PN-ABE-626
65228

ANALYSIS OF ALTERNATIVE PRODUCER PRICE POLICIES IN SENEGAL USING A MICRO-MACRO MODELLING APPROACH

by

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Paper submitted to the AAEA
for presentation at the AAEA Annual Meetings,
Knoxville, Tennessee, July 31 to August 3, 1988.

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Staff Paper No. 88-18

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ABSTRACT

The impacts of three producer price policies on Senegal's food and agriculture system are examined using a micro-macro modelling approach. The alternative policies are: a general cereals price increase, establishment of a protected cereals market in West Africa, and economic (border) pricing. Results suggest limited potential cereals supply response.

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INTRODUCTION: BACKGROUND AND OBJECTIVES

The West African country of Senegal has been experiencing severe economic and food security problems for the last 10-15 years. The level of cereals self-sufficiency in milled product equivalents dropped sharply from 61% in 1974-76 to 39% in 1983-85. The share of food aid in total cereals supply increased threefold over the same period, from 5% to 14%. Rice imports rose from 100,000 to over 300,000 metric tons (t). Faced with declining agricultural production, and public finance and balance of payments deficits, the Senegalese government announced a New Agricultural Policy in 1984 which included the objectives of boosting domestic cereals production and achieving 80% food self-sufficiency by the year 2000.

As part of an ISRA (Institut Sénégalais de Recherches Agricoles) research program, the authors developed a linear programming model of the agricultural sector to examine the feasibility and economic cost of alternative strategies for meeting the Government's goals. This paper examines the impact of alternative producer price policies on the composition of output, the cereals self-sufficiency rate, costs to government and consumers, and the trade balance. The three policies examined were: (1) an equal percentage increase in the prices of rice, millet/sorghum, and maize; (2) establishment of a protected cereals market in West Africa by imposing tariff barriers and raising the consumer prices of rice and wheat, and the producer price of rice; and (3) implementation of economic (border) prices.

A micro-macro approach was used to analyze these policies. The objectives and constraints of both farmers and the Senegalese government were

explicitly incorporated so that strategies identified by the model would be feasible and consistent at both levels.

The first part of the paper describes how the model was used to evaluate the alternative price policies. The second part of the paper sets forth the results of the modelling analysis, and discusses their policy implications.

METHODOLOGY FOR THE MODELLING ANALYSIS

The modelling analysis involved five steps:

Step 1. The elaboration of 181 detailed crop budgets in 11 production zones covering the major crops in Senegal. Up to five technologies were considered for the cultivation of each crop. Yields and prices were estimated in 15 states of nature, each state corresponding to a particular combination of rainfall quantity and distribution within the rainy season. Average yields and prices per crop per zone were calculated using the probabilities of occurrence of each state of nature. The data used in the crop budgets were collected through a review of published crop budgets, data from recent farm surveys and agronomic experiments, and in-depth interviews with ISRA and WARDA (West African Rice Development Association) researchers at the regional research stations.

Step 2. The construction of 13 typical farm models, one per production zone, except for two zones which were each broken into two subzones. Linear and separable programming was used, including a variation of the MOTAD technique (Hazell, 1971). The objective function specified for the producer was to maximize profits under a number of food security and resource constraints. The priority given to food security by the Senegalese farmer was reflected by the inclusion in each farm model of:

a. Two types of cereal production activities representing the objectives of home consumption or sale.

b. Nutritional and food habits constraints. The calorie needs of the farm household must be met through the production of cereals-for-consumption and/or through cereals purchases. Food preferences were included in the form of minimum and maximum consumption levels by cereal.

c. A cereals self-sufficiency constraint. The farm household must produce enough cereals-for-consumption to satisfy a significant share of its calorie needs. Two target shares were specified, for the "average" and "worst possible" states of nature;

d. A minimum income constraint in the "worst possible" state of nature. Even in this case, farm production for sale must create enough income to cover part of the purchase of basic consumption goods, and to provide the starting capital needed to buy agricultural inputs at the beginning of the next cropping year.

These constraints were represented by including rows of average yield or income coefficients, and several rows including the deviations from the mean in the "worst" states of nature. Transfer activities caused any accumulated negative deviations to require a fractional increase in production of cereals-for-consumption, to provide a food security margin. The farm models were calibrated by comparing the model results with recent official statistics and farm survey data on acreage by crop and by technology, and on farm income. (For details, see _____, 1988.)

Step 3. The aggregation of agricultural supply at the regional and national levels. The gross regional production of each crop was obtained by multiplying the output of the typical farm model by the number of farms in the region. Gross national production is the sum of gross regional production. Net production at the regional and national levels was then

calculated by multiplying gross production by a coefficient incorporating the effects of storage and processing losses and reconstitution of seed stocks.

Step 4. The derivation of agricultural supply curves. The farm models were run with several different price vectors. Each price vector is a particular set of input and output prices which is consistent across all zones, i.e., the prices vary between regions only by transport and marketing costs. The basic price vector consisted of 1986-87 financial prices for inputs and outputs at the farm gate. The three price policies were:

a. An overall increase in all cereals prices. Five higher price vectors were derived from the basic price vector by increasing all cereals prices by a given percentage: 20%, 40%, 60%, 80% and 100%.

b. An increase in rice and wheat prices only. The producer price of rice and the consumer prices of rice and wheat were increased by 50%.

c. Use of economic prices. Economic prices were calculated and incorporated for all major inputs and outputs.

Step 5. The construction of an agricultural sector model. This model includes activities representing national (aggregate regional) production and input use for each of the six price vectors; processing; domestic and international trade for inputs and outputs; and consumption.

Separable programming techniques were used to ensure that the same price vector was applied in all regions. The objective function was to minimize the cost (net of the value of exports) of meeting the food needs of the Senegalese population given a set of constraints on food habits, input and output transfers, and macro food security. Solving this model generates the "optimal" pattern of production and trade for Senegal, given the assumptions made about the objectives of farmers and of the government. The agricultural sector model was calibrated by comparing the model's results regarding the

international and interregional flows of inputs and outputs with official statistics and experts' opinions.

A macro food security constraint forces the model to achieve a given level of cereals self-sufficiency. To reach higher levels of self-sufficiency, the government must offer higher cereals prices to producers to induce a larger supply of cereals. The model chooses the level of prices required to meet the cereals self-sufficiency constraint at least cost. An infeasible solution indicates that the self-sufficiency objective could not be obtained even at a 100% cereals price increase. This approach reveals the trade-offs between the objectives of self-sufficiency and economic efficiency, as well as shedding light on the feasibility of the Government's planned targets.

The strengths of the overall model are: (1) the much more thorough and up-to-date specification of production technology and farmer objectives and constraints than in earlier models (e.g., Jabara and Thompson, 1980; SONED-SEMA, 1979; and Braverman, Hammer, Levinsohn, 1983); and (2) the consistency of macro-level food security objectives with farmer-level objectives and constraints. Its principal weakness is the specification of fixed demand, and lack of endogenous price determination, which is a strength of the Braverman, Hammer, Levinsohn (1983) model.

MODEL RESULTS AND POLICY IMPLICATIONS

1. Analysis of a general cereals price increase.

a. Implications for the cereals self-sufficiency (CSS) rate.

Output in the model does not seem to respond significantly to an increase in cereals prices. When the farm models are run with a 100% cereals price increase, the overall CSS rate increases only 8.3 percentage points, from 47.3% to 55.6%. When optimistic assumptions are made about the creation of new irrigated perimeters and the development of double cropping between

now and the year 2000, the CSS rate increases 10.2 percentage points, reaching 57.5% (given 1986-87 prices and population level).

When marginal rainfed land is included in the farm models and a 40% increase in cereal prices is considered, the CSS rate increases only 6.4 percentage points compared to 5.9 percentage points for a 40% price increase with no marginal land. When optimistic assumptions about expansion of irrigated and marginal land are both included, the cereals self-sufficiency rate increases 17.1 percentage points for a 40% cereals price increase, reaching 64.4%, the best CSS rate achieved.

Overall, the research results constitute strong evidence that the price elasticity of cereals supply is rather low in Senegal and that the government's objective of 80% cereals self-sufficiency by the year 2000 is too optimistic. Two main factors explain this result. First, groundnuts are much more profitable than millet/sorghum, even with substantial increases in the millet/sorghum price. Second, the expansion of rice cultivation is limited by a tight land constraint, both for irrigated land in the Senegal River Basin and for lowland suitable for rice in the Casamance.

b. Implications for the production of major crops.

A general cereals price increase results in changes in the production of major crops. The most striking change is that most of the increase in cereals production comes from an increase in maize production. When prices increase by 40%, millet/sorghum and rice production increase only 2% while maize production increases 101%, from 58,680 t to 117,841 t. When prices rise by 80%, rice production goes up 2%, millet/sorghum 8% and maize 137%. The share of maize in cereals production measured in billions of calories rises from 12% with present prices to 22% with a 40% cereals price increase, and to 25% with an 80% price increase. Conversely, groundnut production goes

down 13% with a 40% cereals price increase (from 518,850 t to 431,344 t), and 24% with an 80% price increase.

The major implication is that maize would replace groundnuts to some extent, potentially creating a maize surplus problem. Maize is not a major part of the Senegalese diet, which consists mainly of rice in the cities and millet/sorghum (and some rice) in the countryside. Industrial uses of maize now total about 15,000 t, virtually all of which is imported since imports provide a cheaper and more reliable supply than local production. Assuming no change in present food prices, the present maize deficit would change to a surplus of 29,730 t with a 40% cereals price increase, and to a surplus of 50,680 t with an 80% price increase (including industrial uses of 15,000 t).

In the long run, one might expect consumer food habits and industrial procurement patterns to change in favor of local maize, as increased supply reduces its price. The increase in maize consumption necessary to avoid a surplus was estimated with the agricultural sector model. With a 40% price increase, maize consumption would have to increase 25%, and with an 80% price increase, 65%. A 25% increase in maize consumption seems reasonable, but a 65% increase does not seem attainable in the near future.

c. Cost implications.

The cost implications of alternative levels of food self-sufficiency can be estimated in two ways. First, there is the social cost of meeting a given level of cereals self-sufficiency, valuing all resources at their shadow prices. The value of the objective function in the agricultural sector model, which is defined as the cost of meeting the population's cereals needs less the value of exports, provides one estimate of this cost. This value increases 20% with a 40% cereals price increase and 39% with an 80% price increase.

Second, there is the cost to the public budget. It is hard to evaluate precisely the impact of different levels of cereals self-sufficiency on the state budget because the higher producer prices can be paid either by the consumers in the form of higher prices, or by the state in the form of producer or consumer subsidies. Given the low standard of living of many consumers, it makes sense to assume that the state would pay for the extra costs of greater self-sufficiency. However, to implement higher producer prices for cereals, the state would have to pay a subsidy only on the marketed production.

This subsidy can be estimated by multiplying marketed production in the farm models by the difference between the current cereals price and the higher price. The estimated subsidy is 6.3 billion CFAF with a 40% price increase, which would increase the CSS rate 5.9 percentage points above the present level. It is 15.1 billion CFAF with an 80% price increase, which would increase the CSS rate by 8.3 percentage points. These subsidies amount to 11% and 27% respectively of the state deficit in 1983.

Apart from these price subsidies, a major burden on the public budget is the cost of developing irrigated agriculture in the Senegal River Basin. Given the supply response results mentioned earlier, investment in irrigation appears to be the only way of significantly increasing the rate of cereals self-sufficiency in Senegal. An FAO study (1985) estimated that 38,000 hectares must be irrigated in order to achieve 75% cereals self-sufficiency by 1995. If we accept a cost of 1.5 million CFAF per new irrigated hectare, we obtain a required investment cost of 57 billion CFAF. This amount can be compared to the 1987 national budget deficit of 55.47 billion CFAF (IMF, 1987). It is clear that the irrigation development required to meet the government's self-sufficiency objective will impose a major burden on the state budget, unless donors cover part of the investment costs.

d. Implications for the agricultural trade balance.

An agricultural trade balance is calculated in the agricultural sector model by tracking the uses and sources of foreign exchange. Surprisingly, the overall agricultural trade deficit does not change much when cereals prices are increased. This results from several counterbalancing effects. On the negative side, when cereals prices increase, groundnut production an exports fall, reducing sources of foreign exchange. Fertilizer use rises slightly, increasing uses of foreign exchange. However, on the positive side, the uses of foreign exchange for agricultural equipment, crop protection products, transportation, and processing go down slightly with t reduction in groundnut production. Finally, cereals imports fall since domestic production rises.

2. Analysis of a price increase for rice and wheat only.

This policy option reflects a recommendation made at the 1986 CILSS-Cl du Sahel conference at Mindelo, i.e., that a protected regional cereals market be created in West Africa (Gabas, Giri, Mettetal, 1987). Only the prices of cereals which are not produced (wheat) or currently little produc (rice) would be increased. Wheat and rice consumer prices would be raised i favor the consumption of local millet/sorghum and maize. The producer pric of rice would also be increased to promote local rice production and substitution of local rice for imports.

The model developed in this study is not well-equipped to handle change on the demand side. However, it can offer insights on the probable supply response to an increase in the producer price of rice. Assuming a 50% increase in the rice price (which in Senegal is already 60% above the import parity price), the resulting supply response was minimal. The CSS rate increased only by 0.6%. The other performance variables considered were affected to a similarly slight degree.

The major reason for lack of response to a higher rice price is the land constraint. Irrigated perimeters already produce mainly rice; the only real means of expanding rice production is to expand the irrigated area. (The model showed little response to an assumed increase in the share of double-cropped area from 10% to 50%, which is optimistic.) The area available for lowland rice and transplanted rice in the Casamance is constrained by climate and soil factors. Several years of relative drought have lowered the water table and increased the salt content of soils in many lowland areas. Upland rainfed rice is less profitable than other upland crops, even at a 50% higher price, and it is also a relatively risky crop.

Overall, such a price policy seems likely to have minimal effects on supply, but strong effects on the demand side. One could anticipate significant reductions in the real income of consumers, primarily but not exclusively urban consumers.

3. Analysis of an economic price policy.

Another policy option is to move toward economic prices, defined as import parity prices for cereals and agricultural inputs, and export parity prices for cash crops. For non-traded inputs, the economic price is the domestic market price. The advantage of this price policy is that economic prices provide a true indication of the opportunity cost of production of different crops and therefore give correct signals for an optimal allocation of resources by the various microeconomic agents.

Economic prices were estimated for major agricultural inputs and products in Senegal. Comparing these prices with financial prices leads to three observations. First, Senegalese agriculture is already well-protected. Except for cotton, which is taxed by nearly 30%, the

prices. Second, economic prices are relatively much lower (about 60% lower) than financial prices in the case of cereals compared to the case of groundnuts (about 25% lower) (_____, 1988). Third, the economic price of tomato (a potentially key crop in the Senegal River Basin) seems much higher than its current financial price, although the data are not adequate to support a firm estimate of the economic price.

As these observations lead one to expect, running the farm and agricultural sector models with economic prices gives net margins per hectare that are considerably lower than with financial prices. Groundnut production increases while cereals production decreases. This tends to support the argument that Senegal has a comparative advantage in producing groundnuts rather than cereals. On irrigated perimeters, tomato becomes more profitable than rice, and tomato production expands while rice production decreases.

The net cost of meeting the population's cereals needs drops 27% when economic prices are used instead of financial prices. The estimated agricultural trade deficit goes up 35% as a result of greater cereals imports and greater groundnut production (which uses more foreign exchange for production, transportation and processing). Unfortunately, the sustainability of a strategy based on specialization in groundnut production and exports to pay for rice imports is becoming questionable because of the projected stagnation of the world market for groundnut products.

SUMMARY AND CONCLUSIONS

It is clear that none of these policies offers an attractive trade-off between success in boosting cereals production and the cost of doing so. Price policy alone has limited scope for improving the CSS rate. Even a 100% increase in cereals prices increased the CSS rate only from 47.3% to 55.6%, and at a substantial cost to government and to consumers.

Most of that increase came from much higher maize production, which current consumer and industrial demand is inadequate to absorb.

The modest cereals supply response stems primarily from limited land for expanding irrigated and rainfed rice, and from the continued profitability of groundnuts relative to millet/sorghum. Higher prices stimulate adoption of intensive cropping practices, yet the higher yields have little impact on the CSS rate. The same is true of making marginal rainfed land available, and assuming increased double-cropping of rice. Only an optimistic assumed increase in development of new irrigated land raises the CSS rate significantly (to 64.4%), and even that assumes 1987 population levels.

The model may underestimate supply response by omitting sources of increased productivity such as possible urban-to-rural migration leading to more labor-intensive practices. On the other hand, the model probably overestimates the likely rate of expansion of maize production. Also, the model assumes in effect that market sale opportunities and the given supplies of chemical inputs are open to all farmers, which is often not the case.

In searching for a policy solution, a key dimension appears to be time. In the short run, if the government wants to increase the CSS rate, a sensible approach would be to implement a moderate general increase in cereals prices. This would limit the additional costs to the state and to consumers, and avoid creating a large maize surplus. However, the effect on the CSS rate would also be limited.

In the longer run, certain disadvantages of a higher cereals price policy would become less important. Food habits would have time to change in favor of maize, and more irrigated land would be available for expanded rice production. However, a comparative advantage (cereals import) strategy could also become more attractive if other sectors such as fisheries and tourism began to replace groundnuts as the major source of foreign exchange.

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