Title
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Author
Rausser, Gordon C.

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FOOD GRAIN POLICY IN BANGLADESH

by

Gordon C. Rausser

California Agricultural Experiment Station
Giannini Foundation of Agricultural Economics
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1. INTRODUCTION

Governmental intervention in food and agricultural markets is pervasive throughout the world and is especially pronounced in developing countries. The use of sound economic analysis, operations research, or dynamic modeling in the evaluation of these governmental intervention schemes has been rather minimal. As countries grope with various trade-offs, it is expected that these tools of analysis will find increasing use by public officials. To be sure, they will continue to provide only one input into the evaluation process. If they are well structured and reflect sound judgment of the research analyst, they will represent an important and perhaps even a dominant input. Short of these features, it is expected that such analyses will continue to be dominated by interest groups seeking rents in political forums (Rausser, Lichtenberg, and Lattimore, 1982).

In this paper, a dynamic inventory planning model under uncertainty is constructed to assist the country of Bangladesh to evaluate their food grain market intervention schemes. The constructed model is based upon the work of a team of researchers and a Ph.D. thesis completed in the Department of Economics at the Massachusetts Institute of Technology by L. Berlage (1972). I was the leader of this team of researchers that was asked to perform an evaluation of existing policies and how governmental policy instruments might be implemented in the future.

During the preliminary stages of our investigation, it was strongly suggested by the Minister of Agriculture that we concentrate on the huge amounts of money spent in foreign currency to import rice and wheat and the high cost of governmental food grain storage. There were also complaints of food shortages in those years when production of domestic rice was low.

During this preliminary stage, three major positions on current governmental food grain policy emerged.

The first position was consistent with T. Schultz's (1964, 1978) view of governmental intervention in developing-country markets. In essence, this view holds that, if the government continues to import huge amounts of grains and especially if these grains are supplied through a rationing system, the price of rice will not increase; and there will be no incentive for farmers to grow rice and to become more efficient by adopting new technologies. As a result, no productivity gains will occur; and the government will have to import growing amounts of food grain using scarce foreign exchange. In addition to its financial implications, some government officials argued that this policy also increased the dependency on foreign suppliers which indirectly resulted in political weakness.

The second position emphasized the humanitarian aspects of governmental intervention. This position argues that government cannot sacrifice the lives of its citizens by allowing them to starve in the name of an economic exercise which, in the long run, may or may not be effective. The implication of this position in terms of policy was that government should continue to import food grains until, if ever, domestic production becomes sufficient to meet internal consumption needs. Supporters of this view based many of their arguments on the work of Dantwala (1967, 1981) who maintains that policies of the sort pursued by the Bangladesh do not necessarily depress price incentives or result in appreciable price reduction below long-run market equilibrium. Policies such as compulsory food procurement at fixed prices and subsequent distribution to low-income consumers can be justified because they prevent their real income from declining below a subsistence level.[1]

Still, another position emphasized the opportunity costs of governmental imports of food grains, food grain storage, and the existing rationing system. This position held that there was no reason to subsidize imported rice to the detriment of other services that the government should provide its citizens. Some advocates of this position argued that a tariff should be imposed on rice imports at levels similar to the tariff imposed on all other imported goods.

After much discussion, the team was instructed to develop a model which took as given the existing governmental policies of rationing, governmental import purchases, and public storage. In what follows, the existing policies, along with the food grain production consumption and imports of Bangladesh, are described in section 2. The model framework that was developed is advanced in section 3. The empirical estimates required to implement the model are outlined in section 4. Finally, some selected empirical results are reported in section 5.

2. CASE BACKGROUND

2.1. History

Although rice was, by far, the most important crop in Bangladesh, the country has almost permanently had a deficit in its supply of food grain since it became a separate political entity in 1974. To keep prices at a reasonable level or, conversely, to keep per capita supply at or above a certain minimum, it was necessary to originally import considerable quantities of rice and, in the 1960s, also of wheat. It was generally accepted that a clear consumer preference existed for local over imported rice varieties and for rice over wheat. Throughout this period, the government had a monopoly of importing food grain and of the wholesale distribution of imports. The distribution of imported food grain was based on a rationing system whereas, for locally produced food grain, markets were essentially free.

TABLE 1

Production, Local Procurement, and Imports of Foodgrain in Bangladesh 1950/51 – 1968/69 (1000 tons)

	Production		Local Procurement of Rice by Government†	Imports‡			
				Rice		Wheat and Wheat Products	
	Rice	Wheat		West Pakistan	Abroad	West Pakistan	Abroad
1950-51	6260	20	65	131	-	11	-
1951-52	5900	23	19	75	-	18	-
1952-53	6160	24	15	214	-	71	-
1953-54	7010	24	26	112	-	87	-
1954-55	6420	26	125	6	-	44	-
1955-56	5420	22	-	-	-	1	-
1956-57	7100	23	-	85	449	12	40
1957-58	6490	22	33	13	419	40*	35
1958-59	5840	25	33	-	336	8	114
1959-60	7260	29	197	-	296	5	156
1960-61	8350	32	24	83	319	3	174
1961-62	8330	39	26	95	262	-	187
1962-63	7670	44	10	75	195	57*	447
1963-64	10200	34	4	204	143	-	142
1964-65	9430	34	13	33	62	30	219
1965-66	9400	35	93	311	48	8	521
1966-67	9200	50	8	239	193	35	611
1967-68	10440	58	22	158	150	-	712
1968-69	9990	92	9	236	-	145	739

† Up to 1963-64, government procurement data are for calendar years, corresponding to the second half of the fiscal year. In calendar year 1964, the figure was 125.

‡ Up to 1962-63, import data are for calendar years corresponding to the first half of the fiscal year. For calendar year 1963, the import data were for rice 328 and 237, and for wheat and wheat products 2 (Central Reserve) and 923.

* Central Reserve, except 5000 tons of flour from West Pakistan in 1957.

Source: Rice production: Government of East Pakistan, Directorate of Agriculture, Agricultural Production in East Pakistan (1947-65) and complements; local procurement and imports; Government of Bangladesh, Food Department, unpublished data.

As indicated in Table 1, both production and imports of food grain have risen considerably since the early 1950s. Per capita figures, however, suggest a deterioration of the food situation in the 1950s and a slight recovery in later years. Per capita production of rice was higher in 1950- 1955 than in 1955-1960 and was only slightly higher in 1965-1969. Per capita imports of food grain, on the other hand, have on the average risen quite considerably with a shift from rice to wheat imports occurring in 1962-63.

The data of Table 1 seemed to confirm the belief that wheat was traditionally not an element of the consumption basket of most consumers. The sudden increase in the consumption of imported wheat was made possible only by a drastic reduction in its rationing price. Even so, in 1966 the government had to establish a ratio between the rice and wheat rations in order to assure the distribution of the wheat imports. Finally, the quality of wheat in inventory deteriorates fast under the climatic conditions of Bangladesh. As for imported rice, a large quantity coming from West Pakistan was of low quality. Experts indicated that it could not be sold on world markets. Varietal differences and deterioration of rice in government storage were other possible explanations for the preference for locally produced rice.

2.2. Institutional Setting

The role of the government in local rice markets was quite restricted. Until 1957, it attempted, through various measures of compulsory delivery, to assure itself the transfer of rice from surplus areas to deficient urban centers. The limited success of this policy is clear from the quantities procured by the government as given in Table 1. Since 1958, the government has collected local rice on a compulsory basis only in areas within 5 miles of the Indian border. In other areas, government procurement was on a voluntary basis at a fixed price which almost always appears to have been below the market price. Once in years of communal strife or tension along the border, however, did the government collect an amount of local rice higher than 30,000 tons. The ineffectiveness of compulsory procurement policies in border areas was a result first of the low price the government paid and second of the fact that prices in neighboring regions of India, which traditionally depended on East Bengal for their rice supply, were higher than market prices in Bangladesh. A significant amount of smuggling across the Indian border seems to have been taking place. Because of the illegal nature of this business, no data, not even approximate ones, are available.

Local rice markets are essentially free. Marketing is done by a large number of dealers. Most dealers, called beparis or farias, are based on rural areas and buy paddy[2] directly from farmers, either on the farm or in primary markets, or they buy paddy or rice from other dealers. Large intermediate markets and wholesale terminal markets are dominated by a limited number of wholesale traders (aratdars). Rice milling is done by approximately 100 large rice mills and by a large and growing number of husking machines. The large mills, usually using old equipment, acquire paddy from farmers either directly or through aarias and sell rice either to local aratdars or to traders from the consumption centers. Paddy not going through large mills is processed by intermediaries (kutials), either on the village or on the intermediate market level.

The main role of the government is the import of rice and wheat and their distribution. Throughout the period under consideration, the government had a monopoly on importing food grain. Imports used to be contracted by the Central Government of Pakistan, whereas the scheduling of imports, handling, transporting, storing, and the wholesale distributing of imported food grain were assured by the (formally provincial) Food Department. The retail distribution was performed by private dealers under rules established by the Food Department.

Finally, the government holds stocks of food grain in silos; central godowns, which are called central supply depots (CSDs); and local godowns, which are called local supply depots (LSDs). Silos and CSDs have a central storage function. The function of the LSDs is to keep some stocks to provide food grain to local rationing shops. However, CSDs have, in addition to their central storage function, the same role as LSDs for the urban center in which they are located. Total capacity of CSDs and silos together is greater than that of LSDs. In 1969-70 a total of 233,000 tons of rice were held in government storage. Of these rice stocks, 52 percent were held in CSDs and 33 percent of the wheat stocks were held in CSDs. It was generally accepted that loss rates were higher in godowns than in silos and higher in LSDs than in CSDs.

2.3. The Rationing System

The distribution of imported (and locally procured) food grain was done through a system of rationing. After the bumper harvest of 1953-54, the government tried to eliminate this system. From August, 1955, to January 1956, the rationing system was abolished; and stocks in government hands were sold to dealers at reduced prices. The 1955-56 harvest, however, was one of the worst in the period under consideration. Rationing was reintroduced on January 31, 1956.

The rationing system has undergone changes quite frequently. One of the main characteristics is the distinction between areas of statutory rationing and areas of modified rationing. In statutory rationing areas, including the three main urban areas--Dacca, Narayanganj, and Chittagong--and, since 1959, 19 other areas, the government guaranteed a certain weekly ration to every resident. In the rest of the country, modified rationing applied. The population was divided into four classes on the basis of the taxes they paid. The Union Committee (lowest administrative level) decides monthly on the classes to which the distribution of rationed food grain would be extended--constrained, of course, by the quantity of food grain allocated to the Union every month.

In addition, rationed food grain was allocated to large employers of labor, employing more than 200 people (since 1958); to government employees and primary school teachers (since 1957, extended in 1968); and to a number of priority consumers (police, East Pakistani Rifles, hostels and halls of educational institutions, etc.) and was used for relief operations in case of natural disasters. The government also sells wheat to wheat mills that supplied flour for wheat products consumed mainly by higher income classes. Before October 6, 1971, the ration for an adult was 2.625 seers per week (1 seer = 2.05725 pounds). From that date to January 30, 1971, it was 3 seers and, henceforth, 3.5 seers in statutory rationing areas. The ration for minors was half these quantities.

Up to 1966, there was no fixed rice-wheat proportion. When, in 1962, wheat imports increased dramatically, the release of more wheat was assured by lowering the rationing price by 25 percent. In 1966, however, the wheat price was increased and a fixed rice-wheat proportion 1:2 was introduced, except for Dacca where a 1:1 ratio was applied.

The Food Department had the responsibility of selling the food grain under its control to dealers at a fixed price which was changed at irregular intervals. It also fixed a retail price at which retailers had to sell to consumers.

3. MODEL FORMULATION

The key decisions that must be made by the government include rice and wheat imports, the distribution of local and imported rice and wheat, and indirectly the amount of stocks to hold of each commodity. This decision problem will be characterized first as a one-product stochastic inventory model. This basic model will assume the form of a dynamic programming framework which will be extended to include one imported product, viz., rice. Subsequently, a complete model, involving both rice and wheat, will be developed.

Consider the following problem: A company which is selling a given product has to import this product yearly before it knows the exact amount which will be demanded during the year. At the time of ordering, however, it knows the probability distribution of demand. Delivery is assumed to be instantaneous[3]. The company starts the year with a given stock. If this stock, plus the new imports, is greater than actual demand, the firm will be left with stocks at the end of the year and incur an inventory-holding cost. The stock, however, has a positive value as it reduces the amount of the product that has to be imported. The company incurs a shortage cost, e.g., loss of clients whose demand cannot be satisfied. No backlogging of demand is possible. Thus, the costs faced by the company are import cost, shortage cost, and holding cost. The company wants to minimize expected present value of total costs over a planning horizon of T years.

Define:

S_t = initial stock in year t

Y_t = quantity available in year t after new imports are received

D_t = demand in year t

$\phi_t(D_t)$ = probability distribution function of demand in year t

$C_t(Y_t - S_t)$ = import cost function in year t

$H_t(Y_t - D_t)$ = holding cost function in year t; the function is zero if $D_t > Y_t$

$G_t(D_t - Y_t)$ = shortage cost function in year t; the function is zero if $Y_t > D_t$

$F_t(S_t)$ = minimum expected present total cost at the beginning of year t over all coming years if the initial stock equals S_t; the function is equal to $F_t(0)$ if its argument is negative

$f_t(S_t)$ = expected present total cost at the beginning of year t over all coming years if the initial stock equals S_t

and

δ_t = discount factor.

The problem, if the initial stock at the beginning of the planning horizon (i.e., at the beginning of year 1) is S_1, is then simply to calculate

$$F_1(S_1) = \min f_1(S_1). \tag{1}$$

The minimization is over Y_1 and, for $t = 2, \ldots, T$, over Y_t as a function of S_t. The dynamic programming approach to this problem is to decompose equation (1) in T one-year decision problems.[4] Consider the situation in year t, with initial stock S_t. If the imports equal $Y_t - S_t$ and demand is less than availability after imports, the minimum expected total present costs over the remaining planning horizon are

$$C_t(Y_t - S_t) + H_t(Y_t - D_t) + \delta_t F_{t+1}(Y_t - D_t).$$

On the other hand, if demand exceeds availability, these costs are

$$C_t(Y_t - S_t) + G_t(D_t - Y_t) + \delta_t F_{t+1}(0).$$

Minimum expected present total costs are then

$$F_t(S_t) = \min_{Y_t \geq S_t} \Big\{ C_t(Y_t - S_t) + \int_{D_t} [H_t(Y_t - D_t) + G_t(D_t - Y_t) + \delta_t F_{t+1}(Y_t - D_t)]\, d\phi_t(D_t) \Big\} . \tag{2}$$

This problem can be solved as a one-period problem if F_{t-1} has been calculated for all values $(Y_t - D_t)$. We can go forward in time until we come to the beginning of year T. At this point, the problem is

$$F_T(S_T) = \min_{Y_T \geq S_T} \Big\{ C_T(Y_T - S_T) + \int_{D_T} [H_T(Y_T - D_T) + G_T(D_T - Y_T) + \delta_{T+1}\, F_{T+1}(Y_T - D_T)]\, d\phi_T(D_T) \Big\} \tag{3}$$

F_{T+1} gives the value (i.e., negative cost) of stocks left after the planning horizon. This function is given.

The solution strategy is to calculate first F_T for all values of S_t. If this is done, F_{T-1} can be calculated, again, for all values of S_{T-1}. This way, we can go backward in time until F_2 is calculated for all values of S_2. Once F_2 has been specified, $F_1(S_1)$ can be calculated.

Thus, the basic approach is to decompose the problem into a number of stages (years). At the beginning and end of each stage, the problem is characterized by one or more variables--state variables. In this case, there was one state variable--the stock of the product. Finally, at each state, the optimal value of one or more variables (decision variables) and the corresponding value of the objective function have to be computed for each value of the initial state variable or variables. Here, the decision variable was the import quantity (Y_t - S_t) or, alternatively, the quantity available after imports are received, Y_t, with $Y_t \geq S_t$.

If the state and decision variables are discrete and, if the number of alternative values of these variables that has to be considered is not too high, F_t and the corresponding values of the decision variables may be calculated for all values of the state variables. Otherwise, the range of each state variable is discretized and F_t is computed for all combinations of the (discrete) values of the state variables. This usually implies that F_t, necessary to compute F_{t-1}, is not calculated for a number of values of the state variables. In such cases interpolation is used to compute F_{t-1}.

In addition, if the structure of the problem does not allow the use of a special algorithm to compute the optimal value of the decision variables at each stage, direct search can be limited by discretizing the decision variables and searching over all combinations of their respective values.

3.1. One-Product Food Grain Supply Model

The above model can be extended to describe the framework for decision making on food grain procurement and distribution by the government in Bangladesh considering only rice imports. Specifically, this problem facing the government is formulated as follows. At the beginning of the year, the government disposes of stocks of local and imported rice. It can also order imports of rice before actual local production is known. However, the government has some information on local production which is incorporated in a probability distribution. When production is known, the government can calculate excess demand (demand minus local rice available from production) at a target price which it wants to maintain. It can try to cover this excess demand by distributing both local and imported rice. When excess demand is negative, the government can buy local rice. If the quantities of food grain available to the government are not sufficient to cover excess demand, a shortage cost is incurred. On the other hand, if less food grain is distributed than is available, or if local rice is procured, stocks at the end of the year will be positive. In this case, a holding cost is incurred. The stocks at the beginning of the following year equal end-of-year stock minus storage losses.

The dynamic programming formulation contains the following elements.

1. Objective function: minimize the expected present total costs, consisting of import, shortage and holding costs.

2. State variables: the stocks of local and imported rice.

3. Decision variables: rice imports and, for given local production, distribution of local and imported rice (alternatively called offtake of local and imported rice from government stocks). Procurement of local rice is identical to negative distribution of this product.

Define S_{Rt}, S_{rt} = initial stocks of local and imported rice in year t;

Y_{rt} = quantity of imported rice available in year t after imports are received;

Q_t = local rice production in year t;

$\Phi(Q_t)$ = probability distribution of local rice production in year t;

$O_{Rt}(Q_t), O_{rt}(Q_t)$ = distribution of local and imported rice in year t, if local rice production is Q_t;

$D_t^*(Q_t)$ = demand for local rice at the target price in year t, if local rice production equals Q_t;

$C_{rt}(Y_{rt} - S_{rt})$ = import cost function for rice in year t;

$G_t\left[D_t^*(Q_t), Q_t, O_{Rt}(Q_t), O_{rt}(Q_t)\right]$ = shortage cost function in year t;

$H_t\left[S_{Rt} - O_{Rt}(Q_t), Y_{rt} - O_{rt}(Q_t)\right]$ = holding cost function in year t;

$F_t(S_{Rt}, S_{rt})$ = minimum expected present total cost at the beginning of year t over all coming years if initial stocks equal S_{Rt} and S_{rt}.

$f_t\left(S_{Rt}, S_{rt}\right)$ = expected present total cost at the beginning of year t over all coming years, if initial stocks equal S_{Rt} and S_{rt};

F_{T+1} = function defining the value (i.e., negative cost) of stocks left after the planning horizon, which goes from year 1 to year T;

$T_t\left[S_{Rt} - O_{Rt}\left(Q_t\right), Y_{rt} - O_{rt}\left(Q_t\right)\right]$ = vector valued function giving stocks at the beginning of year t +1 as a function of stocks at the end of year t (this function incorporates storage loss rates);

δ_t = discount factor in year t.

The problem then is to calculate

$$F_1\left(S_{R1}, S_{r1}\right) = \min f_1\left(S_{R1}, S_{r1}\right) . \tag{4}$$

As before, the problem can be decomposed in T one-stage optimization problems

$$\begin{aligned} F_t\left(S_{Rt}, S_{rt}\right) = \min C_{rt}\left(Y_{rt} - S_{rt}\right) + \int_{Q_t} \Big(& H_t\left[S_{Rt} - O_{Rt}\left(Q_t\right), Y_{rt} - O_{rt}\left(Q_t\right)\right] \\ & + G_t\left[D_t^*\left(Q_t\right), Q_t, O_{Rt}\left(Q_t\right), O_{rt}\left(Q_t\right)\right] \\ & + \delta_t F_{t+1}\left\{T_t\left[S_{Rt} - O_{Rt}\left(Q_t\right), Y_{rt} - O_{rt}\left(Q_t\right)\right]\right\}\Big) d\Phi_t\left(Q_t\right) \end{aligned} \tag{5}$$

for t = 1,..., T. The minimization is over Y_{rt} and over $O_{Rt}\left(Q_t\right)$, $O_{rt}\left(Q_t\right)$ as functions of Q_t. The following constraints must be satisfied.

$$Y_{rt} \geq S_{rt} \tag{6}$$

$$O_{Rt}\left(Q_t\right) \leq S_{Rt} , \qquad 0 \leq O_{rt}\left(Q_t\right) \leq Y_{rt} . \tag{7}$$

In addition there is a capacity constraint stating that total stocks at the end of the year must be less than or equal to total capacity

$$S_{Rt} - O_{Rt}\left(Q_t\right) + Y_{rt} - O_{rt}\left(Q_t\right) \leq C_{St} + C_{GCt} + C_{GLt} , \tag{8}$$

where C_{St} = silo capacity in year t;
C_{GCt} = central godown capacity in year t;
C_{GLt} = local godown capacity in year t.

$F_1(S_{R1}, S_{r1})$ is again calculated (5) beginning with t=T and going backwards in time, for all combinations (within the capacity constraint) of the discretised values of the stock variables, S_{Rt} and S_{rt}.

3.2. *Two Product Good Grain Supply Model*

The complete dynamic programming (DP) formulation for both rice and wheat supply may be formulated as follows: for t=T,...,1,

$$\begin{aligned} F_t\left(S_R, S_r, S_w\right) = \min\ & C_r\left(Y_r - S_r\right) + C_w\left(Y_w - S_w\right) \\ & + \int_Q \Big\{ H\left(S_R - O_R(Q), Y_r - O_r(Q), Y_w - O_w(Q)\right) \\ & + G\left(D^*(Q), Q, O_R(Q), O_r(Q), O_w(Q)\right) \\ & + \delta F_{t+1}\left[T\left(S_R - O_R(Q), Y_r - O_r(Q), Y_w - O_w(Q)\right)\right]\Big\}\, d\Phi(Q) . \end{aligned} \tag{9}$$

The minimization is over $Y_r, Y_w, \left\{O_R(Q), O_r(Q), O_w(Q)\right\}$ for each Q and is subject to the following constraints

$$Y_r \geq S_r , \qquad Y_w \geq S_w \tag{10}$$

$$O_R(Q) \leq S_R \tag{11}$$

$$0 \leq O_r(Q) \leq Y_r , \qquad 0 \leq O_w(Q) \leq Y_w$$

$$S_R - O_R(Q) + Y_r - O_r(Q) + Y_w - O_w(Q) \leq C_S + C_{GC} + C_{GL}. \qquad (12)$$

The subscripts r and w now stand for imported rice and imported wheat.

4. EMPIRICAL ESTIMATION

To implement the model presented in section 3, local rice production, demand relationships, and food grain storage costs must be estimated. The rationing system for imported rice and wheat complicates the interpretation of available data and, thus, the estimation of these relationships. Two basic premises dictated the treatment of the available data. First, Bangladesh food grain supply can be described in terms of a free market for local rice and a rationing system for imported rice and imported wheat. Both sources are interrelated by the effect of the distribution of imported food grain on the demand for local rice. Second, supply (marketed surplus) and demand are equalized in a market framework by the price of local rice. Demand, however, is influenced by the supply of imported rice and imported wheat through the system of rationing.

Given the above premises, the analysis presented here concentrates on estimating the local rice production, demand for rice, and the storage costs of food grain stocks. Local rice production was specified by alternative trends and a probability distribution about each trend projection. The trend projections were computed under a constant growth rate specification, until self-sufficiency was reached, at which time the growth rate was assumed to taper off.

On the demand side, the following equation was specified:

$$R' = \alpha_0 + \alpha_1 \log \tilde{y} + \alpha_2 \log \frac{p_R}{p_F} + \alpha_3 \Delta R' - \alpha_r r - \alpha_{wo} w + \alpha_{w1} w^2 \qquad (13)$$

$$\tilde{y} = y + (\alpha_r \, p_R - p_r) \, r + [(\alpha_{wo} - \alpha_{w1} w) \, p_R - p_w] \, w \tag{14}$$

where

$R' = R + \Delta S$

R = per capita local rice consumption

p_R = market price of local rice

p_f = $(i \neq R, r, w)$ price of products other than food grain

r = imported rice ration, equal to per capita offtake from government stocks

w = imported wheat ration, equal to per capita offtake from government stocks

$\tilde{y}$ = per capita disposable income adjusted for the income effect of rationing

y = per capital disposable income

p_r = price of rationed rice

p_w = price of rationed wheat

and

S = stocks of local rice.

Unfortunately, attempts to estimate equation (13) were fraught with problems of availability and quality of data (Tables 2 through 4). Population data were available only for census years. Thus, interpolations had to be performed between census years; disposable income data were not directly available and thus had to be constructed; local rice production data could be obtained only from sample surveys and crop-cutting experiments; a nonfood grain price index had to be constructed; and consumption data of rationed rice

TABLE 2

Population, Disposable Income, Rice Production and Rice and Wheat Offtake from Government Stocks, 1950/51 — 1968/69

	Population (Millions) (Jan. 1)	Disposable Income (Million Rs.)	Rice Production (Million tons)	Offtake from Government Stocks (Million tons)	
				Rice	Wheat
1950-51	43.29	11,992	6.20	.15	.04
1951-52	44.36	12,387	5.90	.21	.04
1952-53	45.45	12,725	6.16	.19	.05
1953-54	46.57	13,264	7.01	.06	.05
1954-55	47.72	12,967	6.42	.06	.02
1955-56	48.90	12,394	5.42	.20	.03
1956-57	50.10	13,727	7.10	.53	.07
1957-58	51.34	13,433	6.49	.37	.06
1958-59	52.60	12,855	5.84	.67	.10
1959-60	53.90	14,059	7.26	.41	.15
1960-61	55.60	14,747	8.35	.31	.17
1961-62	57.30	15,651	8.33	.35	.22
1962-63	59.10	15,707	7.67	.60	.65
1963-64	60.90	17,163	10.20	.24	.42
1964-65	62.80	17,641	9.43	.23	.51
1965-66	64.60	18,379	9.40	.42	.55
1966-67	66.50	18,959	9.20	.50	.58
1967-68	68.40	20,451	10.44	.23	.43
1968-69	70.40	20,946	9.99	.26	.80

TABLE 3

Per Capita Data for Local Rice Available for Consumption, Disposable Income, Rice and Wheat Offtake from Government Stocks, and Change in Rice Production, 1950/51 – 1968/69

	Rice Available for Consumption[†] (Lbs.)	Disposable Income (Rs.)	Rice Offtake from Government Stocks (Lbs.)	Wheat Offtake from Government Stocks (Lbs.)	Change in Rice Production (Lbs.)
1950-51	288.7	277.0	7.8	2.1	0.0
1951-52	268.1	279.2	10.6	2.0	-15.1
1952-53	273.2	280.0	9.4	2.5	12.8
1953-54	303.5	284.8	2.9	2.4	40.9
1954-55	271.2	271.7	2.8	0.9	-27.7
1955-56	223.5	253.5	9.2	1.4	-45.8
1956-57	285.7	274.0	23.7	3.1	75.1
1957-58	254.8	261.6	16.1	2.6	-26.6
1958-59	223.8	244.4	28.5	4.3	-27.7
1959-60	271.5	260.8	17.0	6.2	59.0
1960-61	302.8	265.2	12.5	6.8	43.9
1961-62	293.1	273.1	13.7	8.6	- 0.8
1962-63	261.6	265.8	22.7	24.6	-25.0
1963-64	337.7	281.8	8.8	15.4	93.1
1964-65	302.7	280.9	8.2	18.2	-27.5
1965-66	293.4	284.5	14.6	19.1	- 1.
1966-67	278.9	285.1	16.8	19.5	- 6.7
1967-68	307.7	299.0	7.5	14.1	40.6
1968-69	286.1	297.5	8.3	25.5	-14.3

[†] Production minus 10% for feed, seeds and wastage.

TABLE 4

Price Data, 1950/51 - 1968/69 per ton

	Market Retail Price of Local Rice (Medium) (Rs.)	Food Price Index (Exclusive of Foodgrain) (1959-60 = 100)	Retail Price of Local Rice / Food Price Index	Retail Prices of Rationed Foodgrain (Rs.)	
				Rice	Wheat
1950-51	26.99	79.66	33.88	20.00	18.75
1951-52	27.80	81.62	34.06	20.00	18.75
1952-53	30.50	71.20	42.84	20.47	18.75
1953-54	28.61	77.27	37.03	21.25	14.68
1954-55	20.24	77.95	25.97	21.25	13.75
1955-56	27.53	76.84	35.83	17.10	14.81
1956-57	28.61	85.47	33.47	20.00	19.37
1957-58	28.67	100.17	28.62	21.45	19.37
1958-59	30.19	96.66	30.29	22.50	18.48
1959-60	31.91	100.00	31.91	23.06	18.81
1960-61	29.30	107.35	27.29	23.75	18.12
1961-62	30.21	113.93	26.52	23.75	16.97
1962-63	32.22	116.75	27.60	23.75	12.50
1963-64	28.96	118.46	24.45	23.75	13.58
1964-65	29.80	128.21	23.24	25.40	12.40
1965-66	35.95	118.12	30.44	26.13	13.53
1966-67	46.10	129.15	35.70	28.22	18.40
1967-68	42.50	129.74	32.76	30.17	20.66
1968-69	46.23	134.70	34.32	30.80	20.38

Sources: See text.

and wheat were not available. Thus, it was assumed that these consumption levels were equivalent to amounts released from government stocks. For the data actually used (annual for the period 1950-51 to 1968-69), it was found that precise estimates of α_0, α_1, α_2, and α_3 could be obtained all with the right signed effects. The estimates of α_r, α_{wo}, and α_{w1} were imprecise largely because the sample data were not sufficiently rich to accurately measure the marginal rate of substitution of imported rice for local rice (α_r) and the marginal rate of substitution between imported wheat and local rice ($\alpha_{wo} + 2\alpha_{w1}\ w$). However, utilizing some theoretical arguments on the effects of rationing and visual examinations of the relationship between (i) per capital wheat stock releases (rationing wheat price/market price, local rice) and (ii) per capita rice stock releases (rationing rice price/market price, local rice), the following prior estimates: $\alpha_r = 0.85$, $\alpha_{wo} = 0.75$, and $\alpha_{w1} = 0.007$ were imposed.

For storage costs, two cost components were taken into account: fumigation costs (R_s, 15.12 per ton per year for godowns, and R_s, 1.89 per ton per year for silos) and drying, cleaning, handling contaminated stocks, and restacking (total variable costs of R_s, 15.94 per ton for godowns, and R_s, 2,240 for silos). Existing government storage capacity was estimated to be 447,000 tons for LSDs, 352,000 tons for CSDs, and 225,000 tons for silos. Finally, based upon the work of a private engineering firm, storage loss rates were estimated

Rice: 12 percent for LSDs, 9 percent for CSDs, and 5 percent for silos; and

Wheat: 20 percent for LSDs, 15 percent for CDSs, and 5 percent for silos.

5. EMPIRICAL RESULTS

Once the empirical results of section 4 are introduced into the two-product food grain supply model [equations (9)-(12)], optimal government policies can be determined. However, in this process, two major difficulties are encountered. First, the number of computations is exorbitant.[5] Direct enumeration over the values of all decision variables is cost prohibitive.

Second, by the internal logic of the problem, certain undesirable solutions will arise. As imported rice and imported wheat are imperfect substitutes for local rice, more than one unit of either has to be stored to have the same effect as one unit of local rice in the next period. Therefore, it will always be cheaper to distribute all available quantities of imported rice and wheat and stock their local rice equivalent. This would require that the government intervene directly in local rice markets--before the country is self-sufficient--even at the most unfavorable harvest (lowest value of Q_t). Furthermore, the model, which is necessarily an abstraction from reality, would in this way neglect the fact that, if the government distributes imported food grain, there will inevitably be some amounts of this food grain in the pipeline.

For the above reason, two major simplifications are imposed. First, the planning horizon has been divided in three regimes--each with its own predetermined institutional setup. These regimes do not represent a necessary time sequence; there might be forward and backward switching between regimes. However, it turns out that, with our demand function and with reasonable future growth rates for local rice production, there will be no switching back from later into earlier regimes. The regimes are:

Regime 1: Local rice production is not sufficient to cover rice demand at the target local rice price even at the highest value of Q. During this period, the government procures, distributes, and keeps inventories of imported food grain only.

Regime 2: The country is self-sufficient in years of a good harvest but not on the average, i.e., when Q equals its trend value. The government then performs the same function as in Period 1 but, in addition, buys, sells, and stocks local rice.

Regime 3: Expected production of local rice is sufficient to cover rice demand at the target local rice price. Imports are now halted, and the government is restricted to intervention on local rice markets.

The introduction of the three regimes means that the government starts handling local rice only when local production can cover demand. In addition, the number of state variables is reduced to two in Regime 1 and to one in Regime 3 involving a large reduction in the number of computations.[6]

The second simplification treats the distribution and local procurement as predetermined. The determination of this policy is based on the following rules:

1. The government uses all available food grain to keep prices at the target level.
2. If the available food grain quantities are more than sufficient to keep prices at this level, the surplus is kept in inventory.
3. In Case 2 if storage capacity is not sufficient, higher quantities than those required to keep the price at its target level are distributed.
4. Imported food grain is distributed before local rice.

5. In Cases 2 and 3 imported rice and imported wheat are distributed in proportion to the quantities available.
6. The government buys local rice if there is excess supply of food grain (local rice is equivalently greater than demand at the target price) and free storage capacity.

The above distribution policy seems reasonable. It rules out the possibility of not using all available food grain to bring the market price of rice down to its target level as well as the distribution of higher quantities than necessary to reach the objective of price stability. Together with the distinction between the three regimes, it helps to prevent undesirable solutions for food grain storage.

After introducing further simplifications in Regimes 1 and 2 (based on the logic of dynamic programming for each stage t) to reduce the search, the model was used to determine (i) import quantities and (ii) the quantities to be distributed or locally procured. Once the country becomes self-sufficient, only (ii) was determined. These results are reported in Table 5.

Note that the results in Table 5 are based on three levels of growth rates: low growth (4 percent for rice production and 5 percent for income); medium growth (5 percent for rice production and 6 percent for income); and high growth (6.8 percent for rice production and 9 percent for income). Sensitivity analysis is performed on these growth rates along with the rate of substitution between local rice and imported rice (α_r); the rate of substitution between wheat and rice ($-\alpha_{wo} + 2\alpha_{w1}$); and different levels of rationing prices. For each run, the number of periods reported terminates when the country becomes self-sufficient. For example, in Run 4, self-sufficiency occurs in the 23rd year.

TABLE 5

Results for the Two Product Foodgrain Supply Model, when Beginning Stocks in Each Year are Zero

Year	Rice Imports (1000 tons)	Wheat Imports (1000 tons)	Cumulative Expected Present Total Cost † (Rs. millions)
Run 1	Medium Growth Rates; $\alpha_r = .85$, $\alpha_{w0} = .75$, $\alpha_{w1} = .007$		
1	500	1000	7222.9
2	500	1000	6476.0
3	500	900	5763.8
4	500	800	5124.8
5	600	600	4540.2
6	400	700	4018.8
7	200	800	3577.6
8	100	800	3220.4
9	0	700	2956.2
10	0	600	2809.0
Run 2	Medium Growth Rates; $\alpha_r = .85$, $\alpha_{w0} = .75$, $\alpha_{w1} = .007$; Rationing Prices decreased by 50%.		
1	500	1000	7531.0
2	500	1000	6738.3
3	500	900	5988.3
4	500	800	5315.4
5	600	600	4699.1
6	500	600	4152.5
7	200	800	3689.4
8	100	800	3313.8
9	0	700	3036.3
10	0	500	2880.3

(Continued on next page.)

TABLE 5--continued.

Year	Rice Imports (1000 tons)	Wheat Imports (1000 tons)	Cumulative Expected Present Total Cost† (Rs. millions)
Run 3	Medium Growth Rates; $\alpha_r = .95$, $\alpha_{w0} = .75$, α_{w1} Declining Linearly from .007 in Year 1 to 0 in Year 30		
1	500	1000	6891.5
2	500	1000	6189.8
3	500	900	5526.4
4	500	800	4936.1
5	600	500	4396.2
6	500	600	3918.6
7	200	800	3511.2
8	100	800	3178.7
9	0	700	2933.6
10	0	600	2795.3
Run 4	Low Growth Rates; α_r, α_{w0}, and α_{w1} as in Run 3.		
1	500	1000	10893.
2	500	1000	10396.
3	600	900	9881.9
4	500	1000	9385.2
5	600	900	8867.2
6	600	900	8360.5
7	600	900	7844.5
8	600	900	7313.5
9	600	800	6768.9
10	600	800	6220.4
11	500	900	5670.8
12	400	1000	5121.8
13	400	900	4577.1
14	300	1000	4042.3
15	100	1[illegible]0	3531.2
16	0	1200	3047.9
17	0	1100	2602.8
18	0	1000	2199.3
19	0	900	1853.1
20	0	700	1571.5
21	0	500	1354.0
22	0	400	1208.4

Numerous simulations of the basic model were conducted. As expected, the underlying rate of growth in local rice production was the most critical factor in the cost of governmental intervention and the period of time before Bangladesh becomes self-sufficient. In comparison, the rate of substitution between local rice and imported rice, as well as the rate of substitution between wheat and rice, was not nearly as important. The rationing system, although important in determining the level of governmental costs, played an insignificant role in influencing the length of time before self-sufficiency occurred. To be sure, this result is explained in part by the model's treatment of production.

The principal value of the model in the evaluation of food grain policy in Bangladesh was not based on the results reported here. Instead, the model served as an effective negotiation tool to resolve quantitatively the implications of the three positions outlined in section 1. It clearly demonstrates what the costs of the current governmental policies would be if effective implementations of import purchases, rationing, and storage decisions were pursued. Perhaps even more importantly, the model provides a quantitative focus which can be extended to investigate the implications of the alternative positions. For example, after the initial simulations were conducted and summarized for government officials, two extensions were suggested. The first involved placing various shadow values on scarce foreign exchange to determine how importing strategies would be altered. The second placed a tariff on both wheat and rice exports and also placed various opportunity cost measures on governmental funds used to pay storage costs for food grains. The first extension was advocated by Treasury officials, while the second was promoted by officials from the Ministry of Education. Both of these extensions crystallized the debate; and, in effect, made the modeling analysis a critical focal point for resolving different perceptions of the system, different views of the uncertainties faced, different values and trade-offs among governmental objectives, what was and what was not legitimate, and what policy alternatives should be seriously considered on the political agenda. These outcomes represented the major benefits of the modeling effort reported in this paper.

FOOTNOTES

[1]In the context of India, Dantwala (1967, p. 7) has argued that "It is well known that whenever there is procurement by the government, open market prices go up steeply and disproportionately to the quantum withdrawn by government from the open market. As such, it would be reasonable to hold that the weighted average price received by the producer for the total sales (to the Government and in the open market) is no less than what he would have received in the absence of procurement."

[2]The term paddy is used for the rice kernel and its outer shell or husk. The usual conversion from paddy into rice weight is 2/3.

[3]Alternatively, demand may be thought of as concentrated at the end of the year.

[4]The conditions under which a mathematical programming problem may be decomposed in this way are discussed in detail by Rausser and Hochman.

[5]Consider, for example, the case in which S_{Rt} = 500,000 tons, $S_{rt} = S_{wt} = 0$, and there is an upper limit on imports of rice and wheat of 500,000 and 1,000,000 tons, respectively. With total capacity of 900,000 tons, the probability distribution of Q discretized into 10 values and the state and decision variables discretized by increments of 100,000 tons, an upper bound on the number of computations, each of which involves a number of operations, is given by 66 x 10 x 180 = 118,800. The first figure is the number of different import combinations, the 10 comes from the different output figures, and 180 is the number of sales from stock combinations if S_R = 500,000; Y_r = 500,000; and Y_w = 1,000,000. The actual number of computations may be much lower as, with lower Y_r, Y_w, less stock release

combinations are possible. But the bounds of Y_r and Y_w are lower. Furthermore, with the given storage capacity and the stock variables discretized by increments of 100,000, 220 inventory combinations are possible, for each of which a number of computations of the same order of magnitude must be made.

[6]The number of computations grows with the product of the number of alternative values of each state variable.

REFERENCES

Berlage, L. (1972). The Demand and Supply Policies for Food Grains in Bangladesh, Unpublished Ph.D. thesis, Department of Economics, Massachusetts Institute of Technology.

Dantwala, M. L. (1967). Incentives and Disincentives in Indian Agriculture. Indian Journal of Agricultural Economics, Vol. 22, 1967, pp. 1-25.

__________ (1981). Agricultural Price Policy, Economic Times. Feb. 6, 1981.

Rausser, Gordon C., and Eithan Hochman (1979). Dynamics of Agricultural Systems: Economic Prediction and Control, North Holland Book Publishing Company, Amsterdam, 1979.

Rausser, Gordon C., Erik Lichtenberg, and Ralph Lattimore (1982). New Developments in Theory and Empirical Applications of Endogenous Governmental Behavior, in Gordon C. Rausser, ed., New Directions in Econometric Modeling and Forecasting in U. S. Agriculture, Elsevier North Holland, Inc., New York, forthcoming.

Schultz, T. W. (1964). Economic Crises in World Agriculture, The University of Michigan Press, Ann Arbor, 1964.

__________ (1978). On Economics and Politics in Agriculture, in T. W. Schultz, ed., Distortions of Agricultural Incentives, Indiana University Press, Bloomington, 1978.