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SESSION 4: POLICY OBJECTIVE 1. PRICE STABILIZATION

Background paper (4c):

THE DESIGN OF FOODGRAIN STOCK POLICY

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THE DESIGN OF FOODGRAIN STOCK POLICY

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2

THE DESIGN OF FOODGRAIN STOCK POLICY

(Chapter 7 to Chapter 9 from: The Liberalization of the Public Foodgrain Distribution System in Bangladesh by Francesco Goletti, December 21, 1992)

CHAPTER 7: THE DESIGN OF FOODGRAIN STOCK POLICY

1. INTRODUCTION

The foodgrain sector in Bangladesh is characterized by the active presence of the government sector, which is involved in various operations related to domestic procurement, public distribution, imports, and open market sales. Central to this involvement is the management of public foodgrain stocks.

In the past, food security in Bangladesh has been often identified with high levels of public foodgrain stocks. This perception was consistent with recommendations coming from different quarters. In 1979 the World Bank, for example, recommended a stock level of 1.5 million metric tons as of July 1 of every year and 1.2 million tons as of November 1. In the years following 1981, government stocks have rarely exceeded the level of 1.2 million tons. Taking into account the population growth, the per capita figures of stock levels have been much smaller than those the World Bank recommended in 1979. This situation has not prevented prices of rice and wheat to become more stable in the period from the 1970s to the 1980s. Table 52 indicates both lower coefficients of variation of price and smaller yearly spreads between high and low prices for rice and wheat. The variability of total stocks did not increase during 1972/73-1989/90 (Tables 52 and 53), even though Bangladesh experienced two of the worst production calamities of its history in 1987/88 and 1988/89.

The foregoing observations suggest that stock policy guidelines have to be revised substantially. During 1981-91 the foodgrain sector of Bangladesh has witnessed a few remarkable changes: a changed pattern of seasonality of production and prices (Ahmed and Bernard 1989; Chowdhury 1987); a reduced degree of subsidized food distribution (Chowdhury 1990); increasing experience with open market sales (Chowdhury 1990); reduced gaps between market prices, ration prices, and procurement prices (Abdullah 1989b); reduced subsidies on agricultural inputs such as fertilizers and irrigation equipment (Abdullah 1989a, and Gisselquist 1992); and a sustained situation of self sufficiency in rice production during the most recent period starting from 1989/90. At the same time, the need for a new framework to analyze the public foodgrain policy has arisen. The initial attempts by Abbott (1988), Ahmed and Bernard (1989), Chowdhury (1987, 1988, 1990), Shahabuddin (1990), and Goletti, Ahmed, and Chowdhury (1991) form part of the growing literature. The general direction of these studies is away from a passive endorsement of quantity targets toward a more complete analysis of the food system of Bangladesh that tries to capture the complex interrelation between the open market and government operations. Moreover, a new concern related to the optimal stock problem has been emerged, where the word "optimal" refers to some prespecified policy or welfare concept (see Goletti, Ahmed, and Chowdhury 1991). In particular, there is a growing awareness of the financial cost implications of different stock levels.

To give a very rough dimension of this financial cost, one may think of the cost of 100,000 tons of foodgrains (35 percent of which consists of rice and the rest of wheat) evaluated at average 1988/89 world prices. This cost, equal to US$20.8 million, or 671.2 million taka (Tk), represents approximately 5.4 percent of the agricultural Annual Development Programme (ADP) budget and 1.4 percent of the total ADP budget. The average public stock of foodgrains in 1988/89 in Bangladesh was 1.2 million tons.

The main purpose of this chapter is to present a general framework for designing a cost-effective stock policy that addresses the government's concerns related to ensuring price stability and the food security of the vulnerable groups. The design of an optimal foodgrain stock policy entails the construction of a dynamic model of the foodgrain sector of Bangladesh and the use of programming techniques to facilitate the analysis of different policy interventions (for a similar approach applied to foodgrains in India, see Krishna and Chhibber 1983; for other commodities, see Ghosh, Gilbert, and Hughes Hallett 1987).

Table 52—Nominal rice and wheat prices, 1972/73-1989/90

Year[a]	Rice Price			Wheat Price		
	Average	c.v.[b]	Spread[c]	Average	c.v.[b]	Spread[c]
	(Tk/maund)	(percent)		(Tk/maund)	(percent)	
1972/73	75	14	50	n.a.	n.a.	n.a.
1973/74	100	21	64	62	35	143
1974/75	210	17	89	141	22	120
1975/76	124	24	94	77	34	157
1976/77	113	11	42	79	12	44
1977/78	138	6	20	91	9	40
1978/79	152	18	68	91	10	40
1979/80	201	8	31	124	15	64
1980/81	168	6	22	111	3	11
1981/82	220	17	69	135	15	48
1982/83	240	6	21	162	9	36
1983/84	262	7	23	167	9	25
1984/85	294	6	23	170	8	29
1985/86	280	7	22	181	7	26
1986/87	341	9	34	209	5	20
1987/88	352	5	17	215	6	22
1988/89	362	5	18	224	5	12
1989/90	355	5	20	233	3	13

Source: Based on data from Bangladesh Bureau of Statistics, Monthly Statistical Bulletin, various dates.

Note: n.a. means not available.

[a] The fiscal year starts in July.
[b] C.v. is the coefficient of variation, computed with monthly prices.
[c] Spread is the percentage difference between the highest and the lowest price of the year.

Table 53--Rice, wheat, and total foodgrain stocks, 1972/73-1989/90

Year[a]	Rice Stocks		Wheat Stocks		Average Total Stocks	C.V. of Total Stocks	Average Total Stocks per Capita	Security Days[c]
	Average	c.v.[b]	Average	c.v.[b]				
	(1000 MT)	(percent)	(1000 MT)	(percent)	(1000 MT)	(percent)	(kilograms/person)	
1972/73	44	44	282	45	326	39	4.44	10
1973/74	38	48	201	39	239	29	3.18	7
1974/75	63	102	200	45	262	41	3.39	8
1975/76	382	43	470	17	852	16	10.76	24
1976/77	311	28	272	33	583	29	7.2	16
1977/78	234	64	373	35	608	17	7.3	17
1978/79	200	30	437	39	637	26	7.48	17
1979/80	294	35	372	34	666	28	7.62	17
1980/81	453	38	777	25	1230	15	13.79	31
1981/82	481	26	548	32	1029	27	11.34	26
1982/83	312	12	375	27	687	17	7.39	17
1983/84	213	30	424	29	637	20	6.7	15
1984/85	268	43	549	21	817	21	8.36	19
1995/86	400	14	482	26	882	17	8.86	20
1986/87	215	36	520	41	736	36	7.23	17
1987/88	350	21	703	14	1053	15	10.09	23
1988/89	540	26	668	21	1208	18	11.33	26
1989/90	619	25	562	44	181	20	10.82	25

Source: Bangladesh Bureau of Statistics, *Monthly Statistical Bulletin*, various issues.

[a] The fiscal year starts in July.
[b] C.v. is the coefficient of variation, computed with monthly stocks.
[c] Security days express the number of days that public stocks would guarantee to the population of Bangladesh for that year a ist of 15.5 ounces of foodgrains.

5

2. CHOICE OF APPROACH TO THE OPTIMAL STOCK PROBLEM

The search for an effective stock policy has been constantly demanded equally by policy makers in Bangladesh and by donors. The general perception is that there may be a precise figure that represents the optimal level of public stocks. In the context of the present study, *the optimal level of public foodgrain stock is defined as the level of stock that helps attain certain objectives such as price stabilization and targeted public distribution at a minimum cost.*

This definition is somewhat limited, since the benefits of these public interventions are not precisely evaluated and incorporated into the analysis. Important questions related to the targeting, effectiveness, and leakages associated to public distribution programs have to be examined within a household and intra-household approach (see Ahkter Ahmed 1992). An attempt to address some of these issues was done in chapter 4 by considering the effect of price stabilization on poverty and consumer's surplus of different groups of the population. Moreover, the policy process through which the objective function of the policy problem is reached is not modelled. The specification of policy objectives is the result of the weight of different interest groups. Without entering into the area of political economy, this study offers enough flexibility to change the weights given to different objectives reflecting alternative equilibria of the political process influencing the foodgrain policy in Bangladesh.

However, various levels of these interventions and their implications for the estimates of optimal stocks are covered in this study. *This enables one to recommend the optimal level of public stock under the present degree of public interventions and under reduced degrees of such interventions.* This procedure gives a range of estimates of optimal stocks and the corresponding degrees of public interventions, providing room for gradual reform in public stock management and interventions.

The estimation of the optimal public stock obviously requires a comprehensive model that integrates a dynamic foodgrain sector with chosen policy regimes and well-defined objectives and cost functions. Three stages are involved in the design of the optimal stock policy problem. The *first stage* consists of the specification of policy objectives, policy constraints, and policy instruments. These elements constitute the necessary ingredients for the formulation of alternative policy options. Most of these policy options can be formulated as the outcome of optimization exercises. The *second stage* consists of the specification, identification, and estimation of a dynamic model of the foodgrain sector on the basis of which the optimization exercises described in the first stage are conducted. The *third stage* is the evaluation of different policy options computed by solving the optimization problems posed in the first two stages.

DESIGN OF FOODGRAIN STOCK POLICY

Stage 1 Policy Objectives, Policy Constraints, Policy Instruments, and Policy Options

Stage 2 Dynamic Model of the Interrelations between Private Sector and Public Sector

Stage 3 Evaluation of Different Policy Options

The optimal stock problem may be formulated as the optimization of some objective function defining the priorities of the government, subject to the constraints imposed by the feasible performance of the market, and additional policy and institutional constraints.

6

Formally, the optimization problem $[\mathcal{P}]$ can be expressed as follows:

$$[\mathcal{P}]:\ J_{t,T} = \min_{\{x_\tau\}}\ E_t\,(z_T P z_T + \sum_{\tau=t}^{\tau=T-1} W_\tau),$$

subject to

$$z_{\tau+1} = A_\tau \cdot z_\tau + B_\tau \cdot x_\tau + \epsilon_\tau \qquad [81]$$

and

$$l_\tau \le z_\tau \le u_\tau, \qquad [82]$$

where

$$W_\tau = z'_\tau \cdot \Theta_\tau \cdot z_\tau + x'_\tau \cdot R_\tau \cdot x_\tau \qquad [83]$$

and the time index $\tau = t,\ldots,T$.

In this notation z_τ is a vector of state variables, x_τ is the vector of control variables, with respect to which the government is optimizing, and ϵ_τ is the vector of error terms. T is the time horizon of the optimization exercise, and the length of the optimization period is $T - t + 1$. P, A_τ, and Θ_τ are matrices conformable with the vector z_τ; B_τ and R_τ are matrices conformable with x_τ.

The current period objective of the government is W_τ, which is assumed to be a quadratic form in the state and control variables; the final period objective is $z'_T P z_T$.

The state variables evolve according to the law of motion specified in equation (81) and are subject to inequality constraints as in equation (82). l_τ is the lower bound and u_τ is the upper bound for the state variable z_τ.

The optimal policy is a sequence of T-t+1 functions x_τ^* satisfying the problem $[\mathcal{P}]$.[4]

Note that by specifying different government objectives and instruments, the general model can be used to deal with many different policy issues. The system in equation (1) represents the structural model of the foodgrain private sector, which the government is influencing by releasing or withdrawing stock in the market. During the design of stock policy, the government takes into account the reaction of the private sector implied by a dynamic model of market behavior. At the same time, a set of other inequality constraints is imposed as specified in equation (2). Examples of these inequality constraints are capacity constraints, minimum stock requirements for food security, foreign reserves ceilings on food imports, and so on.

The rest of this chapter will carry out the analysis involved in stage one of the design of stock policy. Chapter 8 deals with the specification of the dynamic market response (stage two), and chapter 9 gives the evaluation of different policy options (stage three).

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[4] Because of the recursive structure of the problem, the optimal policy functions can be found by applying Bellman's equation recursively:

$$J_{t,T}(z_t) = \min_{x_t}\ E_t\ [W_t(x_t, z_t) + J_{t+1,T}(z_{t+1})],$$

subject to

$$z_{t+1} = A_t z_t + B_t x_t \quad \text{and}$$

$$l_t \le z_{t+1} \le u_t.$$

In the numerical solution of the optimal policy options considered in the text, the GAMS software has been used to find an open loop solution (Brooke, Kendrick, and Meeraus 1988).

7

3. POLICY OBJECTIVES AND POLICY CONSTRAINTS

The broad concern of foodgrain stock policy is to provide food security to the population. The major policy issue examined in this study is to understand how this broad concern can be implemented efficiently. For that purpose it is useful to declare the framework of policy design.

Policy Objectives

The setting of *policy objectives* of the public foodgrain system depends on the policy process and the interrelations between different interest groups. The formalization of a measure of achievement of these objectives is often made difficult by their being expressed in very general terms. Nevertheless, the formalization of policy objectives is critical in the effort to operationalize the policy design.

In this sub-section, three specific objectives are considered: price stabilization, price support, and cost minimization. The more general goal of poverty reduction will be incorporated into the analysis by imposing different degrees of targeted distribution to the poor.

The *objective of price stabilization* can be understood as minimization of the variance of prices around a target. In order for such an objective to be made precise, a target price θ_τ has to be specified for the period of the policy exercise going from $\tau = t$ to $\tau = T$.
The objective can then be expressed as follows:

$$\sum_{\tau=t}^{T} (p'_\tau - \theta_\tau)^2/(T - t+1) \ . \qquad [84]$$

where p'_τ is the price of rice at time τ.

The difficulty lies with an appropriate specification of the *target price*. Several elements will be taken into account in the specification of the target price. First, a long-term trend of domestic prices; second, a concern for seasonality fluctuations; third, the behavior of world prices. The target becomes a weighted average of these elements, where the weights reflect the relative importance attributed to them by the policy makers.[5]

The *objective of price support* can be easily expressed after specifying the support price level. Let p^s_τ be the support price for rice a time τ. Then

$$p'_\tau > p^s_\tau \qquad [85]$$

is the simple expression of the objective. Note that such price support is often implicit in the stronger objective that prices should be within a certain band, around a target price θ_τ. The latter objective can be expressed as

$$| p_\tau - \theta_\tau | \leq \text{bndw} \qquad [86]$$

where bndw is the width of the band. In this case the support price is the lowest price allowed in the band, namely $p^s_\tau = \theta_\tau - \text{bndw}$.

The *objective of cost minimization* can be readily specified, once an expression for the cost is provided. The relevant cost expression here is the operating balance of the food accounts.

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[5] The expression for the weighted average is

$$\ln(\theta_\tau) = A_1 \cdot \ln(p^l_\tau) + A_2 \cdot \ln(p^{seas}_\tau) + A_3 \cdot \ln(wop^l_\tau).$$

where p^l_τ denotes the long-term domestic price of rice, p^{seas}_τ is the seasonal factor, and wop^l_τ is the world price of rice. Note that the target price considered here is the target for rice prices.

6

Basically this cost refers to the difference between expenditures and revenues associated to operation of the public foodgrain system. Expenditures arise from the domestic and international procurement of foodgrains, and from storage costs. Revenues arise from sales of foodgrains through either subsidized channels or through open market operations. For the time period of the policy exercise, the expression of the cost is given by

$$\sum_{\tau=1}^{T} \sum_{i=r,w} \beta^{\tau-1}[wop_\tau^i m_\tau^i + pp_\tau^i qp_\tau^i + c(stock_\tau^i) - p_\tau^i oms_\tau^i - pr_\tau^i mof_\tau^i]. \qquad [87]$$

Expenditures are here simply given by the value, at international prices, of food imports (the term $wop_\tau^i \cdot m_\tau^i$), by the cash outlays for domestic procurement (the term $pp_\tau^i \cdot qp_\tau^i$), and by the storage costs $c(stock_\tau^i)$. Revenues are given by the monetary offtakes evaluated at ration prices (the term $pr_\tau^i \cdot mof_\tau^i$) and by the value of open market sales, evaluated at market prices (the term $p_\tau^i \cdot oms_\tau^i$). β is the parameter used to discount the future.

Policy Constraints

There are different types of policy constraints, expressing various degrees of policy concern, and feasibility of policy. Some of these constraints simply state the *nonnegativity* of endogenous variables such as prices and stocks. Some other constraints are *capacity* constraints, imposed upon stock variables to take into account the physical storage facilities constraints. The capacity constraints are expressed as follows:

$$stock_\tau^i \leq G_{max}^i, \qquad [88]$$

where i stands for either rice or wheat, $\tau = t,...,T$, $stock_\tau^i$ is the public stocks of grain i at time τ, and G_{max}^i is the maximum stock of grain i (assumed independent of time). As an example of capacity constraint, the storage capacity of government food godown and silos as on June 30, 1990 was 1761 thousand metric tons (BBS 1991).

A third set of constraints on stock variables takes into account minimum stock requirements that may be related both to *deadstocks* (the amount of stock needed for the system to be operational) and to the *minimum stock levels needed for food security* considerations. An example of the latter is that the public food distribution system must hold sufficient stocks to meet three months of offtake requests (505,000 tons), allowing the time period necessary for importing foodgrains to replenish the stock facilities. This security stock would serve as a cushion against events such as severe cyclones, droughts, and flooding.

These minimum stock requirements can be expressed as follows:[6]

$$stock_\tau^i \geq G_{min}^i. \qquad [89]$$

A fourth set of constraints is related to *maximum domestic procurement* and can be expressed as follows:

$$qp_\tau^i \leq \gamma \cdot q_\tau^i, \qquad [90]$$

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[6] Note that both minimum and maximum stock requirements imply constraints for decision variables. For example, assuming that the decision variables are open market sales (oms_τ^i), then

$$G_\tau^i \leq G_{max}^i$$

is equivalent to

$$oms_\tau^i \geq \delta^i G_{\tau-1}^i + m_\tau^i + qp_\tau^i - mof_\tau^i - nmof_\tau^i - G_{max}^i.$$

9

where qp^i_τ is procurement of grain i at time τ, and q^i_τ is production of grain i at time τ, that is, maximum procurement is just a fraction, γ, of total production. The motivation behind this type of constraint is the need to limit the extent of public intervention in the marketing system.

Finally, a fifth set of constraints that are considered in the following policy exercises is related to *foreign reserves*. This type of constraint can be expressed as follows:

$$wop^i_\tau \cdot m^i_\tau \leq F^i_\tau \qquad [91]$$

where wop^i_τ is the world price of grain i at time τ, and F^i_τ is the maximum amount of foreign exchange allocated to food imports m^i_τ. This constraint tries to incorporate the consideration that food imports have to compete with other imports in the allocation of scarce foreign reserves.

4. SPECIFICATION OF POLICY INSTRUMENTS AND POLICY OPTIONS

The process of liberalization of the public foodgrain distribution system can be interpreted as the progressive removal of regulations that hinder the development of markets. In the past, regulations have often taken the form of price fixing, such as in procurement, ration distribution, and even "open market" sales. The resulting dual system is gradually changing into a more market oriented one. Instrumental to this process of reform is the use of open market operations, both sales to reduce prices and purchases to support prices. Moreover, the possibility of using international trade through a more efficient phasing of imports and exports opens the way to a new set of policies, the effectiveness of which should be evaluated vis à vis a baseline.

The main policy instruments considered in the following pages are therefore open *market operations* (both sales and purchases), and *exports and imports of foodgrains*.

Having specified the sets of possible objectives, constraints, and instruments, each policy option can be thought of as a *package* of elements of these sets.

In the simulation of each policy option for the foodgrain sector of Bangladesh, several elements have to be clarified at the outset of the exercise. Among these elements are the time period of the simulation, the initial conditions, the exogenous variables, the endogenous variables, the policy instruments, the objectives of the policy, and the constraints.

In the remainder of this section several policy options are evaluated: the *benchmark* policy given by price stabilization cum cost minimization; the purely *price stabilization* policy conducted only though open market operations; the *import* policy that stabilizes prices only through imports; the purely *cost minimization* that uses both open market operations and imports, but is not concerned with price stabilization; the *no ration* policy where all subsidized distribution is eliminated; the *trade* policy where both imports and exports are allowed, the *transfer* policy where a part of ration distribution is transferred directly to target population, and a *price band* mechanism.

A summary of these options is given in table 54. A detailed description of each policy follows.

Benchmark: Price Stabilization cum Cost Minimization Policy

In this policy option the objective is to minimize the cost of operations, maintaining prices within a price band of 4 percent around the target. The policy instruments are given by both open market operations and imports. Constraints on capacity and food security stock requirements are specified, as well as on maximum procurement and on foreign exchange reserves. The foreign exchange constraint imposes a ceiling on foreign exchange that can be spent on imports. The ceiling is given by the foreign exchange equivalent of foodgrain imports in the baseline.

Table 54--Characteristics of Policy Options

Policy Options	Objectives	Instruments	Constraints
Benchmark: Price Stabilization Cum Cost Minimization	*Maintain* Prices within a Band around Target *Minimize* Cost	Open Market Operations and Imports	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement 5. Foreign Reserves
Price Stability	*Minimize* Variance of Prices around Target	Open Market Operations	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement
Import	*Minimize* Variance of Prices around Target	Imports	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement 5. Foreign Reserves
Cost Minimization	*Minimize* Costs	Open Market Operations and Imports	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement 5. Foreign Reserves
No Ration	*Maintain* Prices within a Band around Target *Minimize* Cost	Open Market Operations and Imports	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement 5. Foreign Reserves 6. No Ration Distribution
Transfer	*Maintain* Prices within a Band around Target *Minimize* Cost	Open Market Operations and Imports	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement 5. Foreign Reserves 6. No Ration Distribution 7. Increased Food Transfers
Trade	*Maintain* Prices within a Band around Target *Minimize* Cost	Open Market Operations, Imports, and Exports	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement 5. Foreign Reserves 6. Maximum Exports
Price Band	*Maintain* Prices within a Band around Target	Open Market Operations	1. Food Security Stocks 2. Dynamic Market Response 3. Capacity Constraints 4. Maximum Procurement

11

Price Stabilization via Open Market Operations

The objective of this policy is to minimize the variance of rice prices around a target price path. The instruments available to the government are only open market operations. Capacity constraints, food security stock requirements, and maximum procurement constraints are specified. Imports are kept at the baseline level; therefore, there is no need to impose a foreign reserves constraint. The interest of this policy lies in understanding what can be *achieved by a purely price stabilization policy, without attention to the cost implications.*

Price Stabilization via Imports

The objective of this policy is to minimize the variance of rice prices around a target price path. The difference between this policy and the previous is in the instruments used. The control variables are now given by imports of foodgrains. It is assumed that no exports take place. Open market operations are eliminated. The comparison of this policy with the stabilization policy via open market operations *highlights the role of import versus open market operations.*

Cost Minimization Policy

In this case the objective of the policy is to minimize the present value of cost. The basic policy issue here is to see how the public food distribution assumed in the baseline can be carried out at minimum cost, *without concern for price stability.* The instruments chosen are open market operations and imports. The constraints are the same as in the previous policy. The comparison of this policy with the benchmark policy highlights the cost of price stabilization.

No Ration Policy

This policy is a special case of the benchmark policy. The objective is again to minimize cost while maintaining prices within a band around the target. The instruments and constraints are also the same as in the case of the benchmark. The particularity of the policy derives from *eliminating ration distribution*, which is the bulk of monetary offtakes. The interest of the policy lies in the recent decision of the government to cancel some ration distribution programs.

Transfer Policy

This policy is a variation of the previous one. Instead of just eliminating monetary offtakes, now half of that rationed *distribution is given in kind to targeted population*, in the form of food for work, and distribution to vulnerable groups. The rationale for considering this policy is that these direct transfers are often considered more effective than ration distribution in reaching the population in need.

Trade Policy

This policy is a generalization of the benchmark policy. Instead of limiting trade transactions only to imports, also *exports are allowed.* As seen in chapter 5 there is a scope for a limited amount of exports of rice to take place. The amount is limited by the likely rice excess supply. A constraint of half a million metric tons was imposed.

Price Band Policy

Whereas all previous policy options were trying to optimizing some prespecified objective function, the price band policy operates differently. Establishing a price band mechanism implies setting a target price, a price band, and a rule of intervention.

The target price is denoted by θ_τ, where the time index τ varies over the period of the policy exercise. Generally, the target price chosen is a weighted average that takes into account the long-term trend of domestic prices, seasonality, and the long-term trend of world prices (Ahmed 1990). The price band is defined with reference to the target price and the specification of *an upper and a lower intervention price that should trigger open market operations*. Usually, the upper and lower trigger prices are symmetrical in relation to the target price.[7]

Under this rule, open market sales are undertaken by the government until either prices drop to the ceiling of the band or public stocks reach the minimum operational level.

Similarly, when prices in the absence of intervention tend to go below the lower price of the band, open market purchases are undertaken by the government until either the maximum stock capacity is reached or prices rise to the lower level of the band.

Finally, when prices are within the band, no open market operations are undertaken unless stock constraints are binding. When this is the case, open market operations are undertaken in order to satisfy the constraints.

The main advantage of a price band rule seems to be that the rule can be simply stated, is relatively easy to implement, and is readily understandable. Therefore, it has desirable features from an operational point of view. Nevertheless, *the outcome is not optimal, because it does not use all the available information*. A price band rule is a fixed rule, clearly suboptimal with respect to the rule that can be computed as a solution of an optimization problem (Buiter 1981).

The most limiting factors about price band rule are their vulnerability to speculative attacks (see Salant 1983), their unfeasibility to accommodate several constraints, and, when feasible, their cost.

5. CONCLUSIONS

This chapter has given the approach to the design of optimal stock policy that is used in the next chapters. The salient features of the approach consist in an explicit determination of the objectives, constraints, and instruments constituting a policy option. Several options relevant to the gradual reform of the Public Foodgrain Distribution System were presented.

There is a large body of literature emphasizing the virtues of simple decision rules to guide policy (Kydland and Prescott 1977, Lucas 1976, Friedman 1953). It is argued that optimal rules are not robust enough to be operated successfully when there are uncertainties related to model specification and estimation, speculative behavior, and numerical implementation. Moreover, policy makers may doubt about complex decision rules that are both difficult to understand and to compute. The virtue of simplicity may have a strong weight in the adoption of a policy.

This suggests the need to consider "simple" policies, easy to understand and to implement, that are good approximation of optimal policies, (Pinckney 1988, 1989). An example of these approximation policies are feedback rules, expressed in terms of the current state of the system. This example will be pursued in a later chapter.

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[7] Denoting these trigger prices by phigh and plow, they are related to the target price, θ_τ, as follows:

$$phigh_\tau = (1 + bndw) \cdot \theta_\tau, \text{ and}$$

$$plow_\tau = (1 - bndw) \cdot \theta_\tau.$$

CHAPTER 8: A DYNAMIC MODEL OF THE FOODGRAIN SYSTEM

1. INTRODUCTION

The design of foodgrain stock policy requires knowledge about the functioning of the foodgrain system. Without understanding the way the markets react to public intervention it is very difficult to propose and evaluate different policy options to improve upon the current situation. This chapter gives some basic facts about the major forms of public interventions in the foodgrain system of Bangladesh. After reviewing their performance in the past two decades, a model of the functioning of the foodgrain system is presented. The model captures the interrelation between the public foodgrain distribution system and the private market decisions involving consumption, storage, and marketing; in particular, it captures the multi-commodity nature of the system, based on rice and wheat, the seasonality of production, and the dynamics of expectations. The specification and estimation of the model complete the second stage of the general approach to the design of stock policy introduced in chapter 8.

2. THE EXTENT AND COST OF PUBLIC INTERVENTION IN THE FOODGRAIN SYSTEM.

The Government affects the availability of foodgrains through imports, domestic procurement, and public distribution. Each of these activities is reflected in the public stocks balance equation that follows.

$$stock^i_t = \delta^i \cdot stock^i_{t-1} + m^i_t + qp^i_t - offtakes^i_t - oms^i_t \qquad [92]$$

where $stock^i_t$ denotes public stock of grain i at time t, m^i_t denotes imports of grain i at time t, qp^i_t is procurement of grain i at time t, $offtakes^i_t$ is public distribution of grain i at time t, oms^i_t denotes open market operations of grain i at time t, and δ^i accounts for losses of grain i in public godowns.

One way to gauge the extent of government operations in the foodgrain sector is to consider the ratio of total offtakes to total availability, the latter being defined as net domestic production (gross production less 10 percent for wastage and feed) plus imports plus opening stocks, for any particular year. The dimension of government intervention in foodgrain distribution has been substantial, ranging from 8 percent to 21 percent, with an average value of 13 percent for the ratio of total offtakes to total availability (Table 55).

There are three sources of public supply: domestic procurement, imports, and government stocks. The relative importance of each of these factors is illustrated in Table 56. Whereas domestic procurement has been unable to supply the public distribution of foodgrains, the role of imports has always been crucial, with an average ratio of total imports to offtakes of foodgrains equal to 90 percent over the period from 1972/73 to 1989/90.

From a public finance perspective it is important to accurately assess the aggregate cash deficit on the food account, which is simply the difference between cash revenues and cash expenditures. Cash savings can be used for financing development planning.

From an efficiency point of view, the food-security objectives of the government should be pursued, keeping in mind minimization of the total cost of food operations. To measure the total cost, cash revenues have to be subtracted from cash expenditures.

Table 55—Components of public distribution of foodgrains, 1972/73-1989/90

Year[a]	Production	Net Production[b]	Offtake	Procurement	Initial Stocks	Imports	Avail-ability[c]	Offtake/ Availability
	(1,000 metric tons)							(percent)
1972/73	10,023	9,021	2,657	0	303	2,871	12,195	21.8
1973/74	11,832	10,649	1,756	72	269	1,719	12,709	13.8
1974/75	11,226	10,103	1,785	129	215	2,401	12,848	13.9
1975/76	12,780	11,502	1,679	503	761	1,488	14,254	11.8
1976/77	11,825	10,643	1,374	320	836	825	12,624	10.9
1977/78	13,120	11,808	1,863	559	422	1,665	14,453	12.9
1978/79	13,140	11,826	1,762	358	601	1,165	13,949	12.6
1979/80	13,362	12,026	2,203	354	210	2,809	15,399	14.3
1980/81	14,975	13,478	1,686	1,034	794	1,089	16,394	10.3
1981/82	14,598	13,138	1,840	303	1,208	1,234	15,883	11.6
1982/83	15,312	13,781	1,893	192	615	1,840	16,428	11.5
1983/84	15,719	14,147	1,896	272	611	2,069	17,099	11.1
1984/85	16,086	14,477	2,426	340	800	2,580	18,197	13.3
1985/86	16,083	14,475	1,419	361	1,008	1,198	17,042	8.3
1986/87	16,498	14,848	1,820	188	976	1,767	17,779	10.2
1987/88	16,462	14,816	2,016	374	751	2,911	18,852	10.7
1988/89	16,382	14,744	2,685	408	1,498	2,138	18,788	14.3
1989/90	18,656	16,790	1,981	962	905	1,534	20,191	9.8

Source: Based on data from Bangladesh Bureau of Statistics, Statistical Yearbook 1989, (Dhaka: BBS, 1990).

[a] The fiscal year starts in July.

[b] Net production is 90 percent of production.

[c] Availability = initial stock + net production + imports + procurement - offtakes.

Table 56—Sources of public distribution of foodgrains, 1972/73-1989/90

Year[a]	Procurement	Procurement Ratio[b]	Imports	Imports Ratio	Stocks Change	Stocks Change Ratio	Offtake
	(1,000 metric tons)	(percent)	(1,000 metric tons)	(percent)	(1,000 metric tons)	(percent)	(1,000 metric tons)
1972/73	0	0	2,871	108	0	1	2,657
1973/74	72	4	1,719	98	-34	3	1,756
1974/75	129	7	2,401	134	-54	-31	1,785
1975/76	503	30	1,488	89	546	-4	1,679
1976/77	320	23	825	60	75	30	1,374
1977/78	559	30	1,665	89	-415	-10	1,863
1978/79	358	20	1,165	66	179	22	1,762
1979/80	354	16	2,809	128	-390	-26	2,203
1980/81	1,034	61	1,089	65	583	-25	1,686
1981/82	303	16	1,234	67	415	32	1,840
1982/83	192	10	1,840	97	-593	0	1,893
1983/84	272	14	2,069	109	-4	-10	1,896
1984/85	340	14	2,580	106	189	-9	2,426
1985/86	361	25	1,198	84	208	2	1,419
1986/87	188	10	1,767	97	-32	12	1,820
1987/88	374	19	2,911	144	-225	-37	2,016
1988/89	408	15	2,138	80	747	22	2,685
1989/90	962	49	1,534	77	-593	0	1,981

Source: Based on data from Bangladesh Bureau of Statistics, Statistical Yearbook 1989. (Dhaka: BBS, 1990).

[a] The fiscal year starts in July.
[b] The ratios are taken with respect to offtakes.

16

For the foodgrain operations, the following definitions have been used:

Cash Expenditures	=	Procurement Cost + Value of Imports
Cash Revenues	=	Revenues from Open Market Sales and Ration Distribution
Total Cost	=	Cash Expenditures – Cash Revenues
Cash Outflow	=	Cash Expenditures – Cash Revenues – Value of Food Aid

Using the notation previously introduced,

$$\text{Cash Expenditures}(r) = \Sigma_i \, wop_r^i \cdot m_r^i + pp_r^i \cdot qp_r^i \qquad [93]$$

and

$$\text{Cash Revenues}(r) = \Sigma_i \, p_r^i \cdot oms_r + pr_r^i \cdot mof_r^i \qquad [94]$$

where wop^i are world prices, pp^i are procurement prices, pr^i are ration prices, mof^i are monetary offtakes, and p^i are market prices.

In the definition of cost adopted here, administrative costs are not included; similarly, other types of cost, such as those related to storage, losses, and pilferage, are not taken into account. However, this first attempt at looking at the structure of the food budget is still useful to give a first rough idea of the behavior of some of the budget components (see table 57).

3. COMPONENTS OF THE PUBLIC INTERVENTION IN THE FOODGRAIN SYSTEM

This section describes and analyzes the three main components that affect the stock balance equation, namely domestic procurement, public distribution, and imports.

Procurement

The declared objectives of procuring foodgrains domestically are to support prices and to replenish public godowns. The way the government has implemented such a strategy has been to buy a certain quantity denoted by qp^i at a preannounced price, called procurement price and denoted by pp^i.

Rice procurement has been higher during the 1970s than during the 1980s (Table 58). However, procurement was abnormally high in 1980/81 and 1989/90 following major production shortfalls. Thus, procurement in these years may be seen as an excessive reaction of the government, more for the purpose of replenishing public stocks than to support a floor price. As a percentage of production, procurement of rice averaged 3 percent in the 1970s and 2 percent in the 1980s, whereas wheat averaged 5 percent in the 1970s and 7 percent in the 1980s. Moreover, in per capita terms, rice procurement has been declining, whereas wheat procurement has exhibited an upward trend. Wheat is procured only in the three to four months following the March-April harvest. Rice is procured during two seasons, reaching its peak in December-January, during the aman harvest, and in June-July, following the boro harvest. In the past few years, because of the growing importance of the boro season, rice procured during May-July has been greater than the procurement made during the aman season.

Wheat procurement prices have been closer to market prices than rice procurement prices (Table 59). Moreover, both rice and wheat procurement prices followed a clear pattern during the second part of the 1980s, consisting of a smoothening of the deviations from market prices.

Table 57—Foodgrain nominal and deflated costs, 1976-89

Year	Procurement Cost[a]	Import Cost[b]	Total Expenditure[c]	Open Market Sales[d]	Ration Sales[e]	Revenue[f]	Total Cost[g]	Food Aid[h]	Cash Outflow[i]
				(Tk million)					
				Nominal Costs					
1976	1,039	1,989	3,028	0	2,447	2,447	581	1,531	-950
1977	1,960	3,736	5,696	0	3,348	3,348	2,348	2,692	-344
1978	1,206	2,682	3,888	0	3,352	3,352	536	2,565	-2,029
1979	1,406	9,871	11,277	370	4,317	4,687	6,590	3,906	2,684
1980	4,513	3,805	8,318	0	3,936	3,936	4,382	2,467	1,915
1981	1,447	4,832	6,279	348	5,057	5,405	873	4,012	-3,139
1982	1,021	7,960	8,981	719	5,314	6,034	2,947	4,127	-1,180
1983	1,358	9,238	10,597	852	5,342	6,194	4,403	6,452	-2,049
1984	1,812	12,385	14,197	1,117	6,131	7,248	6,949	5,759	1,190
1985	2,219	6,577	8,795	391	4,012	4,403	4,392	5,949	-1,558
1986	1,349	7,899	9,248	1,763	5,094	6,857	2,392	6,131	-3,739
1987	2,829	15,032	17,861	1,652	5,920	7,572	10,289	8,557	1,732
1988	3,336	14,452	17,788	2,135	6,357	8,493	9,296	9,738	-442
1989	8,500	10,979	19,479	1,320	7,831	9,150	10,329	6,162	4,166
				Deflated Costs					
1976	243	464	707	0	571	571	136	357	-222
1977	413	787	1200	0	705	705	495	567	-73
1978	259	577	836	0	721	721	115	552	-436
1979	244	1715	1960	64	750	815	1145	679	466
1980	700	590	1290	0	610	611	680	383	297
1981	203	679	882	49	710	759	123	563	-441
1982	132	1032	1164	93	689	782	382	535	-153
1983	181	1234	1415	114	713	827	588	862	-274
1984	228	1561	1789	141	773	913	876	726	150
1985	262	775	1037	46	473	519	518	701	-184
1986	150	877	1027	196	566	762	266	681	-415
1987	306	1626	1932	179	640	819	1113	926	187
1988	342	1482	1825	219	652	871	953	999	-45
1989	789	1019	1808	123	727	850	959	572	387

Sources: Based on unpublished data from Bangladesh Ministry of Food; authors' calculations.

Note: The deflator used is the index of manufactured goods.

[a] Procurement cost is obtained by taking procurement prices times procurement quantities.
[b] Import cost is computed at world prices converted in domestic currency.
[c] Expenditure = procurement cost + import cost.
[d] Open market sales (OMS) revenues are computed by taking OMS prices times OMS quantities.
[e] Ration sales are computed by taking ration prices times monetary offtakes.
[f] Revenue = OMS revenue + ration sales.
[g] Cost = expenditures - revenues.
[h] Food aid is computed from total imports, subtracting the commercial imports.
[i] Cash outflow = cost - food aid.

Table 58—Yearly procurement of rice and wheat, 1973/74-1989/90

Year*	Rice	Rice Procurement as Share of Production	Rice per capita	Wheat	Wheat Procurement as Share of Production	Wheat per capita
	(1,000 metric tons)	(percent)	(grams)	(1,000 metric tons)	(percent)	(grams)
1973/74	72	0.6	957	n.a.	n.a.	n.a.
1974/75	129	1.2	1,669	n.a.	n.a.	n.a.
1975/76	503	4.0	6,356	n.a	n.a.	n.a.
1976/77	317	2.7	3,898	n.a.	1.2	37
1977/78	548	4.3	6,576	11	3.1	133
1978/79	306	2.4	3,596	52	10.5	604
1979/80	228	1.8	2,600	126	15.3	1,432
1980/81	855	6.2	9,596	179	16.4	1,998
1981/82	290	2.1	3,201	13	1.3	147
1982/83	168	1.2	1,800	24	2.2	256
1983/84	154	1.1	1,623	118	9.7	1,231
1984/85	130	0.9	1,328	210	14.3	2,143
1985/86	231	1.5	2,322	130	12.5	1,297
1986/87	136	0.9	1,325	52	4.8	506
1987/88	288	1.9	2,747	86	8.2	819
1988/89	364	2.3	3,411	44	5.3	409
1989/90	919	5.1	8,403	43	5.4	391

Source: Based on data from Bangladesh Bureau of Statistics, Statistical Yearbook 1989, (Dhaka: BBS, 1990).

Note: n.a. means not available.

* The fiscal year starts in July.

Table 59—Mean divergence with respect to market prices of rice and wheat, 1972-89

Fiscal Years	Procurement Price	Ration Price	World Price	Open Market Sales Price[a]
		(percent)		
Rice price divergences				
1972-89	-14.4	-27.7	10.2	1.9
1970s	-18.3	-45.1	17.2	-2.5
1980s	-11.3	-13.7	4.7	2.3
1980-84	-11.4	-18.2	17.5	4.4
1985-89	-11.3	-9.1	-8.2	0.3
Wheat price divergences[b]				
1972-89	-8.3	-16.0	-5.4	3.8
1970s	-5.2	-28.7	-9.5	0.3
1980s	-9.8	-7.0	-2.4	4.1
1980-84	-10.8	-9.7	0.0	4.3
1985-89	-8.8	-4.4	-4.9	4.0

Source: Based on data from Bangladesh Bureau of Statistics, Monthly Statistical Bulletin, various dates.

Notes: The divergences are computed with respect to domestic market prices. The 1970s are from July 1972 to June 1980; the 1980s are from July 1980 to June 1990; 1980-84 is from July 1980 to June 1985; and 1985-89 is from July 1985 to June 1990.

[a] Data for open market sales mean divergences calculations are available from July 1979 onward for both rice and wheat.

[b] For wheat, data for ration price and world price mean divergences calculations are available from July 1973 onward and for procurement from July 1975 onward.

How can government ensure that an amount qp^i is procured at price pp^i? Procurement depends on the capacity and willingness of the farmers and traders to sell (Gulati and Sharma 1990). *Unless some forced arrangement is put into effect, procurement is constrained by the supply decisions of traders and farmers.*

Procurement Supply

In order to study the *procurement supply*, a simple model is introduced. For the sake of simplicity, superscripts denoting grains will be dropped in the following discussion.

At the beginning of each time period t, farmers are endowed with an amount, q_t, of foodgrains. They have to decide how much to sell to the market, μ_t, at the market price, p_t, how much to sell to the government procurement station, qp_t, at price pp_t, and how much to store, x_{t+1}.

The objective of farmers is to maximize expected profit, which is given for a two-period problem by

$$p_t\mu_t + pp_tqp_t + \beta p_{t+1,t}x_{t+1} - c_1(qp_t) - c_2(x_{t+1}), \qquad [95]$$

where β is the discount parameter between zero and one, $p_{t+1,t}$ is the price at time t + 1, expected to prevail as of time t, c_1 is the cost of bringing crops to the procurement station, and c_2 is the cost of storing stock.

The constraints faced by the farmers are that all the above-mentioned quantities are non-negative and that they do not exceed the initial amount owned by the farmer:

$$q_t \geq \mu_t + x_{t+1} + qp_t. \qquad [96]$$

It is possible to derive a closed-form solution for this problem if the cost functions c_1 and c_2 are taken to be convex in their respective arguments. Namely,

$$c_1(qp_t) = f_0 + f_1qp_t + 2^{-1} \cdot f_2qp_t^2, \text{ and} \qquad [97]$$

$$c_2(x_{t+1}) = g_0 + g_1x_{t+1} + 2^{-1} \cdot g_2x_{t+1}^2, \qquad [98]$$

where f_2 and g_2 are both positive.

It is then possible to express the solution for this problem as follows:

$$x_{t+1} = \max [0, -g_1/g_2 + (\beta p_{t+1,t} - p_t)/g_2], \text{ and} \qquad [99]$$

$$qp_t = \max [0, -f_1/f_2 + (pp_t - p_t)/f_2], \qquad [100]$$

where

$$\mu_t = q_t - x_{t+1} - qp_t \qquad [101]$$

In this formulation, procurement supply is positively related to the difference between current procurement price and market price. Storage, as seen in chapter 3, depends on the expected differential between future prices and current prices.

It is conceivable that costs of adjustment must be paid in order to change the amount supplied to the procurement station from period to period, and also that the higher is the amount q_t, the lower is the procurement cost. In such a case, the cost function c_1 can be expressed as

$$c_1(qp_t,qp_{t-1},q_t) = q_t^{\alpha} \cdot [f_0 + f_1(qp_t - \gamma qp_{t-1}) + 2^{-1} \cdot f_2(qp_t - \gamma qp_{t-1})^2] \qquad [102]$$

where α and γ are positive constants.

With this modification the procurement supply is

$$qp_t = [- f_1 + q^* \cdot (pp_t - p_t)]/f_2 + \gamma qp_{t-1}. \quad [103]$$

In equation [103] the amount procured is positively related to its lagged value, to the difference between procurement price and market price, and to the amount initially owned by farmers.

A procurement equation derived from the previous model has been estimated in the following linear specification:

$$qp_t = f(pp_t, p_t, q_t, qp_{t-1}). \quad [104]$$

For both rice and wheat, procurement prices do not appear with a significant coefficient (Table 60). This seems a bit surprising given that the rationale for introducing procurement prices is to stimulate procurement and support farmers' prices as a result. Here the puzzle of why procurement prices did not stimulate procurement supply, as one would expect a priori, has to be explained. A possible interpretation for the limited significance of procurement prices is that, since procurement takes place through a system of licensed dealers, rent-seeking behavior may generate a process whereby the level of procurement prices does not become critically important. Rather than through high procurement prices, profits could be made by altering the quality of rice, the moisture content, and the quantities actually procured. However, it is clear that when market prices increase, the incentives to sell to the procurement station diminish, since the marketplace becomes more attractive.

Moreover, by announcing procurement prices in advance of harvest time, the government cannot really know the level of quantity that it can procure. Therefore, it is important to explore different and more reliable ways to support prices than establishing procurement prices. One such way is that of *open tender* implying that the government is buying from the market at the best offered price. This idea is at the basis of the use of open market operations, the use of which will be explored in the next chapter.

Offtakes and Imports

Offtakes

The purported objective of a dual market system is to make foodgrains available to those sections of the population that are most sensitive to food prices and who, even in normal circumstances, experience malnutrition and hunger. Unfortunately, in the past, most of the public supply in Bangladesh has been geared to the needs of the urban population and government employees, with a strong bias against rural areas, where the food problems are often more severe. This long-term bias has been partly corrected in recent years through changes in the rationing system (Chowdhury 1988; World Bank 1990; Goletti and Ahmed 1991, Ahmed 1992).

Wheat offtakes have been growing both in absolute levels and in per capita terms. Rice has exhibited an opposite trend, to the extent that wheat offtakes in the most recent years have been about three times as much as rice offtakes (Table 61). The seasonal pattern of rice offtakes and wheat offtakes is quite similar, with a peak before the aman harvest (October-November) and before the boro season (March-May). In terms of ration prices, the subsidies on both rice and wheat have been gradually reduced (Table 59), and wheat ration prices are closer to market prices than rice.

To model the demand for monetary offtakes (net of open market sales), a distinction in the public distribution system has to be made between channels aimed at direct transfer of food to the poor, and those that consist in food subsidies through the ration system. All of these latter channels have been lumped together in the category of monetary offtakes, denoted by mof_t^l. Since individuals in this group have the option of drawing their quota at the ration price, a model of demand for rationed distribution can be postulated as follows:

$$mof_t^l = f(p_t^l, pr_t^l, y_t, mof_{t-1}^l), \quad [105]$$

Table 60—Ordinary least squares estimation of rice and wheat procurement supply, 1975/76 to 1990/91

Variable	Coefficient	t-Statistic
Rice		
Constant	0.47	0.31
p_t^R	-11.23	-3.04
pp_t^R	10.56	1.54
q_t^R	0.026	5.27
qp_{t-1}^R	0.13	1.25
N	63	
R^2	0.51	
SEE	0.97	
Wheat		
Constant	-0.16	-0.45
p_t^W	-2.70	-1.89
pp_t^W	4.06	1.67
q_t^W	0.044	5.42
qp_{t-1}^W	0.24	2.25
N	63	
R^2	0.45	
SEE	0.25	

Source: Estimated by the authors based on construction of seasonal data

Definitions of terms:

p_t^i = price of grain i at time t;

pp_t^i = procurement price of grain i at time t;

q_t^i = production of grain i at time t;

qp_{t-1}^i = quantity of grain procured at time t-1; and

SEE = standard error of estimation.

23

Table 61—Yearly offtakes of rice and wheat, 1972/73-1989/90

Year*	Rice	Rice per Capita	Wheat	Wheat per Capita
	(1,000 metric tons)	(grams)	(1,000 metric tons)	(grams)
1972/73	425	5,794	2,232	30,348
1973/74	125	1,660	1,630	21,639
1974/75	182	2,356	1,603	20,768
1975/76	502	6,339	1,177	14,902
1976/77	717	8,830	656	8,086
1977/78	600	7,218	1,263	15,195
1978/79	569	6,683	1,193	13,978
1979/80	695	7,962	1,508	17,290
1980/81	450	5,049	1,236	13,867
1981/82	589	6,479	1,251	13,752
1982/83	533	5,743	1,360	14,623
1983/84	426	4,478	1,470	15,431
1984/85	360	3,710	2,066	21,248
1985/86	309	3,106	1,110	11,139
1986/87	339	3,322	1,481	14,515
1987/88	340	3,271	1,676	16,088
1988/89	522	4,890	2,163	20,258
1989/90	655	5,990	1,326	12,149

Source: Based on data from Bangladesh Bureau of Statistics, Statistical Yearbook 1989. (Dhaka: BBS, 1990).

* The fiscal year starts in July.

Table 62—Ordinary least squares estimate of rice and wheat monetary offtakes 1975/76 to 1990/91

Variable	Coefficient	t-Statistic
Rice		
Constant	2.55	3.61
p_t^R	-0.59	-0.26
pr_t^R	-9.01	-2.34
y_t	0.002	0.99
mof_{t-1}^R	0.22	1.77
N	63	
R^2	0.36	
SEE	0.64	
Wheat		
Constant	-0.50	-0.34
p_t^W	37.56	6.84
pr_t^W	-24.53	-1.91
y_t	-0.001	-0.54
mof_{t-1}^W	0.19	2.00
N	63	
R^2	0.52	
SEE	0.96	

Source: Estimated by the authors based on construction of seasonal data.

Definitions of terms:

p_t^i = price of grain i at time t;

pr_t^i = ration price of grain i at time t;

y_t = income per capita at time t;

mof_{t-1}^i = monetary offtakes of grain i at time t-1; and

SEE = standard error of estimation.

25

Table 63—Yearly imports of rice and wheat, 1972/73-1989/90

Year*	Rice	Rice per capita	Wheat	Wheat per capita
	(1,000 metric tons)	(grams)	(1,000 metric tons)	(grams)
1972/73	396	5,417	2,475	33,643
1973/74	83	1,115	1,635	21,690
1974/75	270	3,480	2,130	27,542
1975/76	394	4,990	1,094	13,848
1976/77	195	2,402	630	7,743
1977/77	304	3,676	1,361	16,410
1978/79	57	664	1,108	13,045
1979/80	723	8,322	2,086	23,924
1980/81	85	957	1,004	11,302
1981/82	148	1,620	1,085	11,941
1982/83	316	3,411	1,524	16,416
1983/84	185	1,938	1,884	19,781
1984/85	695	7,159	1,885	19,391
1985/86	35	352	1,163	11,663
1986/87	260	2,539	1,507	14,767
1987/88	583	5,606	2,328	22,359
1988/89	75	705	2,063	19,305
1989/90	300	2,767	1,234	11,335

Source: Based on data from Bangladesh Bureau of Statistics, Statistical Yearbook 1989, (Dhaka: BBS, 1990).

* The fiscal year starts in July.

where pr_t^i refers to the ration price of grain i at time t. When the difference between market price and ration price decreases, monetary offtakes are also expected to decrease.

The analysis of the demand for ration distribution shows that ration prices of rice have had a significant impact on ration distribution, whereas for wheat ration prices this is not the case (see table 62).

Imports

Traditionally, imports of foodgrains in Bangladesh (see table 63) have been the domain of public monopoly. The most powerful factor affecting imports has been food aid, which in turn has been responsive to both public stocks and expected production shortfalls.

A simple model of import demand where imports (m) are related to world prices (wp), public stocks (stock), domestic production (q), and lagged imports is estimated.

$$m_t^i = g(wp_t^i, stock_t^i, q_t, m_{t-1}^i), \qquad [106]$$

The analysis shows that imports have not been influenced by world prices (Table 64). This suggests that non price factor such as food aid are more powerful determinants of imports. The significative effect of public stocks suggest that imports are extremely important in replenishing public godowns, in order to maintain them around a certain security level. In the case of wheat, imports are also significantly affected by the level of rice production.

4. A MODEL OF THE PUBLIC FOODGRAIN DISTRIBUTION SYSTEM IN BANGLADESH

Foodgrain prices are determined by the interrelationship between private sector decisions concerning production, consumption, storage, and marketing, and government sector decisions related to public distribution, procurement of domestic production, imports, and stock management. Whereas, in describing the behavior of the private sector, prices may be assumed as given, for the public sector this is not the case, since a large number of options for affecting prices are available to the government. Therefore, in modeling the interaction between the government and private sectors, there is an asymmetry of behavior in relation to prices. The design of stock policy should take into account this kind of asymmetry.

The foodgrain sector in Bangladesh is represented mainly by rice and wheat. Whereas rice is predominant in production, contributing more than 95 percent of total foodgrains, wheat is predominant in public distribution, mainly because of the quantities made available by food aid. Given the substitutability of rice and wheat, the demand for these grains has to be determined simultaneously. Government operations, in both distribution and procurement activities, affect prices of rice and wheat. Both commodities are storable and, especially for rice, there is a very active network of intermediaries between farmers and consumers (Crow and Murshid 1989, Chowdhury 1992). As seen in chapter 3, one fundamental aspect of this network is the presence of storage along with a demand for storage generated by profit motives.

The Model

In equilibrium, demand for foodgrains is equal to marketable supply,

$$d_t^i = ms_t^i, \qquad [107]$$

where d_t^i is the demand for grain i at time t, and ms_t^i is the marketable supply of grain i at time t.

Marketable supply is given by production plus the net distribution from the government, since exports of foodgrains are either not allowed or are not yet feasible, and imports are monopolized by

Table 64—Estimated equations for imports of rice and wheat, 1975/76-1990/91

Variable	Coefficient	t-statistic
Rice imports equation		
Constant	1.44	1.95
wop_t^R	0.94	0.4
$stock_{t-1}^R$	-0.28	-3.89
$stock_{t-1}^W$	-0.187	-0.28
q_t^R	-0.0009	-0.20
m_{t-1}^R	0.23	1.99
N	63	
R^2	0.28	
SEE	0.94	
Wheat imports equation		
Constant	5.24	2.24
wop_t^W	9.80	0.80
$stock_{t-1}^R$	-0.45	-2.14
$stock_{t-1}^W$	-0.53	-2.32
q_t^R	0.027	2.09
m_{t-1}^W	0.028	0.19
N	63	
R^2	0.24	
SEE	2.69	

Source: Estimated by the authors, based on data from Bangladesh Bureau of Statistics, Monthly Statistical Bulletin, various dates.

Definitions of terms:

wop_t^R, wop_t^W = world prices of rice and wheat in period t;

$stock_{t-1}^R$, $stock_{t-1}^W$ = opening public stocks of rice and wheat;

q_t^R = domestic rice production in period t;

m_{t-1}^R, m_{t-1}^W = lagged imports of rice and wheat;

SEE = standard error of estimation.

28

government. The distribution by the government consists of monetized distribution through rationing and open market sales, and in non-monetized distribution such as food-for-work, gratuitous relief, and vulnerable group feeding. To obtain the net distribution from public stock, procurement has to be subtracted from total offtakes. Therefore,

$$ms_\tau^i = q_\tau^i + mof_\tau^i + nmof_\tau^i + oms_\tau^i - qp_\tau^i, \qquad [108]$$

where q_τ^i is the production of grain i at time τ, mof_τ^i denotes monetary offtakes of grain i at time τ, $nmof_\tau^i$ denotes nonmonetary offtakes of grain i at time τ, oms_τ^i denotes open market sales of grain i at time τ, and qp_τ^i is procurement of grain i at time τ.

Note that this equation allows computation of the demand for foodgrains, which consists of both demand for consumption and demand for storage. This can also be expressed by saying that the marketable supply of foodgrains is either consumed or stored; that is,

$$ms_\tau^i = c_\tau^i + \Delta x_\tau^i, \qquad [109]$$

where ms_τ^i is the marketable supply of grain i as of time τ, c_τ^i denotes consumption of grain i as of time τ, and $\Delta x_\tau^i = x_{\tau+1}^i - x_\tau^i$ denotes the variation of private stocks of grain i as of time τ.

Unfortunately, time series data on either consumption or private stock are not available on an aggregate basis. Therefore, both consumption and private stock changes have to be expressed in terms of underlying variables such as prices and income.

In particular, consumption of grain i will be expressed as a function of its own price, p_τ^i, the price of the substitute grain, p_τ^j (where $i \neq j$), and income, y_τ:

$$c_\tau^i = g_1^i(p_\tau^i, p_\tau^j, y_\tau). \qquad [110]$$

Private storage will depend on the difference between expected prices for the next period and current prices, so the change in private storage can be expressed as follows:

$$\Delta x_{\tau+1}^i = g_2^i(\Delta p_{\tau+1,\tau}^i, \Delta p_\tau^i), \qquad [111]$$

where Δ is the difference operator, and $p_{\tau+1,\tau}^i$ is the price of grain i expected to prevail at time $\tau+1$, based on the information available at time τ.

The expression for the change in private stocks can be derived from an underlying model of private storage, similar to that of chapter 3. As a result of this analysis, the behavior of the private sector can be described by the following set of equations:

$$\hat{p}_{\tau-1}^i = f_0^i(\sigma_\tau^i, \eta_{0,\tau}^i), \text{ and} \qquad [112]$$

and

$$p_\tau^i = f_1^i(p_{\tau-1}^i, \hat{p}_{\tau-1}^i, y, p_\tau^j, ms_\tau^i, \eta_{1,\tau}^i), \qquad [113]$$

where the $\eta_{j,\tau}^i$'s are error terms.

The set q^i of instrumental variables is

$$q^i = (stock_{\tau-1}^i, m_\tau^i, y_\tau, losses_\tau) \qquad [114]$$

where $stock_t^i$ is ending period public stocks of grain i at time t, m_t^i denotes imports of grain i at time t, and $losses_t^i$ denotes rice losses at time t.

A three-stage least squares estimation of the system is implemented to take into account the simultaneity of the price of rice and wheat.

The complete specification of the foodgrain dynamic system is given below:

$$\hat{p}_{t+1}^r = a_1 + a_2 stock_{t-1}^r + a_3 m_t^r + a_4 losses_t + a_5 y_t, \quad [115]$$

$$\hat{p}_{t+1}^w = b_1 + b_2 stock_{t-1}^w + b_3 m_t^w + b_4 losses_t + b_5 y_t, \quad [116]$$

$$p_t^r = c_1 + c_2 p_{t-1}^r + c_3 \hat{p}_{t+1}^r + c_4 p_t^w + c_5 ms_t^r + c_6 y_t, \quad [117]$$

$$p_t^w = d_1 + d_2 p_{t-1}^w + d_3 \hat{p}_{t+1}^w + d_4 p_t^r + d_5 ms_t^w + d_6 y_t, \quad [118]$$

$$stock_t^r = \delta^r stock_{t-1}^r + m_t^r + qp_t^r - mof_t^r - nmof_t^r - oms_t^r, \quad [119]$$

$$stock_t^w = \delta^w stock_{t-1}^w + m_t^w + qp_t^w - mof_t^w - nmof_t^w - oms_t^w, \quad [120]$$

$$ms_t^r = q_t^r + mof_t^r + nmof_t^r + oms_t^r - qp_t^r, \text{ and} \quad [121]$$

$$ms_t^w = q_t^w + mof_t^w + nmof_t^w + oms_t^w - qp_t^w. \quad [122]$$

Equations (115) and (116) forecast the next period price by using opening public stocks, imports, forecast of rice losses, and income. Equations (117) and (118) relate the current prices of both rice and wheat to the lagged price, the forecast of future price, the marketable surplus defined in equations (121) and (122), and income. Note that income and current price of the alternative foodgrain come from the demand for consumption, whereas the lagged and expected future prices come from the demand for private stocks. Equations (119) and (120) give the law of motion for public stocks.

Estimation of the Model

The system specified above has been estimated by three-stage least squares using seasonal observations from 1975/76 to 1990/91. Each year contains 4 seasons, and 63 seasons have been used in the estimation. Prices are deflated by the index of manufactured goods and quantities are in per capita terms. For a description of the data see Appendix 2.

The first two equations reported in Table 65 give the instrumental variable estimation of future price, p_{t+1}^i. All the variables have the expected sign and most of them are significant. In particular, opening stocks have an important negative effect on future prices. Since imports add to the available supply, their coefficients are expected to be negative; nevertheless, the coefficients are not statistically significant. Losses in rice production that originate from cyclone, drought, and flood affect future prices because of an expected shortfall over the upcoming period. For rice, the effect of losses on prices is significant, whereas the opposite is true for wheat, mainly because the behavior of expected wheat prices is heavily influenced by the predominant role of wheat imports in the public distribution. Income positively affects future prices by increasing current consumption and lowering the supply available in the future.

In terms of goodness of fit, the price equations explain a good deal of the total variation of prices. For rice, the speculative effect of future prices on current price is particularly important, as demonstrated by the coefficient of p_{t+1}^r. In fact, the coefficient of future price is of the same order

of magnitude as the coefficient of lagged prices, indicating a support for the hypothesis of profit maximizing demand for storage (see chapter 3). Both wheat prices and marketable supply have the expected signs. Wheat prices have a positive effect on rice price due to the substitutability of rice and wheat in consumption.

Income does not have a significant effect on current prices, mainly because its influence is captured by future prices p^r_{t+1}. For wheat, it is noteworthy that the speculative effect is not significant. This has suggested a reestimation of the model with the constraint of zero coefficient of future wheat prices. The reduced form of this estimation is the one that is used in the simulations.

The model tracks the price of rice and wheat quite well. For rice and wheat, the root mean square error for the overall period is 11 and 12 percent, respectively. For more recent samples, the performance improves. For example, for the period 1985/86-1989/90 it is 4 and 5 percent, respectively. Within this model, the tracking of stock variables depends on the accuracy of the data on both procurement and offtakes. The balance equations for stock (given by equations [119] and [120]) are the basis for the tracking of stock variables. The less than perfect match between predicted values and actual values is due to unreported storage losses. By applying a storage decaying factor of 6 percent it is possible to improve the dynamic simulation of stocks considerably.

5. CONCLUSIONS

Foodgrain policy in Bangladesh affects the public stocks through decisions involving imports, domestic procurement, and public distribution. In turn, these decisions impinge upon the available supply and prices. This chapter has given the specification and estimation of a dynamic model of the foodgrain system that tries to link the decision of the government and the private sector. In so far as the model gives the reaction of the private sector to government policy, it has to be taken into account in the design of policy. Its main advantage lies in a combination of desirable features, such as commodity disaggregation, seasonality, and expectations, with enough flexibility to be used in the analysis of different policy issues. The model serves the purpose of a planning tool in the formulation and evaluation of different policy options to be undertaken in the next chapter.

Table 65—Estimated equations of the foodgrain system, 1975/76-1990/91

Variable	Coefficient	t-Value
Equation for lead price of rice		
Constant	0.2258	11.6554
$stock_t^R$	-0.0081	-4.2425
m_t^R	-0.0026	-0.8285
$losses_t$	0.0025	3.0879
y_t	0.0003	8.0605
Valid cases	63	
R^2	0.63	
SEE	0.03	
Equation for lead price of wheat		
Constant	0.1442	11.1412
$stock_t^W$	-0.0028	-2.6875
m_t^W	-0.0002	-0.1983
$losses_t$	0.0000	-0.0535
y_t	0.0002	6.4952
Valid cases	63	
R^2	0.43	
SEE	0.02	
Rice price equation		
Constant	-0.0627	-2.7611
P_{t1}^R	0.3209	5.9081
$\bar{P}_{t+1}^R$	0.5569	6.3696
P_t^W	0.8572	5.3662
ms_t^R	-0.0008	-9.8340
y_t	-0.0001	-2.5276
Valid cases	63	
R^2	0.84	
SEE	0.02	
Wheat price equation		
Constant	0.0509	2.5425
P_{t1}^W	0.2761	2.7483
P_t^R	0.2295	2.4873
ms_t^W	-0.0011	-1.6609
y_t	0.0001	1.8683
Valid cases	63	
R^2	0.61	
SEE	0.02	

(continued)

Table 65—Continued

Source: Estimated by the authors, with seasonal data.

Definitions of terms:

$stock_t^i$	=	stock of grain i at time t;
m_t^i	=	imports of grain i at time t;
$losses_t$	=	losses of rice during time t;
y_t	=	income at time t;
p_t^i	=	price of grain i at time t;
$\hat{p}_{t+1}^i$	=	instrumental variable estimation of price of grain i at time t+1;
ms_t^i	=	marketable supply of grain i time t;
t	=	refers to season (season 1, July-October; season 2, November-February; season 3, March-April; season 4, May-June); and
SEE	=	standard error of estimation.

CHAPTER 9: POLICY EVALUATION

1. INTRODUCTION

This chapter presents the results of the evaluation of different policy options. Each option consists of a set of well specified policy objectives, a set of constraints including the dynamic model of the foodgrain system, and a set of policy instruments needed to achieve those objectives. The evaluation of different policy options is done based on a series of criteria such as price stability, fiscal cost, foreign reserves needed to import foodgrains, and the level of public stocks. The comparison of different outcomes allows the policy makers to gain a better understanding of the trade-offs involved in the different options. Such an understanding is important to improve upon the current policies.

For policy evaluation t[illegible] e me[illegible] ful, a relevant baseline has to be considered. The baseline refers to the three-yea[illegible] period 1988/89-1990/91, a total of 12 seasons (each year comprises four seasons), and is characterized by enough variability including a "bad" year (1988/89), a "good" year (1989/90) and one "normal" year (1990/91). The choice of the baseline reflects the movement of the foodgrain sector toward a sustained growth of production.

The *baseline* for these simulations is constructed by taking exogenous values and predetermined variables at their historical values and running the reduced form of the model in order to get the endogenous variables (prices and stocks). In the policy options presented below, open market operations and imports are policy instruments that, as such, are choice variables in the optimization problems considered. Their counterparts in the baseline are open market sales, procurement quantities, and imports actually performed by the government during the period 1988/89 to 1990/91. The total cost for the baseline is more than Tk 21 billion, the coefficient of variation of rice prices is 6.4 percent, and the average foodgrain stock level is nearly 1.1 million tons. The [illegible] of variables and costs in the baseline are reported in table 66 and 67.

The insight gained from this type of exercise facilitates comparison of different policy options with the one that is already in place from the perspective of the government's objectives of ensuing price stability, cost efficiency, and food security.

An important element of policy evaluation is the *operational feasibility* of alternative options. Th chapter concludes with an indication of how the optimal rules can be approximated at the implementation stage.

2. EVALUATION OF POLICY OPTIONS

This section gives the results of the solution of the different policy options considered in chapter 8. To facilitate the reading of the chapter, each options is summarized with a flow-chart indicating the objectives, constraints, and instruments that characterize each policy. When appropriate, the formal model used to conduct the numerical estimation of the policy is also introduced. The summary statistics of the various policy options are reported in table 68.

Table 66-Variables in the baseline, 1988-91

Year/ Season[a]	Price[b] Rice	Price[b] Wheat	Stock Rice	Stock Wheat	Open Market Operations[c] Rice	Open Market Operations[c] Wheat	Imports Rice	Imports Wheat
	(Tk/maund)				(kilograms/capita)			
1988/89								
Aus	35.8	22.2	6.11	3.98	0.36	0.47	0.33	1.35
Aman	37	22.4	4.86	6.71	0.4	0.35	0.21	11.75
Winter	38.6	22.3	4	5.42	0.75	0.03	0.18	3.32
Boro	37	23.2	4.2	6.28	0.12	0	0	3.55
1989/90								
Aus	37.9	23.3	6.53	9.68	0.02	0.01	2.36	7.66
Aman	32	21.9	8.83	4.68	0.04	0.01	0.4	0.87
Winter	34.5	21.6	6.65	3.2	0.09	0.01	0.11	0.67
Boro	34.1	22.6	8	4.41	0	0.03	0	2.57
1990/91								
Aus	35.1	22.7	6.13	6.73	0.24	0.04	0	6.06
Aman	31.3	21.8	4.51	4.5	0.23	0.06	0.01	2.79
Winter	36.8	22.1	3.24	5.78	0.16	0.02	0.01	3.73
Boro	36.7	23.1	5.52	5.37	0.1	0	0.08	2.18
Mean	35.6	22.4	5.72	5.56	0.21	0.09	0.31	3.87
Standard deviation	2.3	0.6	1.86	1.7	0.21	0.15	0.66	3.2

Source: Estimated by the author.

Note: The baseline is obtained by simulating the foodgrain model for the period July 1989 to June 1991.

[a] The seasons are defined as follows: aus, July-October; aman, November-February; winter, March-April; and boro, May-June.
[b] Prices are deflated by the index of manufactured goods.
[c] Positive open market operations have to be interpreted as open market sales; negative open market operations have to be interpreted as domestic procurement.

Table 67-Costs in the baseline, 1988-91

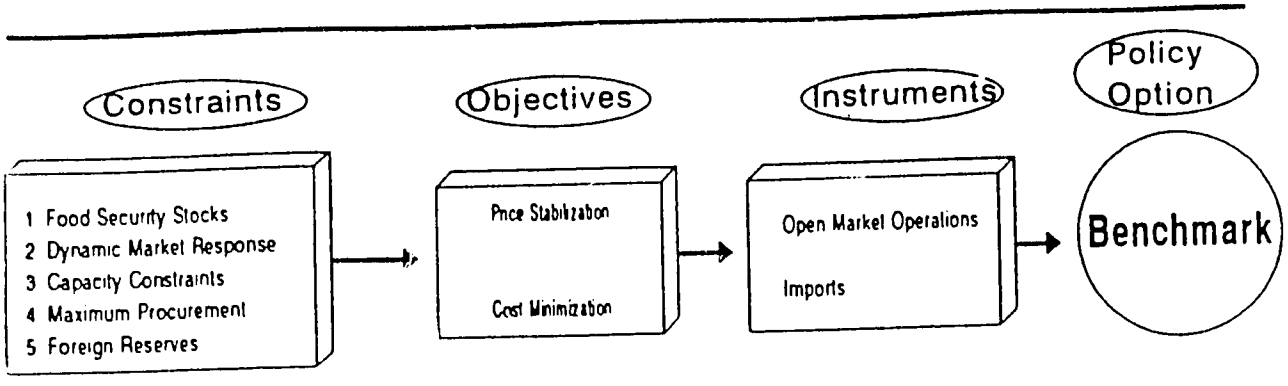
Year/ Season[1]	Procurement Cost	Imports	Ration Sales	Open Market Sales	Total Cost[2]	Foreign Exchange	Cash Outflow[3]
			(Tk million)			(US$ million)	(Tk million)
1988/89							
Aus	1271	1224	2236	605	-346	38	-1069
Aman	554	8347	2402	608	5891	259	191
Winter	135	2492	857	820	1151	77	-507
Boro	1376	2447	1067	120	2635	76	942
1989/90							
Aus	1615	7793	3224	26	8158	241	1931
Aman	3724	986	2717	41	1951	31	1443
Winter	280	556	1664	109	-936	16	-1267
Boro	2890	1585	1332	23	3118	45	2046
1990/91							
Aus	1444	3120	4457	291	-184	88	-2296
Aman	1471	1409	4965	277	-2362	39	-3313
Winter	493	1971	1541	210	713	55	-617
Boro	3851	1239	1361	117	3611	35	2810
Mean	19104	33188	27623	3247	21401	1001	284
Standard deviation	1213	2472	1285	255	2524	77	1790

Source: Estimated by the author.

Note: The baseline is obtained by simulating the foodgrain model for the period July 1989 to June 1991.

[1] The seasons are defined as follows: aus, July-October; aman, November-February; winter, March-April; and boro, May-June.
[2] Total cost = procurement cost + import cost - ration sales - open market sales.
[3] Cash outflow = total cost-foreign exchange.

The Benchmark Policy: Price Stabilization cum Cost Minimization



The baseline gives the behavior of prices, and stock when the exogenous variables are kept at their historical level. The benchmark case gives the outcome that would result if policy were designed and implemented according to the approach outlined in the previous two chapters. The objective of the policy is to minimize cost and to guarantee enough price stability and public distribution so that the concern for food security is properly addressed within the resource basis available. *Open market operations and imports* are the main instruments available to reach these objectives. Open market operations are here regarded both as open market sales and as open market purchases. The main difference with respect to the dual system of the past are that: i) open market operations are undertaken at market prices and not at fixed prices; ii) open market purchases are undertaken in the open market, and not through a system of licensed dealers such as in the old procurement system. The design of the policy should take into account the behavior of the private sector, in particular of the effect of consumption and storage decisions upon prices. Finally, the policy considers a series of constraints originating from capacity availability of foodgrain storage facilities, from minimum stock requirements deemed consistent with food security and normal operations, and from foreign reserves availability.

Formally, the benchmark policy consists of choosing a path for imports, open market sales, and open market purchases of both rice and wheat to minimize the cost of food operations as follows:

BENCHMARK POLICY

$$\min \sum_{t=1}^{T} \sum_{i=r,w} \beta^{t-1}\{wop_t^i m_t^i + p_t^i omp_t^i + c(stock_t^i) - p_t^i oms_t^i - pr_t^i mof_t^i\},$$

subject to equations:

$$\hat{p}_{t-1}^i = f_0^i(\sigma_t^i, \eta_{0,t}^i), \text{ and} \quad [123]$$

$$p_t^i = f_1^i(p_{t-1}^i, \hat{p}_{t-1}, y, p_t^i, \bar{m}s_t^i, \eta_{1,t}^i), \quad [124]$$

where

$$\bar{m}s_t^i = q_t^i + offtakes_t^i - (oms_t^i - omp_t^i), \quad [125]$$

$$stock_t^i = \delta^i stock_{t-1}^i + m_t^i - offtakes_t^i - (oms_t^i - omp_t^i), \quad [126]$$

$$stock_t^i \geq G_{min}^i, \quad [127]$$

$$stock_t^i \leq G_{max}^i, \quad [128]$$

$$\Sigma_i\, wop_t^i \cdot m_t^i \leq F_t, \quad [129]$$

$$omp_t^i \leq \gamma \cdot q_t^i, \quad [130]$$

$$|p_t^i - \theta_t| \leq 0.04 \cdot \theta_t, \text{ and} \quad [131]$$

$$p_t^i, m_t^i \geq 0, \quad [132]$$

where $i = r,w$ and $t = t,\ldots,T$.

These choices are subject to the constraints given by the dynamic system of the foodgrain private sector (equations [124]-[126]); minimum stock requirements to guarantee the flow of stock operations (dead stocks) and food security (equation [127]); capacity constraints of maximum stocks (equation [128]); foreign exchange constraints (equation [129]); constraints on maximum domestic procurement (equation [130]); constraints on price variability (equation [131]); and non-negativity constraints (equation [132]).

The parameters used in the model are: $G_{max}^r = 8$, corresponding to 842,000 metric tons; $G_{max}^w = 12$, corresponding to 1,263,000 metric tons; $G_{min}^r = 2.0$, corresponding to 210,000 metric tons; $G_{min}^w = 3.5$, corresponding to 316,000 metric tons; $\gamma = 0.5$; $\delta = 0.94$; and $Fr = 10$, corresponding to US$956 million.

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Table 68-Summary of various policies

Policy	Baseline[a]		Benchmark[b]		Price Stabilization via Open Market Operations[c]		Price Stabilization via Imports[d]		Cost Minimization[e]		No Ration[f]		Transfer[g]		Trade[h]		Approximation to the Benchmark[i]		Rigid Price Band[j]	
	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std
Rice Price	378	27.5	381	23.3	372	21.4	376	30.8	410	33	381	22.4	381	23	378	20.8	380	26.6	358	29.6
Wheat Price	239	18.0	239	13.9	237	16.1	238	18.4	248	17	238	11.1	238	12.2	228	8.8	238	15	233	15.4
Open market sales	31		263		170		31		184		490		380		819		184		84	
Open market purchases	0		324		272		0		230		198		258		518		285		163	
Rice stock	602	174	535	250	627	268.6	541	175	261	82	531	265.7	529	259.6	655	274.7	576	201.3	767	288.5
Wheat Stock	585	176	384	46.8	529	193.2	388	6.1	384	47	407	78.4	398	48.9	388	6.1	438	100.9	586	198.1
Rice imports	32	69	0	0	32	69	193	217.7	0	0	8	18.6	0	0	-282	343.4	0	0	135	359.4
Wheat imports	406	332	467	471	406	331.6	381	222.8	456	458	506	628.4	496	542.7	1113	1070.8	417	352.6	406	331.6
	Total	Std	Total	Std	Total	Std	Total	Std	Total	Std	Total	Std	Total	Std	Total	Std	Total	Std	Total	Std
Total cost	21401	2524	12248	3910	17838	3422	20836	2389	12771	2103	8161	3663	23736	3707	2823	3274	16329	3431	26390	4011
Procurement cost (Tk million)	19104	1213	34429	2346	30353	2896	0	0	25907	1460	20601	1841	27407	2059	58570	3365	31666	1822	16937	2023
Foreign exchange ($ millions)	1001	77	897	68	1001	77	1528	74	896	68	904	78	902	71	905	163	830	56	1361	124

Source: Computed by the author.

Notes: Avg = average; Std = standard deviation.
Prices are in taka/maund, not deflated. Quantities are in 1,000 metric tons. Costs are in million taka. Foreign exchange is expressed in million dollars.

[a] The baseline is obtained by simulating the foodgrain model for the period July 1989 to June 1991.
[b] The Benchmark Policy refers to price stabilization cum cost minimization. It uses open market operations and imports to minimize the total cost of food operations.
[c] The Price Stabilization via Open Market Operations Policy uses open market operations to minimize the variance of rice prices around the target.
[d] The Price Stabilization via Imports Policy uses imports to minimize the variance of rice prices around the target.
[e] The Cost Minimization Policy uses open market operations and imports to minimize the total cost of food operations without concern for price stabilization around the target.
[f] The No Ration Policy refers to price stabilization cum cost minimization, when ration distribution is eliminated. It uses open market operations and imports to minimize the total cost of food operations.
[g] The Transfer Policy refers to price stabilization cum cost minimization, when one half of ration distribution is eliminated and the other half is transferred directly as nonmonetary allotment.
[h] The Trade Policy refers to price stabilization cum cost minimization. It uses open market operations and both imports and exports to minimize the total cost of food operations.
[i] The Approximation Policy is an approximation to the benchmark policy computed by stochastic simulation of production shocks.
[j] The Rigid Price Band is a fixed rule that tries to keep prices within a band, intervening through open market operations only when prices are at the ceiling or floor of the band.

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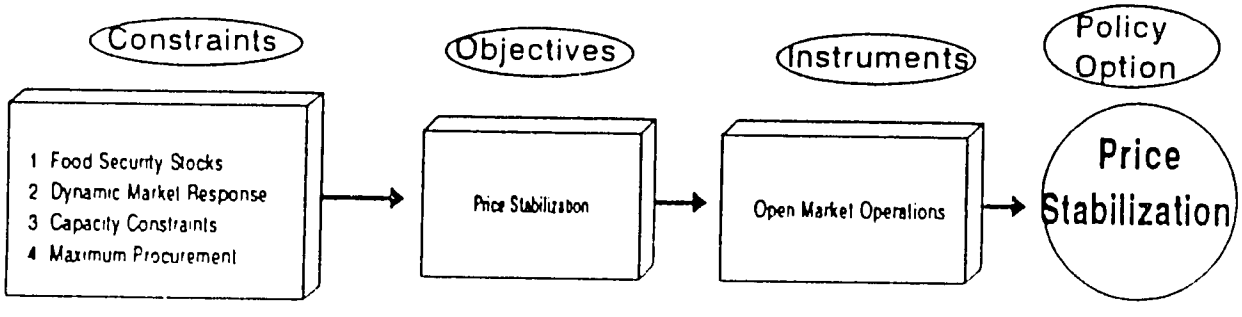
With a total cost equal to only 57 percent of the baseline (that is, Tk 12.2 billion), it is possible to achieve stabilization within a 4 percent band around the target price. The resulting deflated rice price variability is given by a coefficient of variation of 3.1 percent versus a 6.4 percent in the baseline. The flexibility of this policy derives from the use of imports and open market operations to take advantage of both the domestic and the international grain markets. This implies a more effective import policy and more active open market operations. The average foodgrain stock is 920,000 tons.

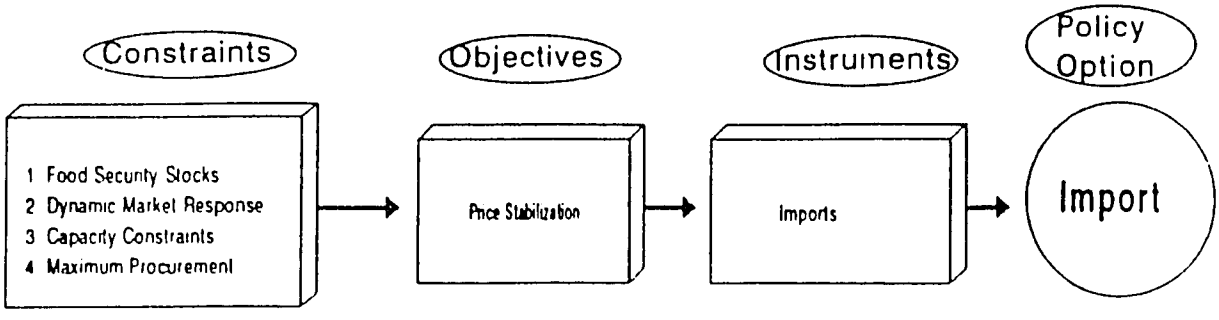
Some interesting patterns emerge from a comparison of the benchmark with the baseline. As already mentioned, the role of open market operations (both including open market sales and domestic procurement) is highlighted. Rice purchases are extensively used during the post-harvest periods and rice sales are used to control price bikes in the winter season. The effect of very high levels of purchases in the open market is responsible for the considerable cost of procurement. However, most of this cost is offset by frequent open market sales, the purpose of which is both to lower total costs and to reduce price volatility. Import costs are slightly lower than in the baseline, mainly because there are no rice import, even though wheat imports are slightly higher.

Price Stabilization via Open Market Operations



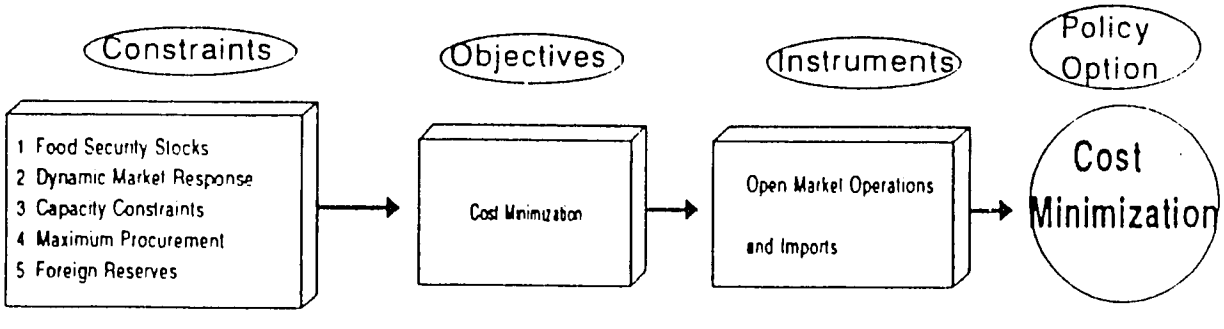
It is useful to compare the benchmark policy with other policies obtained either reducing the number of instruments or the number of objectives. This section considers the policy option of stabilizing prices *only through the use of open market operations*. The specific objective is to minimize the variance of prices around the target price. Imports are kept at the baseline level. Stabilization is perfect and is achieved at approximately 82 percent of the cost of the baseline, that is, about Tk 17.6 billion. The result is due to an intensive use of open market sales and domestic procurement. The rice price variability is reduced to a coefficient of variation of 2.7 percent. Note that in this case both imports and monetary offtakes are kept at their historical levels. If imports were eliminated it would not be possible to sustain the level of offtakes specified in the simulation. This is because domestic procurement of wheat is insufficient to meet the demand of wheat through both monetized and nonmonetized channels of the public food distribution system. The comparison to the benchmark case shows a higher cost and a higher average stock level (1156 thousand metric tons versus 920 thousand metric tons).

Price Stabilization via Imports



Whereas in the price stabilization policy considered above open market operations were used as a policy instrument, in this section only imports are used to stabilize prices. Open market sales are kept at their historical levels. The effect of imports is felt through future prices. Since imports affect the expectations of future prices negatively, they also lower current prices. The price variability is now given by a coefficient of variation of 4.82 percent. Compared with the case where open market operations were the only policy instrument, the total cost associated with the import policy is now higher (Tk 20.6 billion versus Tk 17.6 billion). The total cost of the policy is just 7 percent lower than in the baseline. The main reason for this relatively high cost is that stocks are not used efficiently. In other words, *an import policy divorced from a stock policy is not effective*. This suggests that in order to look for a real improvement in both cost and stabilization, both trade and stock policy have to be used, as in the benchmark case. The average foodgrain stock level for this policy is 909,000 tons.

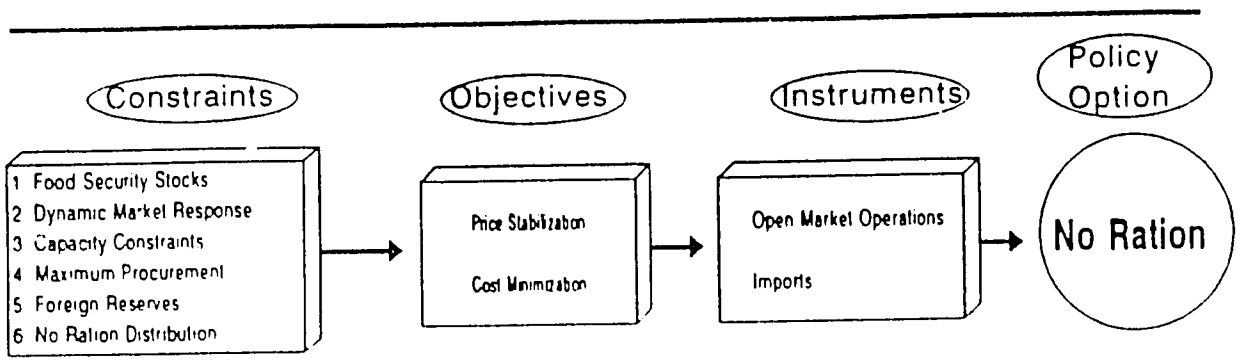
Cost Minimization Policy



In this case the only objective of the policy is to minimize total cost to carry out public distribution. Both open market operations and imports are used to achieve this objective. The outcome is a policy path that results in a total nominal cost of Tk 12.7 billion. The present value of the deflated cost is equal to 4.62 versus 5.15 in the case of the benchmark (see table 70). Under this scenario, the government allows the prices to move up to a relatively high level saving quite a bit of

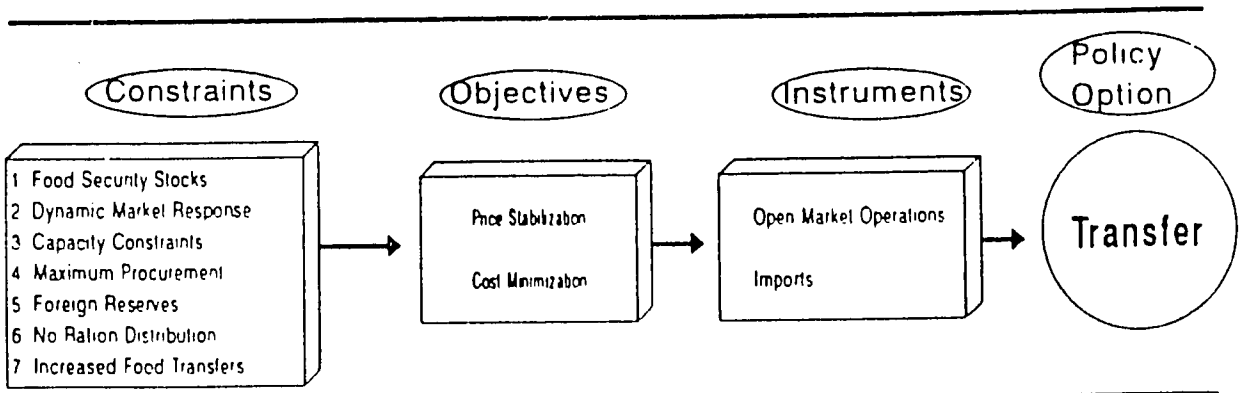
resources in domestic procurement. The rice price variability is about 4.9 percent. The average foodgrain stock level in this case is 645,000 tons. The effect of cost minimization is to reduce the amount of public stock almost to their minimum level. The cost difference between the benchmark and the cost minimization policy can be regarded as a *measure of the cost of price stabilization*, since the two policies differ only in this respect. In real terms, the price stabilization costs 7.2 percent of the baseline cost. In nominal terms this difference is blurred by the fact that both benchmark and cost minimization policy give almost the same amount. However, the major conclusion is that price stabilization does not appear too expensive.

No Ration Policy



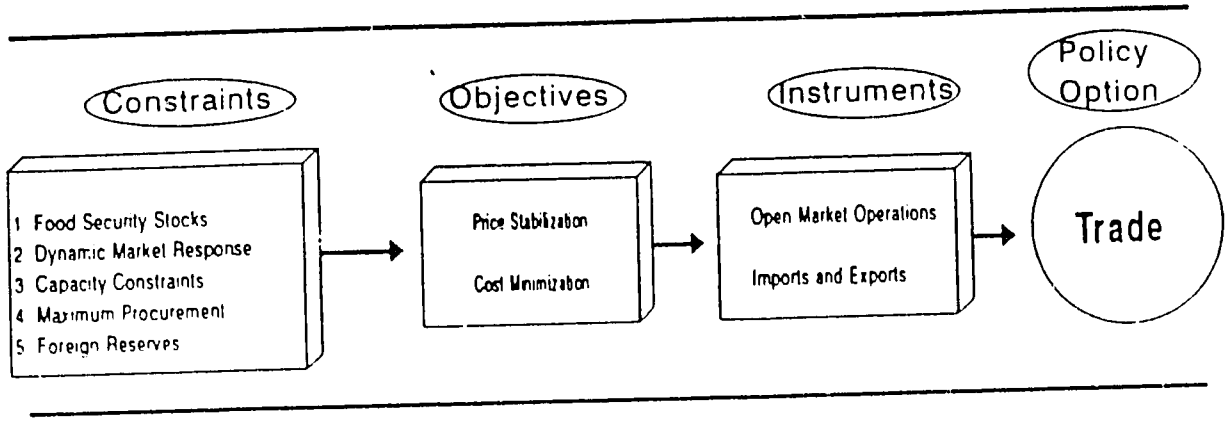
The purpose of this policy option is to consider what is the effect of abolishing that part of monetary offtakes known in Bangladesh as ration distribution. The idea behind this policy is that ration distribution has been considered very deficient in reaching the poor. Its elimination would then save resources to the public sector, without compromising the food security of the population. The outcome of the policy is a total cost of Tk 8.1 billion, equal to 30 percent of the baseline. Price stability is implicit in the implementation of the policy, and rice stock are reduced to about 940 thousand metric tons.

Transfer Policy



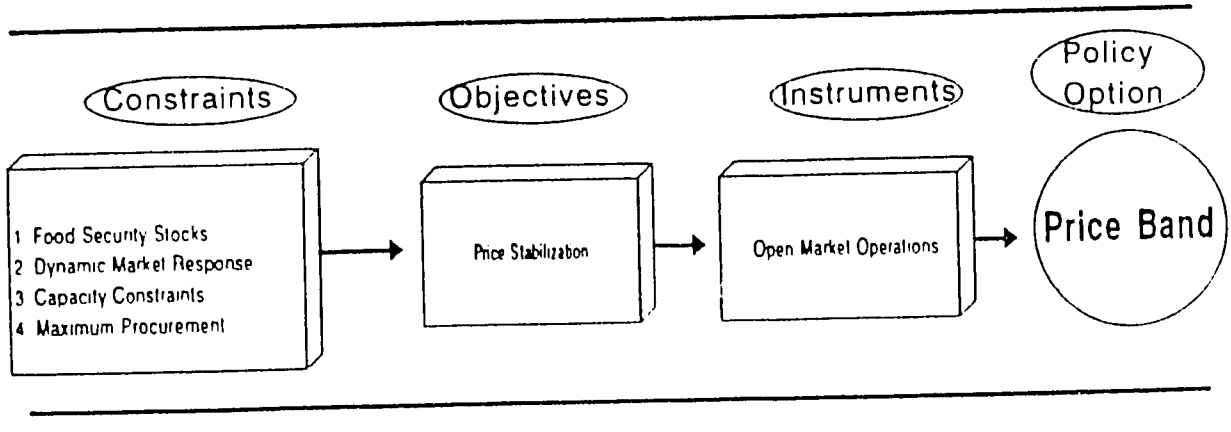
The interest of this policy lies in understanding the effect of a redirection of the public distribution system, from a subsidy orientation toward a direct transfer orientation. The idea behind this scheme is that targeting of the needy population is much more effective in the so called non monetary channels such as food for work and vulnerable group feeding The interesting outcome of this exercise is that with a cost 10 percent above the baseline level, the non monetary distribution could be increase by 34 percent, equal to half the level of current monetary distribution (see table 69). This transfer could be done without compromising price stability, and without depleting public stocks

Trade Policy



The trade policy differs from the benchmark in so far as it allows both import and export of foodgrains besides doing open market operations. Since a new policy instrument (exports) is allowed, the policy gives much better outcome, with a total cost of only Tk 2.9 billion. Noteworthy is the *incentives to export rice in the international markets*, where the quantity of export is limited to half a million tons in any season. Massive amounts of wheat are imported, giving more credibility to the swap of rice exports for wheat imports mentioned in chapter 5.

Price Band Policy



The apparent simplicity of price band rules is quite deceiving. These rules are usually very difficult to implement because they are either not feasible, or they give rise to speculative attacks with a resulting public stock, or they give rise to an exaggerated accumulation of stock with associated high costs.

In the simulation of a rigid price band policy, for example, it was found that the scheme was not feasible to support the baseline level of public distribution. For the level of baseline public distribution to be implemented within a price band scheme, further imports are necessary. By intervening in the market without the discretion coming from new information, the buffer stock manager creates the opposite result of excessive low expectations. The outcome is an accumulation of public stocks together with a very low average price. Public stock are now about 1.363 million metric tons. The price variability is not contained within the band, mainly because the policy does not allow to get rid of high public stocks. Therefore, the attempt to stabilize prices above the floor of the band is frustrated by the rule of operations of the policy. Clearly, this outcome could be avoided if the government were allowing stocks to accumulate indefinitely, but this is not possible given that public storage facilities have a limited capacity (2 million tons is the level used in the simulations). The cost of the program is also higher than in the baseline, reaching a level of Tk 26.1 billion.

Some of these undesirable outcomes may be avoided by planning a more adequate price band width and a different target price. However, the previous observations *caution against an enthusiastic support of fixed rules of operations that do not allow for a necessary degree of flexibility in reacting to new information in an efficient way*. The substance that emerges from this analysis is that price bands are a very complex policy to plan. One main criticism of price bands that should be kept in mind is that, unless the band itself is changed periodically, the buffer stock either tends to deplete to a very low level or to accumulate, at times, to an unmanageably high level. In the simulation presented here, for example, the capacity constraints are binding, since the maximum stock level of almost 2 million tons is reached.

3. APPROXIMATION POLICY

The analysis of alternative policy options should be complemented with a mention to the possibility of implementation. A policy such as the benchmark policy is very exacting computationally, and it requires frequent forecast of exogenous variables.

In this section the benchmark policy is approximated with a simpler rule. The objective is to construct a policy that can be easily related to current information, and is "close" to the optimal path.

The optimal policy is a function of all information available. The relation between the policy and the information is generally very complex. What is needed is to specify a simpler relation between the policy and a subset of all available information. The idea is to express the optimal policy as some computable function of currently available information, such as production, stocks, world prices, etc.

The method followed to obtain this approximation is to use stochastic simulation. A series of random shocks to production generates different paths of exogenous variables from which by regression analysis the coefficient of the function relating the policy to current information could be obtained.

If x_t^* is the optimal solution of a policy problem such as the one described in equations (123)-(132), the problem becomes to find a path x_t^a that approximates x_t^*. In particular, one would like to have a *feedback* policy, expressed as a function of the state variables, that behaves "similarly" to the optimal policy. An appealing approximation would be a linear rule, for its simplicity in calculation. This linear approximation can be expressed as a function of a *subset* ζ_t *of the set of state variables* z_t. The variables in ζ_t should be considered particularly useful to convey information upon which an open market operations mechanism can be based. For example, these variables could be production, losses, rainfall, imports, and lagged endogenous variables. Nevertheless, in trying to get a linear

feedback rule, the possibility that some inequality constraints may be binding has to be taken into account. Therefore, a *truncated* version of a linear rule is more likely to satisfy those constraints.

Using the notation of the general approach of Chapter 3, the control variables, x_t, have to satisfy the law of motion,

$$z_{t+1} = A_t \cdot z_t + B_t \cdot x_t$$

and the inequality constraints,

$$l_t \leq z_t \leq u_t.$$

Then the approximating policy rule is given by

$$x_t^* = \begin{cases} L \cdot \zeta_t & \text{if } l_{t+1} < A_t \cdot z_t + B_t \cdot L\zeta_t < u_{t+1}, \quad [133] \\ B_t^+ \cdot (l_{t+1} - A_t \cdot z_t) & \text{if } l_{t+1} \geq A_t \cdot z_t + B_t \cdot L\zeta_t \text{ and} \quad [134] \\ B_t^+ \cdot (u_{t+1} - A_t \cdot z_t) & \text{if } u_{t+1} \leq A_t \cdot z_t + B_t \cdot L\zeta_t \quad [135] \end{cases}$$

where B^+ is the generalized inverse of B.

The matrix L is obtained by performing a stochastic simulation of exogenous variables in ζ_t and computing the optimal policy numerically. Then the coefficients of a regression of this numerical solution over the variable in ζ_t give the vector L. Equations (133) to (135) define a truncated linear rule to take into account the inequality constraints.

The methodology as applied to approximate the benchmark has given good results. The optimal policy instruments given by open market operations and imports have been approximated by a function of rice production, wheat production, rice opening stocks, wheat opening stocks, and lagged value of the instrument under examination. If the policy instrument is denoted by $instr_t^i$ then

$$instr_t^i = f^i(q_t^r, q_t^w, stock_t^r, stock_t^w, instr_{t-1}^i). \quad [136]$$

Therefore, only production, opening stocks, and lagged values of policy are in the feedback expression.

It is remarkable that the approximate policy tracks the optimal solution quite well (Figures 22 to 26). In terms of outcome, the total cost of Tk 16.3 billion represents a saving of 5 billion Taka, or 24 percent with respect to the baseline. The average foodgrain stock level is 1014,000 tons.

4. CONCLUSIONS

This chapter concluded the third stage of the design of stock policy started in chapter 7. By presenting the structure of various policy options, it was shown that flexible use of open market operations and imports may substantially reduce costs without compromising price stability and food security. The results of the various policies are summarized in table 70. The formalization of the various stages may prove useful to guide policy in the implementation of its programs, making the process of policy design more transparent.

Table 69-Extent of transfer from monetary to non-monetary distribution

Year	Total offtakes	Monetary offtakes	Non-monetary offtakes	Number of people who could be entitled to non-monetary offtakes before the transfer	Transfer = 0.5 * monetary distribution	Transfer as a percentage of non-monetary distribution	Total non-monetary distribution	Number of people who could be entitled to non monetary offtakes after the transfer
	('000 MT)			(millions)		(percent)	('000 MT)	(millions)
1988/89	2685	1413	1272		706	56	1878	
1989/90	1981	791	1190		395	33	1585	
1990/91	2256	682	1574		341	22	1815	
Average	2307	962	1345	8.054	481	37	1828	10.934

Table 70-Average Stock, total cost, and rice price variability under various policies

	Average Total Foodgrain Stock	Total Nominal Cost	Real Cost[a]	Rice Price Variability
	(1000 Metric tons)	(Taka millions)		(percent)
Baseline[a]	1187	21401	9.88	8.48
Benchmark[b]	920	12248	5.15	3.06
Price Stabilization via open market operations[c]	1156	17638	5.36	2.86
Price Stabilization via imports[d]	909	20636	6.59	4.82
Cost Minimization[e]	645	12771	4.62	4.9
No Ration[f]	940	8161	3.85	3.35
Transfer[g]	926	23736	8.59	3.34
Trade[h]	924	2923	2.35	3.65
Approximation to the Benchmark[i]	1014	16329	5.51	4.19
Rigid Price Band[j]	1364	26390	8.44	8.46

Notes: [a] The baseline is obtained by simulating the foodgrain model for the period July 1989 to June 1991.

[b] The Benchmark Policy refers to price stabilization cum cost minimization. It uses open market operations and imports to minimize the total cost of food operations.

[c] The Price Stabilization via open market operations uses open market operations to minimize the variance of rice prices around the target.

[d] The Price Stabilization via Imports Policy uses imports to minimize the variance of rice prices around the target

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[h] The Trade Policy refers to price stabilization cum cost minimization It uses open market operations and both imports and exports to minimize the total cost of food operations

[i] The Approximation Policy is an approximation to the benchmark policy computed by stochastic simulation of production shocks.

[j] The Rigid Price Band is a fixed rule that tries to keep prices within a band, intervening through open market operations on when prices are at the ceiling or the floor of the band.

[a] Real Cost is the present value of total cost computed with deflated prices and per capita quantities.

FIG. 22: PRICE OF RICE

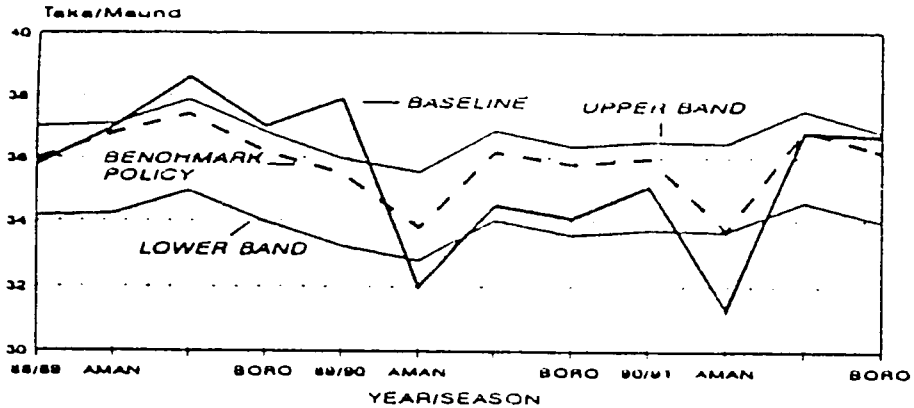

FIG 23 OPEN MARKET OPERATIONS OF RICE

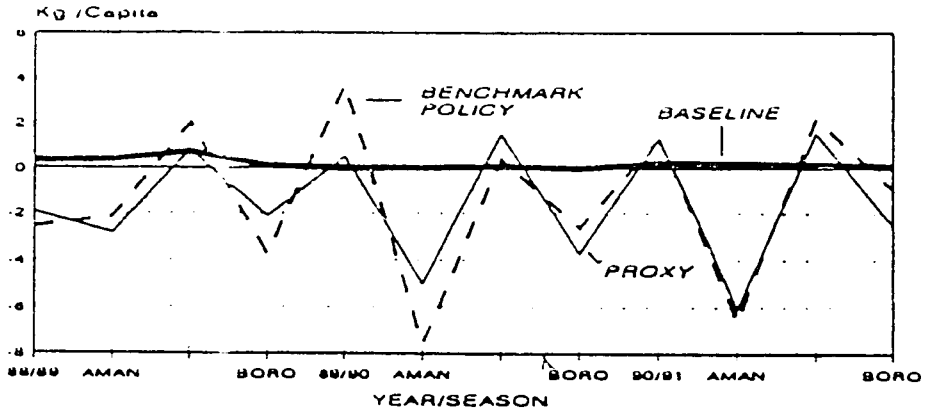

FIG. 24: OPEN MARKET OPERATIONS OF WHEAT

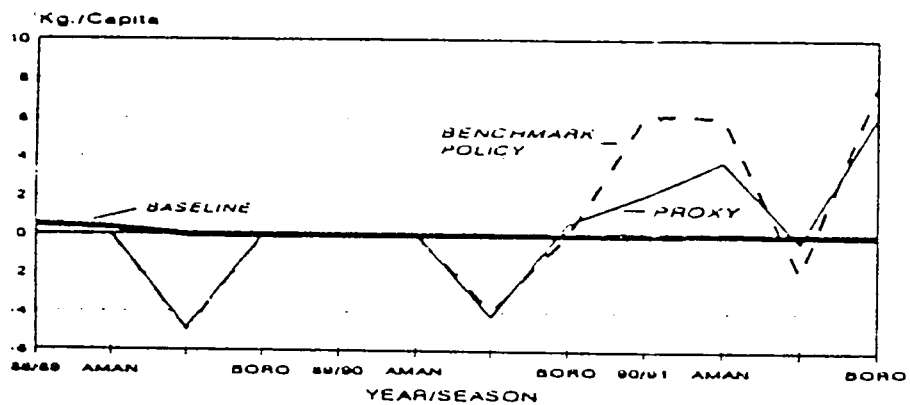

FIG. 25. IMPORTS OF RICE

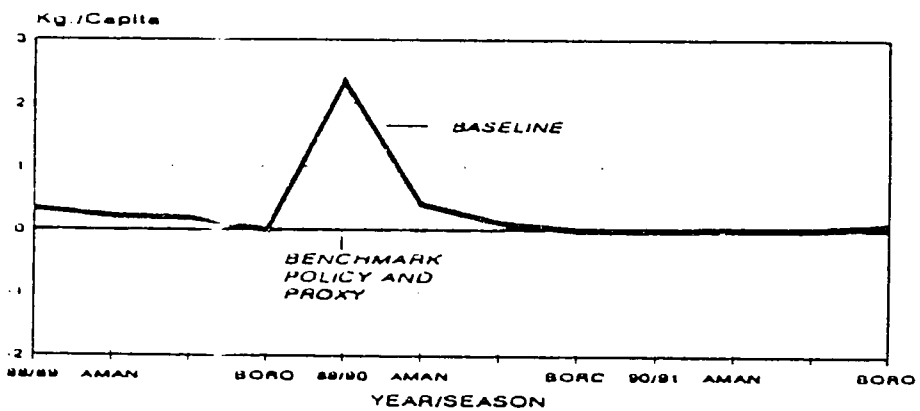
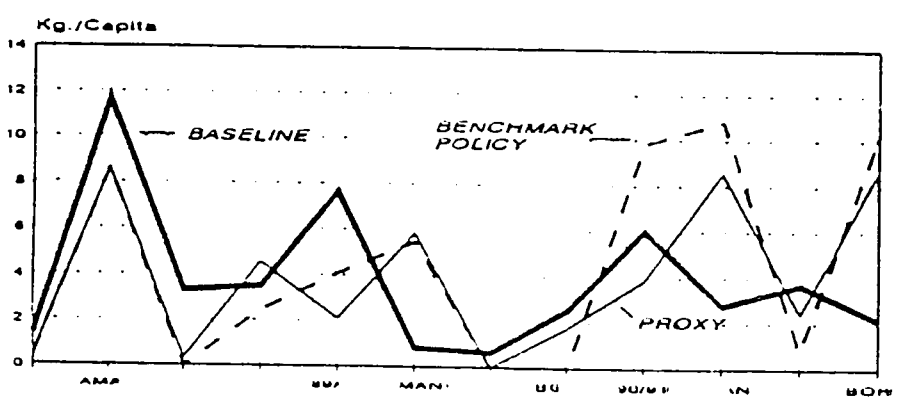
FIG. 26: IMPORTS OF WHEAT