sigma \hat{e}_t \hat{e}_{t-1} / \Sigma \hat{e}^2_{t-1}$; $t = 2, 3, \ldots, T$

(c) Calculate $Y'_t = Y_t - \rho Y_{t-1}$, $X'_t = X_t - \rho X_{t-1}$; $a' = a(1-\rho)$

(d) Obtaining the OLS of $Y'_t = a'bX' + V$ $(V = e_t - \rho e_{t-1})$; and "second-round" estimate of $\hat{\hat{e}}_1, \hat{\hat{e}}_2, \ldots, \hat{\hat{e}}_T$

(e) Calculate new $\rho = \hat{\hat{\rho}} = \Sigma \hat{\hat{e}}_t \hat{\hat{e}}_{t-1} / \Sigma \hat{\hat{e}}^2_{t-1}$, $t = 2, \ldots, T$; construct new variable Y'_t, X'_t with $\hat{\hat{\rho}}$ ... .

(f) Continue the procedure until the value of estimators converges, that is, until we obtain the same value for the parameters round after round. [20, 1978, pp. 39-40]

$$.42RF_t + 101.51DV$$
$$(4.90) \quad (2.24)$$

$\bar{R}^2 = .90$

Durbin-Watson Statistic = 3.07

Standard Error of the Regression = 49.6

Number of Observations = 16

F-Statistic (6, 9) = 13.3

(b) CORC:

$$(4) \quad QMST = \underset{(.27)}{43.57} + \underset{(6.07)}{66PM_{t-1}} - \underset{(-3.73)}{11.41PGN_{t-1}} - \underset{(-6.21)}{38PR_{t-1}} + \underset{(.86)}{5.11PF_t} +$$

$$\underset{(3.97)}{.35RF_t} + \underset{(2.55)}{91.97DV}$$

$\bar{R}^2 = .93$

Durbin-Watson Statistic = 2.25

Standard Error of the Regression = 42.40

Number of Observations = 15

F-Statistic (6, 8) = 18.08

As the functional relationship employed is linear, the estimated coefficients indicate that each unit change in the exogenous variable changes the value of the endogenous variables by the value of the coefficient, assuming that other variables are held constant. The value of the constant term indicates the value of the endogenous variable if all other exogenous variables are held at level zero.

However, since the model was specified to apply to variables which have non-zero value, the value of the constant term has no intrinsic meaning.

The lagged producer price value is an indicator of farmers' price expectations. Last year's prices of crops have a substantial effect on the farmer's decisions concerning his activities (enterprises) for the current year. However, since the majority of farmers are small farmers, the capital investment is minimal and, therefore, it is assumed that farmers' lagged responses cannot exptend for more than one year. The coefficient of the lagged producer price is relatively high, and this is so because of the very positive responsiveness of farmers to previous-year crop prices. However, it is possible that this variable may also pick up some of the trend effect. This contention may be explained by the absence of such a variable as time which usually assumes this role of "gross" estimate, representative of all relevant variables not included in the model, especially technology. The exclusion of the time-trend variable is due to its high correlation with other variables and also the fact that the effect of technology on millet/sorghum production is minimal. Millet/sorghum production has been neglected for a long time because it has been considered to be merely a subsistence crop for on-farm consumption.

All estimated coefficients (except for fertilizer price) have the expected direction of influence and their associated t-statistics indicate that they are highly significant. The fertilizer variable has a positive sign which was not expected, because if the price goes up, farmers tend to apply less. However, little confidence can be maintained in this estimate because of its small estimated t-ratio.

The millet/sorghum production in the current year is thus very positively responsive to the last-year producer price of millet and negatively responsive to last-year producer prices of groundnuts and rice. Rainfall is positively related to quantity produced and highly significant. The dummy variable DV, which represents here the government pricing policy, comes out with the expected positive sign and is highly significant. Compared to equation (3), equation (4) gives a higher $\bar{R}^2$, a $\hat{d}$ statistic closer to 2, and a higher t-ratio. Equation (4), therefore, will be used for the projection of millet/sorghum supply for 1981 and 1985.

B. Demand

Various specifications of the demand model were also tried. A price-dependent equation was initially estimated. But even though a high $\bar{R}^2$ reflected a good

fit and a Durbin-Watson Statistic $\hat{d}$ close to the value of $\hat{d} = 2$ was obtained, the elasticities calculated at the mean value seem to be unrealistic. Different quantity-dependent equations were then estimated using ordinary least square (OLS) regression and in all of the estimated equations a serial correlation problem was evident by a very high Durbin-Watson Statistic. Because the specification was considered to be "correct," the Cochrane-Orcutt technique (CORC) was used to correct for serial correlation. The "best" demand equations were:

(a) OLS:

(5) $TDMS_t = 551 - 8.48PM_t + 2.82PRIR - .0051PY_t - .62DV - 2.1T$

(2.89) (-1.32) (3.5) (-1.76) (.021) (-1.21)

$\bar{R}^2 = .65$

Durbin-Watson Statistic = 2.89

Standard Error of the Regression = 17.00 $\hat{\sigma}$

Number of Observations = 17

F-Statistic (5, 10) = 4.00

(b) CORC:

(6) $TDMS_t = 302.191 - 7.16PM_t + 2.92PRIR + .00021P_{yt} - 1.97DV -$

(3.87) (-2.47) (8.49) (.20) (-.19)

$2.69T$

(-4.69)

$\bar{R}^2 = .93$

Durbin-Watson Statistic = 2.12

Standard Error of the Regression = 7.96

Number of Observations = 16

F-Statistic (5, 10) = 26.14

Where $TDMS_t$, PM_t, PRIR and PY_t are as defined before.

DV = a dummy variable defined as the government policy, which has shifted the price trend upward in the last four years.

As for the supply model, the corrected equation (6) will be preferred to equation (5) for the same reasons, and will be used for the demand projections.

Millet/sorghum is widely consumed by the majority of the Senegalese population, especially in rural areas, and they are generally considered to be inferior goods. This means that, as their income increases, the rural and low-income urban populations will tend to shift part of their consumption from millet/sorghum to other goods like imported broken white rice and wheat, provided that all other factors are held constant. Therefore, one may expect a negative coefficient of the income variable as in the OLS estimation of the model. Imported broken rice and wheat (in the form of bread) are in fact the major substitutes of millet/sorghum in consumption; hence, the positive sign of the coefficient for the price of the imported rice (PRIR) was expected. With an increase in the price of the imported rice, the consumption of millet/-sorghum tends to increase, too. On the other hand, when

the model is corrected for serial correlation, the coefficient of the income variable becomes positive. This would mean that, contrary to common belief, millet/-sorghum is not an inferior good. Accordingly, an increase in the income will result in an increase in the millet/-sorghum consumption, provided all other factors affecting the demand are held constant. This situation could be explained by the fact that millet/sorghum consumption requires some complementary commodities such as meat, fish, and different kinds of vegetables, depending on the nature of the meal. All these complementary commodities cannot be obtained without monetary spending. Transforming millet/sorghum grain into "couscous" by the traditional technology is a very time-consuming process. If we add to this fact the cost of the required complementary commodities, then a meal from millet/sorghum may be one of the most, if not the most, expensive meals in Senegal, especially for the urban population which has to buy everything entering into that kind of meal.

The FAO/CANAS* 1976 study has found a negative income elasticity for millet/sorghum [3, Ch. V, p. 6]. However, our study has not found the income coefficient to be statistically significant, even at the .10 level (in either the corrected or the uncorrected equation).

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*CANAS = Cellule d'Analyse Nutritionelle et Alimentaire du Senegal

Therefore, little confidence can be ascribed to the estimated income coefficient and it is hard to defend whether millet/sorghum is an inferior good or not.

C. Performance of the Models

Demand and supply models can also be evaluated by examining the number of turning-point errors and the frequency of under- or over-estimation. The turning-point errors for each dependent variable are determined by comparing the direction of change in the observed values with the estimated values. This information is summarized in Table VI.

TABLE VI

TURNING-POINT ERRORS, UNDERESTIMATION AND OVERESTIMATION ERRORS FOR ESTIMATED SUPPLY AND DEMAND EQUATIONS

EQUATIONS	VARIABLE	TURNING-POINT ERRORS	UNDER-ESTIMATION ERRORS	OVER-ESTIMATION ERRORS
(3) SUPPLY OLS	QMS_t	1	9	8
(4) SUPPLY CORC	QMS_t	1	8	6
(5) DEMAND OLS	$TDMS_t$	1	8	7
(6) DEMAND CORC	$TDMS_t$	1	8	6

NOTE: The total of underestimation errors plus overestimation errors is not always equal to the total number of observations, because, for some estimations, the difference between the actual and the fitted values is near zero and therefore these observations are considered as matching each other. (This is also a question of scale.)

Visual plots comparing the actual and the estimated values against time are given in Figures 4 and 5.

Elasticities: Assuming that $Y = \alpha + \beta_i X_i$, the elasticity estimate is calculated as:

$$\frac{\partial y}{\partial X_i}\left(\frac{\bar{x}}{\bar{y}}\right) = \beta_i\left(\frac{\bar{x}}{\bar{y}}\right)$$

where y is the endogenous variable, x_i, the appropriate exogenous variable, β_i is the estimated coefficient of X_i, and $\bar{y}$ and $\bar{x}$ are the mean values of the endogenous and exogenous variables, respectively. The own-price, cross-price and income elasticities are calculated from the estimated supply and demand equations and are presented in Table VII-a. The elasticities are calculated at the mean value of the variables during the period under analysis.

For the supply equation, the own lagged price elasticity of 2.5 is positive and greater than one, as expected.

Despite the unavailability of a previous time series study on millet/sorghum in Senegal, such a high price elasticity of millet/sorghum is not unusual. Similar amplitudes and even higher ones have been found for food crops in countries like Syria, Thailand, Iraq, etc., and are shown in Table VII-b. For example, in Syria, supply elasticities of millet/sorghum and maize are respectively 1.21 and 2.27. In Iraq, elasticity for geant millet and rice are,

Figure 4: Per Capita Annual Consumption of Millet/Corghum

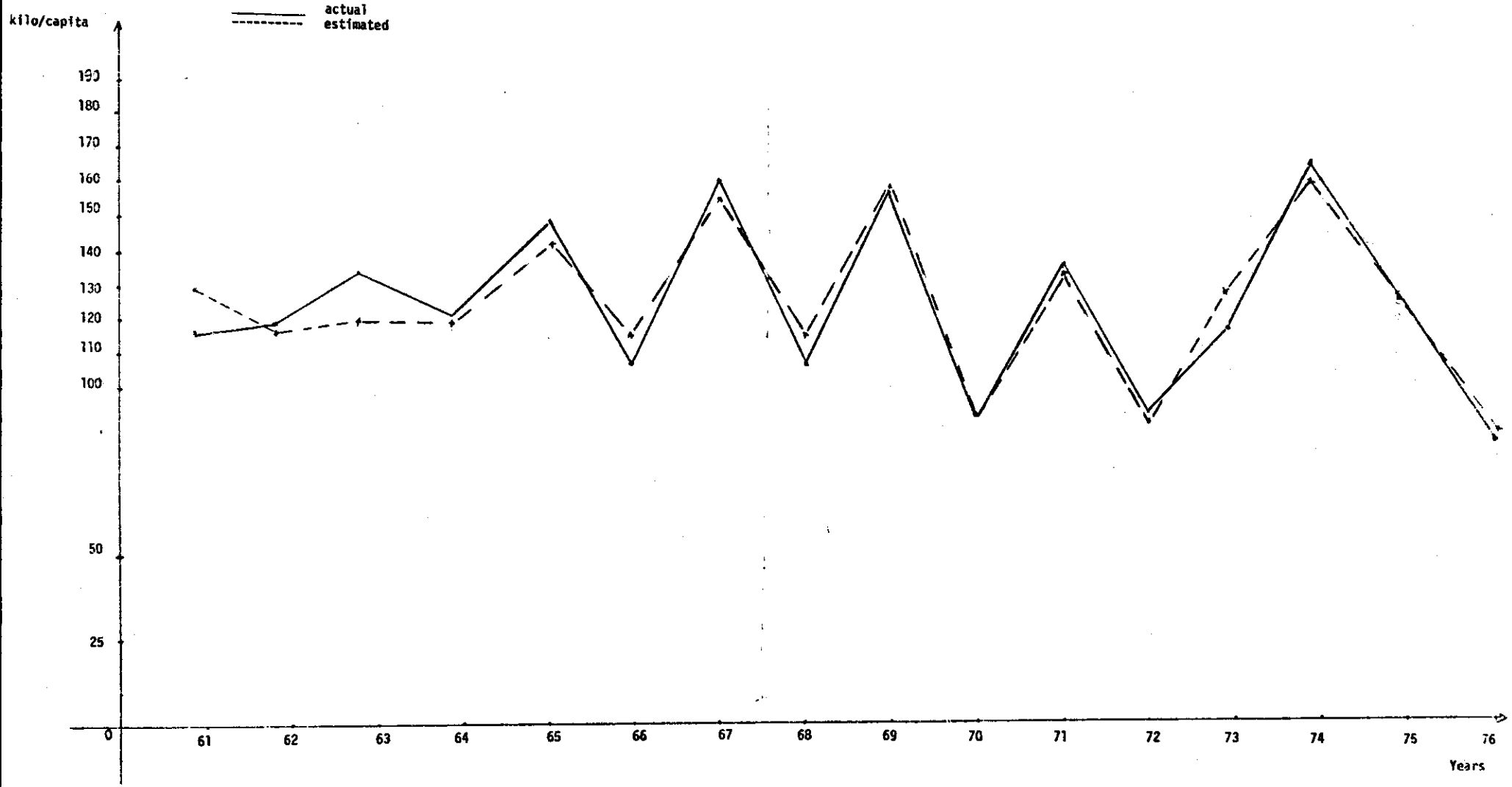


Figure 5: Domestic Supply of millet/sorghum

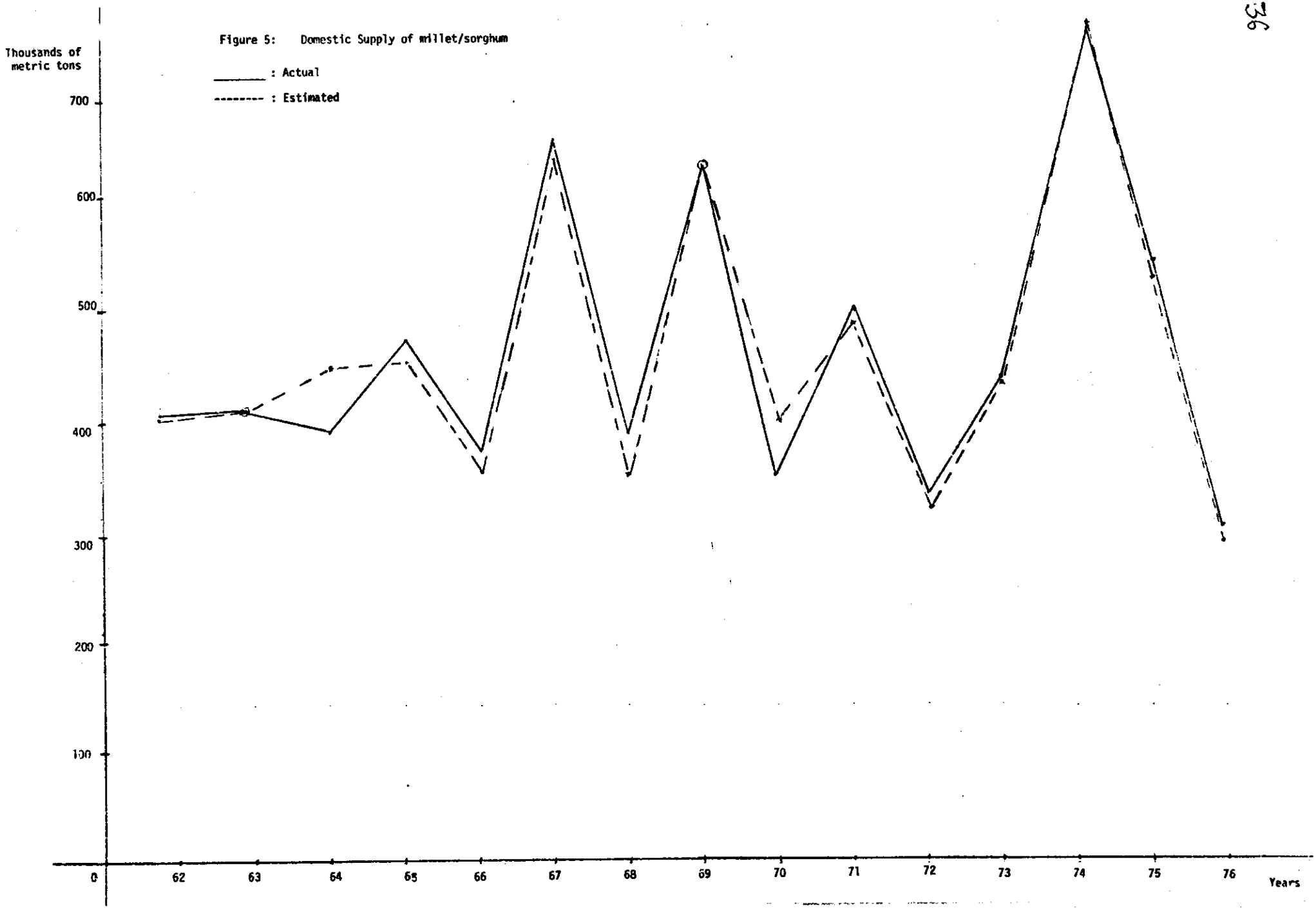


TABLE VII-a

ELASTICITY ESTIMATES

ELASTICITY	SUPPLY		DEMAND	
	OLS	CORC	OLS	CORC
Own-price Elasticity			-1.13	-1.10
Cross-price Elasticity of Substitute--Price of Imported Rice (PRIR)			+1.05	-1.08
Income Elasticity			-2.01	+0.1
Own Lagged Price Elasticity	+2.5	+2.5		
Cross-price Elasticity of Substitute in Production:				
$EPGN_{t-1}$ (groundnut)	-0.55	-0.52		
EPR_{t-1} (rice)	-1.82	-1.75		

TABLE VII-b

SOME SUPPLY ELASTICITIES BY

CROP AND REGION

CROP	COUNTRY	PERIOD	AUTHOR	SHORT-RUN ELASTICITY
Millet	Syria	1967-1972	Harik	+ 1.21
Geant Millet	Iraq	1954-1965	Medani	-25.57
Maize	Syria	1961-1972	Harik	+ 2.27
	Thailand	1949-1963	Behrman	+ 0.27 to + 4.47
Sesame	Iraq	1961-1971	Harik	+ 2.70
Soybean	U. S. A.	1946-1966	Houk and Subotnik	+ 1.70 to + 3.3
	Iraq	1950-1960	Askari and Harik	+ 2.3
		1961-1971	Askari and Harik	- 2.85

SOURCE: Hossein and Askari, International Economic Review, June 1977, Vol. 18 No. 2, pp. 265-279.

respectively, -25.57 and 2.68.

Most estimates in other studies are derived from cross-section data. This makes it very difficult to compare them with the estimates of this study. Cross-section material cannot usually be regarded as representative of the whole population because, in general, it includes only wage and salary earners who, in developing countries, comprise a small percentage of the total population. Cross-section is used for a short period, during which many factors affecting consumption are constant, while in time-series analysis, these factors may change with important implications on the elasticities. Since price is constant by definition in a cross-section study, price elasticities of demand cannot be generated. The comparison is also difficult due to the fact that the definition of variables may differ. In cross-section analysis consumption is usually measured in expenditures, while in time-series analysis it is mostly measured in physical units of the product.

The cross-price elasticities are negative as expected and less than one for the lagged price of groundnuts and the current price of fertilizer. However, the price of fertilizer is not statistically significant.

For the demand equation, the own-price elasticity (about -1.1) is negative as expected, but also large.

The income coefficient is -2.0, with the OLS estimation, and +0.1 with the CORC treatment. However, as noted earlier, it would be arbitrary to conclude anything about its nature, for it is not statistically significant.

The major substitute for millet/sorghum is rice, especially the imported broken white rice. The cross-price elasticity for this type of rice is positive, as expected, but also high (about 1.0).

The calculated elasticities are almost all relatively high. But for the demand equation it was expected to find much lower elasticities because, for the vast majority of the population--especially the rural population--millet/-sorghum consumption is not very much affected by the price variation. The prices used are government official prices. They have been held very low and constant for some periods. Market prices were not available, or if they were, they covered only a few years in the study period.

CHAPTER V

APPLICATION OF THE MILLET/SORGHUM SUPPLY AND DEMAND MODELS

Any attempt to use the results obtained in the preceding chapter for policy analysis and formulation must be made very carefully. This is largely due to the fact that Senegal is a developing country and, like most developing countries, yields a quality of data that is not always satisfactory for studies like this. Moreover, long-term projections are subject to other limitations, such as the following:

(a) Long-term projections are based on a set of assumptions which may not hold over the projection period

(b) Tastes and preferences of consumers change very quickly, due to the developing character of the economy (change in the structure)

(c) Many factors which affect the level of consumption and production of certain commodities are difficult to quantify

A. Millet/Sorghum Production Projection

Instead of a simple linear extrapolation of production, each production determinant is forecast

separately. These forecasts are then inserted into the estimated supply equation (4) to make the projection of the domestic supply for 1981 and 1985.

The millet/sorghum price used here was not entirely determined by the interaction of the market forces of supply and demand. Government intervention has kept millet/sorghum prices below those expected in a free market. However, as indicated in the previous chapter, the traded quantity through the official channel is very small. The major part of the traded quantity is through private channels, where the price is considerably higher. For example, after the 1974 harvest of 777,000 metric tons, millet/sorghum was traded in the private parallel market at a price of FCFA 40/kilo or more, in contrast to the official price of FCFA 35/kilo, which is, however, higher than the international price (∿27 FCFA/kilo). It is very difficult to predict what the price will be in the near future, but, based on the government decision to promote the development of millet/sorghum production, it is expected that the government official price will be much closer, if not equal, to the market price. The official price has been held constant from 1962 to 1965 at 16 FCFA/-kilo; from 1966 to 1979, at 17.5; and then it began to pick up an ascendant trend from 1973 to 1976. These figures correspond to an annual rate of price increase of 5.45 percent for the entire period (1960-1976) and 11.85 percent

for the last four years of the period under analysis (1973-1976).

Based on the general feeling that the future will look more like the recent past than like earlier years, a first assumption would be that the millet/sorghum price will keep its recent trend of annual rate increase (12 percent). Therefore, the estimated prices in 1981 and 1985 will be, respectively, 61.5 FCFA/kilo and 86.32 FCFA/kilo. As this rate of growth, the government official prices will be approximately the same as the private-market price by 1981.

Similarly, the price of groundnuts will also be assumed to follow its recent trend (1973-1976). However, groundnuts are an export cash crop and their price is closely linked with the international price. Therefore, this trend will be arbitrarily adjusted to a more realistic level.

Another assumption is that the producer prices will not change over time until 1981 and then will increase with an annual rate of 1.5 percent. Finally, it is assumed that the prices (including fertilizer) will be somewhere on the average between these constant and high prices. Hence, three possible price scenarios are examined (see Table VIII).

With respect to rainfall, for the entire period 1970-1976 the average annual rainfall was 730 m/m with

TABLE VIII

ASSUMPTIONS ON RELATIVE PRICE

OF PRODUCTS AND INPUT

(Unit of price: FCFA/kilo)

CROPS INPUT	SCENARIO I (CONST. PRICES)		SCENARIO II (HIGH PRICE TREND)		SCENARIO III (AVERAGE)	
	1981	1985	1981	1985	1981	1985
Millet/-sorghum	35.0	45.0	61.05	80.0[a]	48.25	65.65
Groundnuts	41.5	45.0	70.0	96.3	55.75	70.65
Domestic Rice	41.5	45.0	70.0	100.0	55.75	72.51
Fertilizer	20.0	22.0	34.5	49.0	27.25	35.5

[a]adjusted trend

a standard deviation of 176.5. The lowest rainfall recorded was 691 m/m in 1968 and 494 m/m in 1972. These years correspond to the drought years which affected most of the West African countries, especially the 1972-1973 drought in the Sahel.

The average of 730 m/m is a bit higher than the average of 600 m/m based on a 30-year period, usually observed in the Sahelian zone. In this study, the 30-year average (600 m/m) will be used for the projection of millet/-sorghum production for 1981 and 1985.

Using the assumptions above on producer prices, price of input (fertilizer) and rainfall, the projection of the domestic supply of millet/sorghum is then given by the following:

$$(7) \qquad Y_{t+k} = \hat{\alpha} + \Sigma \hat{\beta}_i X_{i,t+k} + (U_t)\rho^k$$

where $\hat{\alpha}$ and $\hat{\beta}$ are estimates obtained from the estimation of the supply equation model after correction by the Cochrane-Orcutt technique; $X_{i,t+k}$ is the projected ith independent variable for the year $t+k$, k being the number of years in the projection period; U_t is the residual of the last observation in the studied period; ρ is the estimated first-order autocorrelation parameter.

The projection with $Y_{t+k} = \hat{\alpha} + \Sigma \hat{\beta}_i X_{i,t+k}$ would be different from projection with formula (7) on two counts. First, it would be biased, since it takes no account of recent disturbances, and second, it would be less efficient since the simple least square estimator on which the projection is based is less efficient than the generalized least estimator. [25, pp. 195-197]

A summary of the results of the projection of millet/-sorghum domestic supply is given in Table IX. The results for 1981 under Scenarios I and III are not very far from the fifth National Development Plan target (750,000 metric tons). These results are also realistic and feasible within the existing state of the arts, provided the assumptions

TABLE IX

MILLET/SORGHUM SUPPLY IN 1000 METRIC TONS

AND PROJECTIONS

YEAR	SCENARIO I	SCENARIO II	SCENARIO III	VTH PLAN	WORLD BANK ESTIMATE
1981	712.54	1131.89	880.80	750.0	660.0
1985	1210.55	986.78	1300.62	. . .	. . .

specified above hold. On the other hand, the results of the supply forecast for 1985 may not be feasible unless a significant technological change occurs. The model indicates only the responsiveness of the supply to the change of relative prices of crops and inputs. It does not take into account the technological and agronomic feasibility, that is, the availability of land, capital, labor, and the level of yields per hectare. The 1985 projection shows only the domestic production affected under the price scenarios when all other constraints are removed.

The supply projection by the Vth National Plan and the World Bank estimation are shown in Table IX. These projections are based on averages of yield and hectarage in the ending year of the plan (1981).

B. The Demand Projection

Similar to the supply projection, an attempt will be made to forecast major variables affecting demand, and use these forecasts to generate an estimate of the quantity of millet/sorghum demanded. For this approach, the assumption regarding the millet/sorghum retail price will be the same as in the supply projection. For the price of imported rice, a similar set of scenarios will be examined--that is, constant prices, high and medium (average) prices for the years 1981 and 1985. Per capita income projection will be made in accordance with the Fifth Development Plan. These assumptions are summarized in Table X.

As for the supply projection, the demand projection for 1981 and 1985 will be given by the same equation (7). The demand forecasts are shown in Table XI. These results

TABLE X

ASSUMPTIONS AND PROJECTION OF VARIABLES AFFECTING DEMAND

	SCENARIO I (Constant Price)		SCENARIO II (High Price; Trend)		SCENARIO III (Average)	
	1981	1985	1981	1985	1981	1985
PM_t (Price of millet)	35	45	61.5	80*	68.25	65.65
PRIR (Price of imported rice)	80	80	100	120	85	100
PY_t (Per-capita income)	60,936	68,900	60,938	68,900	60,936	68,900

*adjusted trend

TABLE XI

DEMAND FOR MILLET/SORGHUM IN 1000 METRIC TONS

FOR 1981 AND 1985

YEAR	MEASURE-MENT	ECONOMETRIC MODEL			FAO-OCDE METHOD	WORLD BANK ESTIMATION
		SCENARIO I	SCENARIO II	SCENARIO III		
1981	Per-capita (kilo)	240	108	159	136.3[a]	. . .
	Total	(1395.9)	(631)	(928.67)	(792.85)	(724)
1985	Per-capita (kilo)	159	24.82[b]	69.6	152.8[a]	. . .
	Total	(1025)	(159)	(448.63)	(985)	. . .

[a] constant price

[b] the price of millet has been adjusted

indicate the per-capita demand for millet/sorghum (in kilograms) under the specified assumptions. The figures in parentheses are the corresponding total demand at the national level in thousands of metric tons. They are obtained by multiplying the per-capita demand by the total population in the projection year. These results show that the consumption of (demand for) millet/sorghum decreased with the increase in price. For 1981 as well as for 1985, the demand is very high when the prices are low and very low when the prices are high. Moreover, the demand decreases with increases in the price ratio of millet/sorghum to rice (millet price ÷ price of imported rice). This ratio seems to be more important than anything else in the millet/sorghum demand.

In fact, the results show that, as this ratio increases, the demand for millet decreases and is theoretically equal to zero for the value of that ratio greater than .68. That is, if the price of millet/sorghum is more than 68 percent of the price of imported broken rice, people other than millet producers will consumer rice rather than millet. The reason for this, as mentioned earlier, is the fact that at the ratio the value added generated in millet/sorghum preparation will finally make it much more expensive than its direct substitutes--the broken rice, and wheat (bread). The projection of demand for millet/sorghum is given in Table XI. In Table XI the figure 24.82 corresponds to the high-price scenario in 1985. It has been obtained after a downward adjustment of the millet/sorghum price from 86.32 (the actual value of the trend in 1985) as previously assumed, to 80. With 86.32 FCFA/kilo, the price ratio was .72 and the demand was theoretically zero, and with the price at 80 FCFA/kilo, the ratio became .67, which corresponds to a demand equal to 24.82 kilo per capita per year, or 159,000 metric tons on the national level. Inversely, the smaller this ratio, the higher the demand for millet/sorghum.

Another method used in this study for the projection of millet/sorghum demand is the FAO-OCDE method, based on income, the elasticity and the population rate of growth, and given by the formula:

(8) $d = pop + \zeta y$

(9) $D_t = D_0(1 + d)^T$

Where:

d = rate of growth of consumption

pop = rate of growth of population

ζ = income elasticity of demand

y = rate of growth of per-capita income

D_0 = consumption in time, $t = 0$

D_t = projected consumption (demand), in time t

T = time in years from D_0 to D_t

The value concerning the rate of growth of the population and per-capita income is given in the National Economic and Social Development Plan (1977-1981) and used in the demand equation of this study. The income elasticity will be that obtained in the demand equation.

When the rate of growth in consumption--d--is obtained from the relation (8) it is used in relation (9) to obtain the projected demand of millet/sorghum in 1981 and 1985. D_0 is the consumption of millet/sorghum in the basis year--1976 in this study. However, because of the fact that, for the study period, the demand did not show any particular pattern, the average of the last five years (1972-1976) has been used for D_0.

The results are given in the fifth column of Table XI. It is hard to make any comparison between these results and those of the econometric model, not only because of the

difference in the methods but also because of the implicit assumption of constant price in the latter method. The figure provided by the World Bank was calculated by using simple linear extrapolation of past trends.

Comparing the supply and demand projection results under the three scenarios, we can calculate the self-sufficiency ratio. This information is summarized in Table XII.

TABLE XII

SUPPLY AND DEMAND FOR MILLET/SORGHUM

AND SELF-SUFFICIENCY RATIO

SCENARIO	1981 SUPPLY	1981 DEMAND	1981 SELF-SUFFICIENCY RATIO	1985 SUPPLY	1985 DEMAND	1985 SELF-SUFFICIENCY RATIO
Scen. I	712.5	1395.9	.51	1210.55	1025.0	1.18
Scen. II	1131.8	631.3	1.79	985.66	159.0	6.2
Scen. III	880.8	928.6	.95	1300.62	448.6	2.91

Only in 1981 for Scenarios I and III is the self-sufficiency ratio less than 1. In all other cases, Senegal will be highly self-sufficient in millet/sorghum, provided the specified assumptions hold.

For 1981 the ratio in Scenario III is close to the National Plan's target (1.11); however, this target is met only with the high-price scenario (II). With the high-price scenario, the supply goes up and the demand tends to

decline. Therefore, the self-sufficiency ratio increases and is very high compared to the other price scenarios. This can be seen for 1981 and 1985 as well.

CHAPTER VI

SUMMARY, RECOMMENDATIONS, CONCLUSIONS AND SUGGESTIONS

A. Summary

Senegal, like other developing countries, especially the Sahelian countries, has launched into a self-sufficiency policy in food crops. This policy was initiated in earlier years after independence, but has been taken seriously only recently, due to the consequences of the 1972-1973 drought in the Sahel. The term self-sufficiency means, here, a national production of food crops sufficient to cover the annual population needs, including poor harvest years. This effectively excludes imports of grain in the total domestic disposal. This self-sufficiency policy implies, then, a noticeable increase in the domestic production of these crops, especially millet/sorghum. This increase in production can be achieved by increasing hectarage cultivated and/or increasing crop yield. The main purpose of this study was to identify the most important determinants of the supply and demand for millet/sorghum. The factors determining the domestic supply and demand have also been studied with the expected future changes. To estimate these relationships,

an econometric model was developed for both demand and supply. In this effort, economic theory and our knowledge of the economic relationships of the Senegal millet/sorghum industry have been drawn upon. The statistical model has been estimated and interpreted and applied to the current conditions as well as in forecasting demand and supply conditions. The major points of these estimations are the following:

• The millet/sorghum supply is highly responsive to the previous year's producer price. The price elasticity is high (2.5). The projected production for 1981 under competing price assumptions is feasible within the existing state of the arts and comparable with the projection done by the Fifth National Economic Plan and the World Bank. On the contrary, the projection for 1985 seems to be very high under all price scenarios. This projection is indicative of the responsiveness of quantity supplied to price changes.

• The demand for millet/sorghum per capita, as well as at the national level, decreases with the increase of the price. The own-price elasticity is also high (-1.1). However, little confidence can be ascribed to the income elasticity estimate which is positive, very small, and statistically insignificant. The projected demand is very high under the assumption of low price and very small under the assumption of high price. The cross-price elasticity of

imported broken white rice is equal to 1. The most interesting finding in the millet/sorghum demand model is the existence of a price ratio between millet/sorghum and the imported broken rice equal to about .68, above which the demand for millet/sorghum may drop and theoretically become close to zero because of its substitution with rice in consumption. The more this ratio decreases, the more the demand for millet/sorghum increases. For Scenario I, it is assumed that the prices will be constant from 1976 to 1981 and they will increase by a low annual rate, 1.5 percent. Scenario II assumes that the prices will continue their recent ascendant trend (1973-1976); Scenario III is the average price between Scenarios I and II.

Comparing demand and supply under the different price scenarios for 1981 and 1985, the self-sufficiency ratio is more than 1 except in 1981 under Scenarios I and II. In this case, the low price stimulates the demand while production decreases or remains relatively constant. For 1981, Scenario III (average price) seems to be more satisfactory in terms of equilibrium and for 1985, Scenario I (constant price) is more satisfactory. These scenarios correspond, respectively, to an average consumption of 160 and 159 kg/capita/year. For the World Bank, the average of the Sahelian countries is about 170 kilograms [22, p. 5].

B. Recommendations

This study represents an attempt to determine the main factors affecting supply and demand of millet and sorghum.

The results of the study must be used very carefully for any strategy or policy formulation by which self-sufficiency in millet/sorghum could be achieved. However, these results leave little doubt that a great effort is needed to achieve that goal. They allow formulation of the following set of recommendations:

- An increase in the producer price should be adopted for the development of millet/sorghum production.
- An increase in producer price of rice should be considered, because it may also increase the millet/sorghum production, because of the possibility of a shift of some farmers from groundnut cultivation to rice as a cash crop by migration to the rice-producing areas. This shift and migration would make more land available for millet/sorghum in the groundnut basin.
- Food crop production increases through establishment of higher producer prices may cause stockage and transportation problems in both traditional and government official marketing channels. The establishment of buffer stock as suggested in [22] may be a solution to such problems and should be considered in order to maintain the price supports

for food crops [22, p. 51].

• Increases in production must be achieved not only through price incentive policies but also through increasing the productivity of crop cultivation. There is a need to increase the average yields and to reduce their variability.

The demand for millet/sorghum will particularly depend on the millet : imported broken rice ratio. The lower this ratio is, the higher the demand will be. This implies, then, if, for supply and rural income considerations, the millet/sorghum price must increase, the only way to lower this price ratio would be to increase the denominator of the ratio by taxation of the imported rice. An effort to reduce the processing cost of milling millet/sorghum into flour may also be necessary in order to make this commodity cheaper for the urban consumer.

One may argue that such policies may have a negative effect on urban population consumption, and it should be necessary to study ways to increase the urban income. However, there is a feeling that the matter will be more focused on the taste aspect than on the purchasing power of the urban population for obtaining domestic commodities.

C. Conclusions

The estimated price elasticity of millet/sorghum supply is high, reflecting a high responsiveness of production

supplied to changes in the producer price. Some experts argue that the achievement of self-sufficiency by raising prices to increase production and eliminate imports may imply a high cost in terms of foregone economic growth and efficiency and, therefore, a trade-off should be made between self-sufficiency and economic growth [24, pp. 34ff.]. The major reason given for this is that raising producer prices above world market levels would stimulate inefficient production and thus decrease economic growth and efficiency. This efficiency is based on the comparative advantage theory. However, future international prices are uncertain, known at best in a probabilistic sense. The earnings from exports may be decreasing and the cost of imports increasing by the variation of world prices, as Senegal is experiencing since its independence, such that the comparative advantage is not always a stable situation. There exists also a risk and uncertainty involved in the availability of the foreign supply and/or the foreign currency to procure that food supply. Therefore, the stated policy of diversification of agricultural production must be strengthened in order to minimize that risk. Producing more millet requires, then, an increase in the producer price.

Since a major way for the government to increase rural income is to increase millet/sorghum and rice producer prices, it is necessary that a market for the increased production exist. The increase in demand for domestic food

crops and especially for millet/sorghum will be possible only if the government price regulation policy is such that it curbs the demand for imported rice and wheat.

The encouragement of millet/sorghum production through the use of trade policy and a simultaneous reduction of the cost of its preparation may contribute effectively to food self-sufficiency. By raising consumer prices on rice and wheat, the government could encourage increased consumption of millet/sorghum and provide some stimulus to production of this crop.

The absorption of the increased production of millet/-sorghum may be handled easily if the blend of millet/wheat flour stabilized by ITA is exploited nationwide. The sooner this new technology is applied, the quicker the goals of the development of import-substitution crops will be achieved.

D. Suggestions for Further Studies

In this study, we have been dealing with millet/-sorghum supply and demand. However, in Senegal, food crops include rice and maize, which is not a negligible staple. The major cash crops in Senegal are groundnuts and cotton. Therefore, any trade-off between cash crops and food crops in any strategy or policy formulation must take into account maize and cotton. Cotton is a substitute for groundnuts in production as cash crop, and maize is another substitute for rice in consumption. Broken maize as a substitute for

imported broken rice may be one of the alternatives for shifting consumption from imported goods to domestically produced goods. Thus, the use of a complete model of simultaneous equations might be an appropriate approach for the study of the interaction of these five markets. Separate studies would also be needed for such crops as maize and cotton. These studies could focus on investigating whether the price variability of a given imported good may explain the variation of its domestic production and/or demand, and explain in what circumstances such variations are possible. These studies must be conducted to determine the process of decision making for a farm unit and a consumer, especially the relative importance of the price of imported goods to the price of domestic goods. Studies based on market prices of these commodities will help evaluate the effect of the government price distortion.

APPENDICES

APPENDIX I

RICE IN SENEGAL

A. The Industry

Except in Casamance and in Eastern Senegal, rice is not considered to be a traditional cereal. This makes the rice consumption pattern very different from that of millet/sorghum. While the urban population and the non-producing regions consume essentially white and broken rice, the rice producer consumes non-white and non-broken rice. The production, importation, and self-sufficiency ratio of rice in Senegal is given in the Appendix Table I.

Contrary to the marketing of millet/sorghum, rice marketing is completely controlled by the government.

The major relationships in the Senegalese rice industry are illustrated in Figure 6-A, and the marketing channels are shown in Figure 6-B.

The quantity traded through government agencies (SAED, SOMIVAC*) is transformed in the milling units of these agencies into white whole and broken rice. The quantity sold in the private local market is non-broken and non-white rice. The consumption of this type of rice is essentially a matter of taste rather than price. However, in

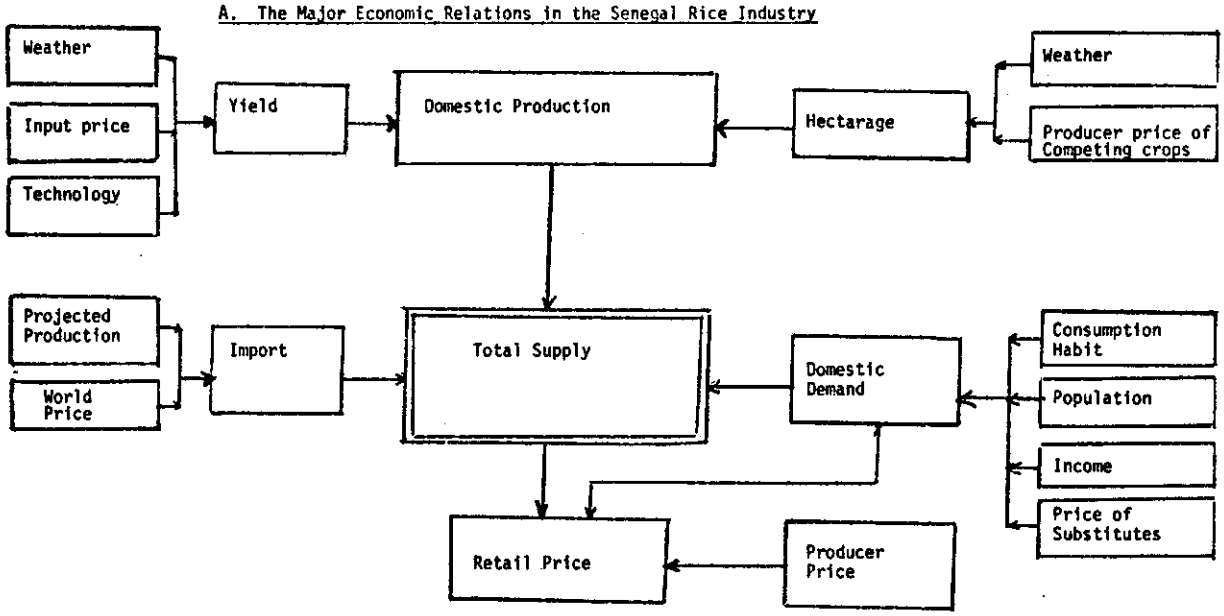
*Societé de Mise en Valeur de la Casamance

FIGURE 6

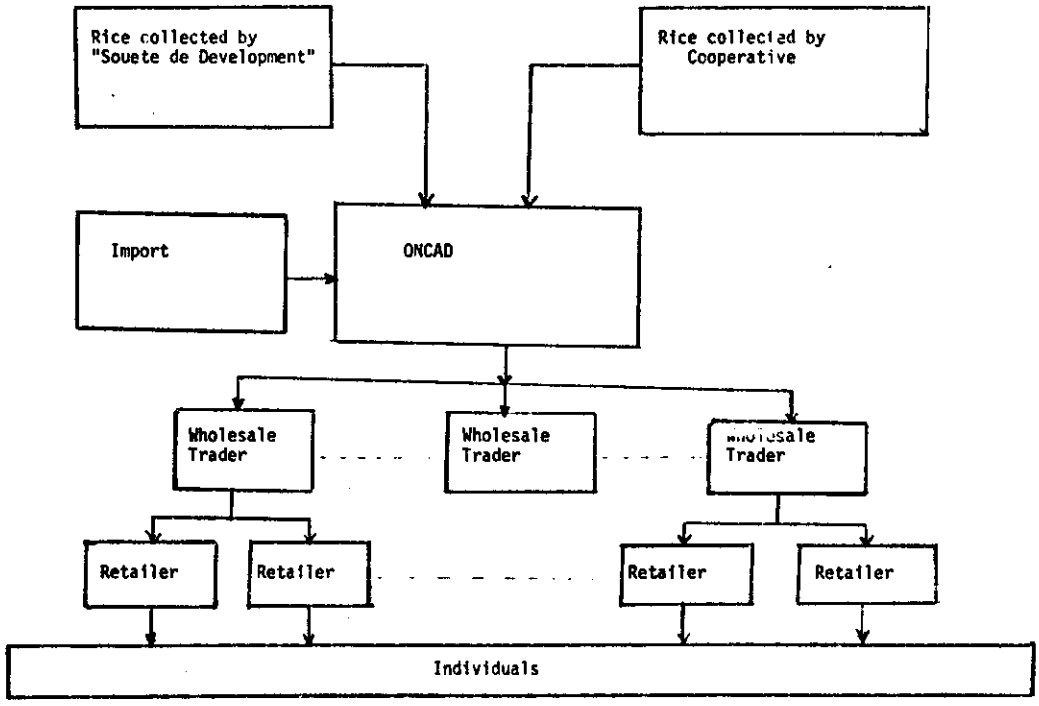
Economic Relationships and Marketing Structure

in Rice Industry in Senegal

A. The Major Economic Relations in the Senegal Rice Industry



B. The Marketing Structure



Source

(88) SONED - Vol. I, p. 105

addition to the taste consideration, the demand is affected by the retail price of the domestically produced rice, the price of the imported broken white rice, and the price of millet/sorghum, both of which are the major substitutes in consumption. Therefore, it is preferable to estimate the demand for domestic rice at these local markets rather than at the national level.

On the contrary, the quantity supplied domestically has to be evaluated because of its new import substitute character and in order to estimate the self-sufficiency ratio.

B. The Supply Model

Dependent variable:

ADR_t = quantity of domestic rice produced in year t (in 1000s of metric tons)

Independent variables:

PR_{t-1} = lagged one year producer price of rice (FCFA/kilo)

PM_{t-1} = one year lagged producer price of millet/-sorghum (FCFA/kilo)

PGN_{t-1} = one year lagged price of groundnut (FCFA/kilo)

RF_t = rainfall in year t (in millimeters)

α = a constant

DV = dummy variable = 1 for years 1973-1976 and 0 elsewhere

The estimated model:

(10) $QDR_t = .409 + 11.47PR_{t-1} - 1.29PM_{t-1} - 2.87PGN_{t-1} -$
(.004) (2.78) (-.19) (1.25)

$.086RF_t - 58.24DV$
(-1.9) (-2.9)

$\bar{R}^2 = .56$

Durbin-Watson Statistic = 1.85

Standard Error of the Regression = 26

Number of Observations = 16

F-Statistic (5, 10) = 2.50

Elasticity:

Own-price elasticity: $E_{PR_{t-1}} = 2.7$

Cross-price elasticity: $E_{PM_{t-1}} = .25$

$E_{PGN_{t-1}} = .68$

The supply model has been estimated by means of OLS, and a brief discussion of the statistical results follows.

The quantity supplied is very responsive to the producer price of last year (elasticity = 2.7) and highly significant. Even though the model gave some insights about the rice-supply shifters, it is not reliable enough for making projections of the production. Further studies of the supply shifts are necessary at the local (micro) level

for each of the major rice-producing regions. Nevertheless, the producer price seems to be the major incentive for development of the production.

APPENDIX II

GROUNDNUTS IN SENEGAL

A. The Industry

From 1960 to 1970, groundnut production contributed about 60 percent of the value added to the general Senegalese economy. The export of groundnuts has been averaging about 45 percent of the export earnings of Senegal during the period 1969-1973 [15]. Over 80 percent of Senegal's groundnut production is exported, and the domestic consumption of groundnuts is relatively small.

ONCAD is the official market outlet for groundnuts. It sets official buying prices and purchases production at the farm level.

The lower producer price from 1967 to 1971 and the drought have encouraged farmers to reduce investment in groundnut production and to initiate a national concern for food-reserve provision.

With respect to allocation of the quantity supplied, two equations have been specified: an equation of demand for groundnut by the local industries, and an equation for the export supply. In fact, these are the major components of groundnut demand. The demand for groundnuts by local

industry is mostly determined by the monetary value of their exports and the Senegalese population which consumes a substantial amount of groundnut oil. The retail price of groundnuts has an insignificant effect on that demand because whatever the price, the local industries will take the product for processing. For the demand for exports, the most important factor is the groundnut world price.

B. The Supply Model

The quantity supplied is mainly determined by the previous year's groundnut price and, to a certain extent, by the previous year's production of millet/sorghum. This means that, if the farmer does not have enough reserve of grain, he will allocate more land to millet/sorghum and this will reduce the area devoted to groundnut production.

The supply is responsive to previous year producer prices of groundnuts. The price elasticity is .69. The lagged quantities produced of millet/sorghum and rice are positive as expected, but not statistically significant. Fertilizer price and rainfall variables have the proper estimated direction of influence and are highly significant.

C. The Demand Model

The quantity of groundnut demanded by the local processing industries has been specified as dependent on

the value of the export of groundnut oil, the value of export of groundnut meal and population of the current year. The value of groundnut oil export has a positive estimated coefficient as expected and is highly significant. As expected, the more the income from export of oil, the more the processing industries will demand groundnut. The negative sign of the coefficient of the groundnut meal variable may be explained by changes in the climate which affect pasture conditions, and hence, groundnut meal to feed livestock. The population variable has a positive coefficient, as expected. As the population increases, the consumption of groundnuts and groundnut products, especially groundnut oil, will increase. All variables are highly significant.

The export of groundnut ($SEXG_t$) depends mainly on the world price of groundnuts in the current year, and the time trend. The price variable comes out with a positive sign as expected and is highly significant. The time trend has a positive sign and is also statistically significant. The price elasticity of export is .25.

The supply model:

Dependent Variable:

QGP_t = quantity of groundnut produced in year t

Independent Variables:

QMS_{t-1} = quantity of millet/sorghum produced in year t-1 (in 1000s of metric tons)

QDR_{t-1} = quantity of rice domestically produced in year t-1 (in 1000s of metric tons)

PGN_{t-1} = one year lagged producer price of groundnuts (FCFA/kilo)

PF_t = price of fertilizer in the current year (FCFA/kilo)

RF_t = amount of rainfall in year t (millimeters)

α = a constant

The estimated model:

$$QGD_t = \underset{}{190} + \underset{(.40)}{.576QMS_{t-1}} + \underset{(1.52)}{2.1QDR_{t-1}} + \underset{(1.42)}{29.8PGN_{t-1}} - \underset{(2.40)}{66PF_t} + \underset{(-3.12)}{.58RF_t} \quad (2.7)$$

$\bar{R}^2 = .703$

Durbin-Watson Statistic = 2.55

Standard Error of the Regression = 145.491

Number of Observations = 16

F-Statistic (5, 10) = 4.75

Price elasticity:

$E_{PGN_{t-1}} = .69$

The Demand Model for Groundnuts

Demand for groundnuts by the local industries ($DGLI_t$):

Dependent Variable:

$DGLI_t$

Independent Variables:

$VEGH_t$ = value of export of groundnut oil in year t

$VEGM_t$ = value of export of groundnut meal in year t

POP_t = population in year t

α = a constant

The estimated model:

$$DGLI_t = -1361 + .024VEGH_t - .17VEGM_t + 533.POP_t$$
$$(3.52) \quad (2.1) \quad (-3.83) \quad (5.04)$$

$\bar{R}^2 = .70$

Durbin-Watson Statistic = 2.51

Standard Error of the Regression = 144.9

Number of Observations = 16

F-Statistic (3, 12) = 9.49

Supply export of groundnuts = $SEXG_t$*:

Dependent Variable:

$DEXG_t$

Independent Variables:

GWP_t = groundnut world price in year t

T = time trend

α = a constant

The estimated model:

$$DEXG_t = 63.38GWP_t + 142.17T - 12002.5$$
$$(2.59) \quad (2.41) \quad (-2.86)$$

*In the computer program, $SEXG_t$ appears as $DEXG_t$.

$\bar{R}^2 = .51$

Durbin-Watson Statistic = 1.96

Standard Error of the Regression = 1084

Number of Observations = 16

F-Statistic (2, 13) = 6.7

Price elasticity:

$E_{GWP_t} = .25$

APPENDIX III

THE RAW DATA USED IN THE STUDY

TABLE III-1

PRODUCTION AND PRODUCER PRICES[a]

YEAR	MILLET/SORGHUM		GROUNDNUTS		RICE	
	PRODUCTION	PRICE	PRODUCTION	PRICE	PRODUCTION	PRICE
1960	397	15	892	22	63	18
1961	413	15	994	22	68	18
1962	424	16	914	22	84	19
1963	477	16	952	21.5	77	19
1964	447	16	993	21.5	106	19
1965	554	16	1122	21.5	110	21
1966	423	17.5	857	21.5	122	21
1967	655	17.5	1005	21.5	125	21
1968	450	17.5	830	18.0	137	21
1969	633	17.5	789	18.5	58	21
1970	401	17.5	583	18.5	156	21
1971	583	17.5	989	19.5	90	21
1972	393	17.5	570	23	118	21
1973	511	25	675	23	37	25
1974	777	30	994	29.8	64	41.5
1975	630	30	1422	41.5	117	41.5
1976	333	35	1182	41.5	108	41.5

SOURCES: Direction Generele de la Production Agricole; annual reports, 1960-76; ONCAD; CILSS.

[a]Production in 1000s of metric tons; price in FCFA/kilo.

TABLE III-2

POPULATION AND GNP, PRICE OF FERTILIZER,

AND RAINFALL

YEAR	PRICE OF FERTILIZER FCFA/KILO[a]	RAINFALL MILLIMETERS[b]	POPULATION MILLIONS[c]	GNP MILLIONS OF FCFA[d]
1960	8[E]	668	3.489	128,100
1961	10	685	3.560	138,400
1962	10	668	3.647	147,100
1963	12	769	3.726	153,200
1964	12	835	3.808	163,900
1965	12	761	3.842	173,500
1966	13	907	3.986	180,200
1967	14	1038	4.082	179,800
1968	16	491	4.180	192,100
1969	16	983	4.280	191,200
1970	12	532	4.383	212,800
1971	12	731	4.497	217,000
1972	12	494	4.589	241,600
1973	12	560	4.708	245,600
1974	12	609	4.831	301,400
1975	16	1014	4.948	362,100
1976	20	617	5.085	404,200

[a]The price used here is the one paid by the farmers to ONCAD, not by the government to the farms. Fertilizer is a subsidized input.

[b]The data used here came from official documents of Centre National de Recherche Agronomique (CNRA) de Bambey, which gives data from 1931 to 1975 at the meteorologic observation post of NIORO du RIP. We assume here that the variability in the amount of rainfall is the same in the whole cultivated area of millet/sorghum, despite the difference in quantity.

[c]Direction of the Statistics: results of 1976 nat'l census.

[d]Ministere du Plan et de la Cooperation, V Plan, Vol. I.

TABLE III-3

QUANTITIES IMPORTED AND IMPLICIT PRICES

OF MILLET/SORGHUM AND RICE[a]

YEAR	IMPORT	IMPLICIT PRICE[b]	IMPORT	IMPLICIT PRICE[b]	RETAIL PRICE TO CONSUMER
1960	15	15.8	83	24	30[E]
1961	3	14.1	110	24.5	30
1962	13.8	14.7	118	25	30
1963	23.6	16.3	101	27.2	35
1964	20.3	15.6	184	26.7	35
1965	22.5	19.2	179	25	40
1966	3.1	16.6	159	27.2	40
1967	3.1	21.1	153	36	45
1968	2.9	15.1	185	38.1	45
1969	38.6	16.3	146	32	45
1970	0.88	22.1	119	28	40
1971	30.3	19.1	188	24.7	40
1972	25.4	17.7	170	25	40
1973	62.4	22.8	192	49.6	60
1974	7.2	27.0	216	83.5	100
1975	2.5	. . .	102	59.3	80
1976	113	. . .	165	48	80

[a]Imports, 1000s of metric tons; implicit prices, 1000s of CFA/MT; retail prices, FCFA/kilo.

[b]Implicit prices are obtained by dividing value by quantity of import. Data found in official documents of ONCAD; Direction du Commerce exterieor; Direction de la Statistique.

TABLE III-4

SHARE OF GROUNDNUTS SUPPLY[a]

YEAR	QUANTITY TREATED BY LOCAL INDUSTRIES	QUANTITY OF GROUNDNUT EXPORTED		GROUNDNUT WORLD PRICE CIF FRANCE (FCFA)
		SHELLED	UNSHELLED	
1960	430	355	256.9	51
1961	453	686	269.4	52.5
1962	471	259	277	52.5
1963	509	1138	204	52.5
1964	533	100	214	52.5
1965	533	146	217	52.5
1966	520	141	297.9	52.5
1967	561	1235	180.2	52.5
1968	464	158	234	40
1969	509	758	95.9	52
1970	300	3248	51.4	61.5
1971	750	412	32.5	71
1972	380	650	13.9	78.5
1973	429	1327	3.4	86
1974	676	5680	5.9	141.5
1975	1320	1389	8.5	97.5
1976	886	3084	130.7	104.5

[a]Quantities treated and exported in 1000s of metric tons; world price in CFA/kilo.

SOURCES: Direction de la Statistique, Comptes economiques du Senegal 1959-1968, Situation economique du Senegal, 1977; ONCAD; FAO, Trade Yearbook, 1960-1977; Le Senegal en chiffre, Societe Africaine d' Edition, 1978.

TABLE III-5

EXPORT OF GROUNDNUT SUBPRODUCTS[a]

YEAR	VALUE OF EXPORT OF GROUNDNUT OIL	VALUE OF EXPORT OF GROUNDNUT MEAL
1960	10,607	2,291
1961	11,593	2,350
1962	10,960	2,131
1963	9,630	1,890
1964	12,039	2,397
1965	13,143	2,553
1966	13,202	2,503
1967	14,407	4,137
1968	13,287	5,400
1969	9,176	3,868
1970	12,976	4,594
1971	7,410	3,138
1972	20,126	7,392
1973	8,330	6,532
1974	25,662	6,918
1975	31,123	7,871
1976	38,177	10,396

SOURCES: Direction de la Statistique, Situation Economic 1960-1977; FAO, Trade Yearbook, 1960-1977.

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