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A DISAGGREGATED MODEL FOR STABILIZATION OF RICE PRICES IN BANGLADESH

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FOREWORD

In early 1989, the International Food Policy Research Institute entered into a contract with the U.S. Agency for International Development (USAID), Dhaka (under Contract No. 388-0027-C-00-9026-00) to conduct research on food policies and to extend technical assistance to the Ministry of Food, Government of Bangladesh. The Bangladesh Food Policy Project is the basis for a tripartite collaboration between IFPRI, the Government of Bangladesh, and USAID, Dhaka. This project consists of four subprojects and a large number of well-defined research topics. The subprojects together constitute a comprehensive approach for addressing the food policy problems of Bangladesh. The subprojects include the following studies: a price stabilization framework encompassing public and private marketing, evaluation of the effects of targeted distribution of foodgrains on consumption and nutrition, diversification of agriculture as a source of sustained growth of production, and capacity building in food policy analysis.

This paper by Quazi Shahabuddin builds on the earlier modeling exercise by Raisuddin Ahmed and Andrew Bernard (IFPRI Research Report 72) for application in the price-stabilization procedure for Bangladesh. Shahabuddin extends the earlier model, which was based on annual prices, to a disaggregated version based on monthly prices. The disaggregated model, which is more feasibly applied, enables the determination of ceiling and support price levels. The ceiling price serves as a guide for determining the release price of public grains and the support price as a guide for determining domestic procurement price for open market sale and domestic procurement of foodgrains by the government. The usefulness of a price-determining framework cannot be underrated in a system where a price-targeted mechanism is considered more desirable than the quantity-targeted management of public foodgrain operations. Currently it is argued that the existing practice of price stabilization should be replaced by an approach employing variable levy and subsidy. Even in that context, the need for a price-determining model would be greater, not lesser.

It is important therefore that modeling exercises on the food system of Bangladesh are documented and available. If the nature of policy problems changes in the future, it will not be necessary to start anew. Documents like this one will always provide a starting point.

The Bangladesh Food Policy Project is designed not only to provide advice on current policies but also to consolidate research results for future policies. Quazi Shahabuddin's study is a contribution towards this goal.

Raisuddin Ahmed

Series Editor and Project Director,
Bangladesh Food Policy Project

1. INTRODUCTION

Maintaining a stable price environment is one of the primary objectives of the Public Foodgrains Distribution System (PFDS) in Bangladesh. Proponents of traditional welfare economics often conclude that schemes to stabilize commodity prices are economically wasteful. Nevertheless, many developing economies use some type of stabilization policy to contain the instability of prices arising from shocks to the domestic supply of foodgrains. In Bangladesh, for one, management of foodgrain prices has far-reaching implications for both short-run food security and long-run economic development (Ahmed 1988). Policymakers in such economies will continue to use stabilization policies to counteract the variability of prices, particularly of primary staple foods.

This report presents the outcome of work to develop a disaggregated model for rice price stabilization in Bangladesh. The objectives of this effort are stated in the terms of agreement, which read:

> The scope of work would consist of (a) application of the price stabilization model already developed by Ahmed and Bernard (1989) and solving the reduced form of the model with a view to deriving the basis of fixation of floor and ceiling prices of rice for the next fiscal year, and (b) further development of this model taking into account more disaggregated data to reflect the seasonal factors influencing the procurement and distribution operations.

This report addresses point (b), as a report covering point (a) was submitted earlier (Shahabuddin 1989). However, this report also presents an integrated framework, based on the results of both aggregate and disaggregated models, for rice price stabilization in Bangladesh. In developing this framework, one consideration was to choose an analytical framework that could be used to reduce both the interyear and intrayear (seasonal) fluctuations in foodgrain prices in Bangladesh. The approach to price stabilization recently formulated by Ahmed and Bernard (1989) appears to fall under this category. However, theirs is an aggregate approach, using annual data to fix both annual and seasonal target prices (floor and ceiling). Since both domestic procurement and open market sales of foodgrains, the two main policy instruments at the disposal of the government for price stabilization, are essentially seasonal operations influenced by seasonal factors such as seasonal demand, market arrivals, traders' expectations of prices, and stocking decisions, a more disaggregated approach using seasonal data is required

to estimate the quantities of rice to be procured or sold to achieve price targets. Such a consistent derivation of quantity targets would not only contribute to the preparation of more realistic food budgets but would also assist in better targeting of the policy instruments for price stabilization.

There is considerable variety in the modeling being used to analyze agricultural pricing policy in developing countries. The models generally range from those covering the agricultural sector as a whole to those that use highly disaggregated data to examine particular components of a price stabilization program.[1]

Two further considerations guided the development of tne multiseason model for the stabilization of the price of rice presented here: it should afford reasonably strong predictive power and be easy for professionals at the Government's Food Planning and Monitoring Unit to operate.

The next section presents the structure of the model and describes its estimation and validation. The application of the model in stabilizing the price of rice in Bangladesh is discussed in the following section. Some concluding observations are made in the final section.

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[1] For a review of the various types of models designed for the analysis of price policy in general and those used specifically in Bangladesh, see Annex 2 in Ahmed 1988.

2. A DISAGGREGATED APPROACH

As mentioned, an aggregate model can be, and has been, used to predict market prices as well as to fix target prices. However, because both governmental procurement and open market sales are seasonal, a more disaggregated approach that considers seasonal factors is needed to estimate the amount of domestic procurement and open market sales of foodgrains required to support prices during the harvest seasons and to contain prices during the peak seasons within the ceiling fixed for price stabilization. For example, the required amount of domestic procurement of a particular crop will be dictated by, among other factors, the volume of its production and prices prevailing in the specific harvesting seasons. In addition, seasonal supply conditions and traders' expectations during the lean months and their consequent upward pressure on market prices will determine the amount of open market sales of grains needed to contain prices in such a period. A disaggregated model that distinguishes the lean from the harvesting seasons should be able to predict the amount of domestic procurement and distribution, including open market sales, needed to achieve seasonal price stabilization better than an aggregate model using annual data.

SPECIFICATION OF THE DISAGGREGATED MODEL

The following structural model was formulated for the disaggregated analysis:

$$PR_t = a_o + a_1Y_t + a_2MSR_t + a_3MSW_t + a_2PR_{t-1},$$

$$MSR_t = QR_t - QRP_t + MRD_t + OMSR_t + NRD_t,$$

$$MSW_t = QW_t - QWP_t + MWD_t + OMSW_t + NWD_t,$$

$$QRP_t = b_o + b_1QR_t + b_2QR_{t-1} + b_3PR_t + b_4PPR_t + b_5OSR_t,$$

$$QWP_t = c_o + c_1QW_t + c_2PR_t + c_3PPW_t + C_4OSW_t,$$

$$MRD_t = d_o + d_1PR_t + d_2RPR_t + d_3ZR_t,$$

$$MWD_t = e_o + e_1PR_t + e_2RPW_t + e_3ZW_t,$$

$$OMSR_t = f_o + f_1PR_t + f_2POMSR_t + f_3ZR,_t$$

$$OMSW_t = g_o + g_1PR_t + g_2POMSW_t + g_3ZW_t,$$

$$ZR_t = OSR_t + MPR_t + QRP_t,$$

$$ZW_t = OSW_t + MPW_t + QWP_t,$$

$$OSR_t = OSR_{t-1} + QRP_{t-1} + MPR_{t-1} - MRD_{t-1} - NRD_{t-1} - OMSR_{t-1}, \text{ and}$$

$$OSW_t = OSW_{t-1} + QWP_{t-1} + MPW_{t-1} - MWD_{t-1} - NWD_{t-1} - OMSW_{t-1},$$

with $a_1 > 0,\ a_2 < 0,\ a_3 < 0,\ a_4 > 0,$

$b_1 > 0,\ b_2 > 0,\ b_3 < 0,\ b_4 > 0,\ b_5 < 0,$

$c_1 > 0,\ c_2 < 0,\ c_3 > 0,\ c_4 < 0,$

$d_1 > 0,\ d_2 < 0,\ d_3 > 0,$

$e_1 > 0,\ e_2 < 0,\ e_3 > 0,$

$f_1 > 0,\ f_2 < 0,\ f_3 > 0,$

$g_1 > 0,\ g_2 < 0,\ g_3 > 0,$

where

PR_t = market price of rice,
Y_t = real income, per capita,
MSR_t = market supply of rice, per capita,
MSW_t = market supply of wheat, per capita,
QR_t = production of rice, per capita,
QW_t = production of wheat, per capita,
QRP_t = domestic procurement of rice, per capita,
QWP_t = domestic procurement of wheat, per capita,
MRD_t = ration distribution (monetized channels) of rice, per capita,
MWD_t = ration distribution (monetized channels) of wheat, per capita,
$OMSR_t$ = open market sales of rice, per capita,
$OMSW_t$ = open market sales of wheat, per capita,
NRD_t = public distribution of rice through nonmonetized channels, per capita,
NWD_t = public distribution of wheat through nonmonetized channels, per capita,

OSR_t = public opening stock of rice, per capita,
OSW_t = public opening stock of wheat, per capita,
PPR_t = procurement price of rice in real terms,
PPW_t = procurement price of wheat in real terms,
RPR_t = ration price of rice in real terms,
RPW_t = ration price of wheat in real terms,
$POMSR_t$ = open market sale price of rice in real terms,
$POMSW_t$ = open market sale price of wheat in real terms,
ZR_t = availability of rice in the government stocks, per capita,
ZW_t = availability of wheat in the government stocks, per capita,
MPR_t = import of rice, per capita, and
MPW_t = import of wheat, per capita.

The model classifies the different channels of the Public Foodgrain Distribution System (PFDS) into three major groupings: monetized ration distribution, open market sales, and nonmonetized public distribution (such as Food for Work, Vulnerable Groups Development, and Relief programs). While the first two are represented as behavioral equations in the model, the third is treated exogenously. Another distinguishing feature of the model is its separate treatment of rice and wheat. It is well known that whereas rice predominates in domestic supply (and domestic procurement) of foodgrains, wheat accounts for the lion's share of the public distribution of foodgrains. This dichotomy was resolved in modeling the rice market in Bangladesh by treating each foodgrain separately. A practical implication of this approach is that it permits the amount of domestic procurement and public distribution of rice and wheat to be projected separately, a capacity that may be useful for budgetary purposes.

The model has 13 endogenous variables and 13 equations. Therefore, it is possible to find solutions for the 13 unknowns (market price of rice [PR_t], domestic procurement of rice per capita [QRP_t], domestic procurement of wheat per capita [QWP_t], ration distribution [monetized channels] of rice per capita [MRD_t], ration distribution (monetized channels) of wheat per capita [MWD_t], open market sales of rice per capita [$OMSR_t$], open market sales of wheat per capita [$OMSW_t$], market supply of rice per capita [MSR_t], market supply of wheat per capita [MSW_t], availability of rice in the government's stocks per capita [ZR_t], availability of wheat in the government's stocks per capita [ZW_t], public opening stock of rice per capita [OSR_t], and public opening stock of wheat per capita [OSW_t]) in different seasons. Of particular interest is that seasonal domestic procurement and open market sales of rice and wheat are consistent with the price targets.

ESTIMATION OF THE EQUATIONS

The equations of the model were estimated using the two-stage least squares method, with seasonal data covering the period 1972/73 to 1987/88. The estimated equations are presented in Table 1. The nature and sources of the data used in estimating the model, especially those related to the derivation of the estimates of quarterly income and crop production, are discussed in Appendix 1; the data set is presented in Tables 9, 10 and 11 at the end of Appendix 1.

The Price Equation

All estimated coefficients of the price equation, except the market supply of wheat, gave the expected signs and were statistically significant. The fact that the coefficient of the lagged price was highly significant is evidence that expectations affect the formation of seasonal prices, but a more rigorous econometric investigation is required to detect the kind of expectation mechanism operating in the Bangladeshi rice market.

Procurement Equation: Rice

The impact of rice production (both current and lagged) on domestic procurement emerged as significant. In addition, both market price of rice and the procurement price seem to exert a substantial influence on the domestic procurement of rice. The opening stock, as expected, has a negative influence on domestic procurement, although it is not statistically significant.

Procurement Equation: Wheat

The level of domestic production of wheat has a significant influence on the procurement of wheat. None of the price variable coefficients, however, was found to be statistically significant.

The Ration Equation: Rice

The coefficients for both price variables in the ration equation gave the expected signs although only the market price coefficient was statistically significant. The offtake of rice through the rationing system was, however, significantly influenced by the amount of rice in the government's stocks available for distribution.

The Ration Equation: Wheat

The ration offtake of wheat was observed to be significantly influenced by the ration price and amount of wheat available in the government's stock for distribution. The explanatory power of the equation was quite satisfactory.

Table 1--Estimated equations of the disaggregated model, Bangladesh, 1972/73-1987/88

Equations and Variables	Estimated Coefficients	T-value	R^2	D.W.
Price equation				
Constant	7.743	2.01	0.60	1.75
Yt	0.023	2.36**		
MSR_t	-0.140	-3.49*		
MSW_t	0.144	0.59		
PR_{t-1}	0.768	6.00*		
Ration distribution equation: rice				
Constant	-1.297	-1.18	0.42	1.66
PR_t	0.046	1.64***		
RPR_t	-0.023	-1.13		
ZR_t	0.329	4.53*		
Ration distribution equation: wheat				
Constant	2.774	1.82	0.67	1.88
PR_t	-0.008	-0.19		
RPW_t	-0.201	-3.49*		
ZW_t	0.406	7.34*		
Domestic procurement equation: rice				
Constant	5.630	2.34	0.52	1.96
QR	0.014	1.82***		
QR_{t-1}	0.014	1.99**		
PR_t	-0.216	-3.01*		
PPR_t	0.081	1.88***		
OSR_t	-0.315	-1.55		
D_1	2.330	0.93		
Domestic procurement equation: wheat				
Constant	-0.158	-0.23	0.49	1.95
QW_t	0.085	5.08*		
PR_t	-0.001	-0.05		
PPW_t	0.009	0.14		
OSW_t	0.011	0.30		
Open market sales equation: Rice				
Constant	-1.194	-2.05	0.34	1.99
PR_t	0.039	2.45**		
$POMSR_t$	-0.007	-.72		
ZR_t	0.048	1.22		
Open market sales equation: Wheat				
Constant	-0.164	-0.35	0.40	1.32
PR_t	0.018	0.89		
$POMSW_t$	-0.044	-0.40		
ZW_t	0.071	2.57**		
D_2	0.432	0.86		

(continued)

Table 1, continued

Source: Author's calculations.

Notes:
- Y_t = Real income per capita,
- MSR_t = Market supply of rice per capita,
- MSW_t = Market supply of wheat per capita,
- PR_t = Market price of rice,
- RPR_t = Ration price of rice in real terms,
- ZR_t = Availability of rice in the government's stocks,
- RPW_t = Ration price of wheat in real terms,
- ZW_t = Availability of wheat in the government's stocks,
- QR = Production of rice per capita,
- PPR = Procurement price of rice in real terms,
- OSR = Public opening stock of rice per capita,
- QW = Production of wheat per capita,
- PPW_t = Procurement of wheat per capita,
- OSW = Public opening stock of rice per capita,
- $POMSR_t$ = Open market sale price of rice in real terms, and
- $POMSW_t$ = Open market sale price of wheat in real terms.

* Significant at the 1 percent level
** Significant at the 5 percent level
*** Significant at the 10 percent level

Open Market Sale Equation: Rice

The market price of rice seemed to influence significantly the offtake of rice through open market sales. The coefficients of the open market sale price and of the availability of government stocks had the expected signs, although they were not statistically significant.

Open Market Sale Equation: Wheat

All the explanatory variables in the estimated equation for open market sales of wheat had coefficients with the expected signs, although only the coefficient for the availability of government stocks was statistically significant. The overall fit of the equation as reflected in the low value of R^2 was also poor.

PREDICTIVE PERFORMANCE OF THE MODEL

In the previous section, each of the estimated equations was evaluated separately. However, it is also important to look at the performance of the model as a whole, as the good fit of the individual equations does not ensure that the whole model will reproduce historical outcomes when simulated with historical data. The model was evaluated for its overall predictive performance by inserting the actual values of

the exogenous variables in each year in the estimated equations and then solving for the endogenous variables in a simultaneous manner, using a computer program.

The predicted values of the seasonal prices and other endogenous variables of the system (such as the distribution of ration rice and wheat, the domestic procurement of rice and wheat, and the open market sales of rice and wheat) are compared with their actual values in Figures 1 through 7. It is readily observed that although the model predicts seasonal prices well, its performance with respect to the quantity variables is not so satisfactory. This difference is also reflected in the computed Theil inequality coefficients presented in Table 2.

Table 2 also shows some, although not much, seasonal variability in the predictive performance for the price, ration distribution, and open market sales of rice. The seasonal variability was quite pronounced for the ration distribution of wheat, domestic procurement of both rice and wheat, and open market sales of wheat. The model performs quite poorly in predicting the domestic procurement of rice, an outcome that is not surprising in view of the various nonprice factors that influence government procurement, such as farmers' access to purchasing centers and the financial resources of the procurement agency.

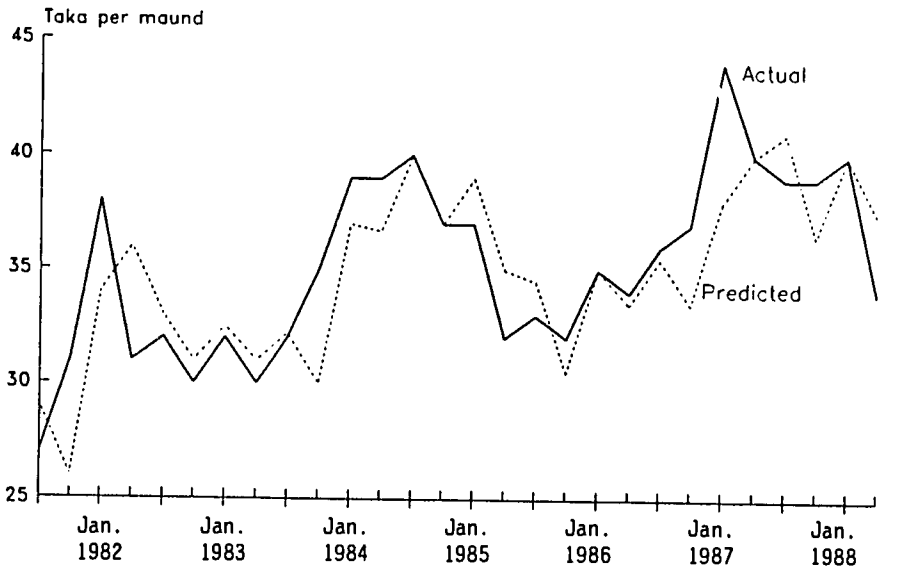
Table 2--Computed Theil inequality coefficients for different variables

	Theil Inequality Coefficient				
		Seasons			
Variables	Overall	I	II	III	IV
Price (PR_t)	0.36	0.024	0.043	0.038	0.035
Ration distribution of rice (MRD_t)	0.223	0.237	0.163	0.283	0.254
Ration distribution of wheat (MWD_t)	0.189	0.110	0.191	0.296	0.320
Domestic procurement of rice (QRP_t)	0.479	0.543	0.359	--	0.681
Domestic procurement of wheat (QWP_t)	0.298	0.482	--	0.303	0.263
Open market sales of rice ($OMSR_t$)	0.349	0.347	0.396	0.351	0.347
Open market sales of wheat ($OMSW_t$)	0.355	0.321	0.385	0.681	0.591

Source: Author's calculations.

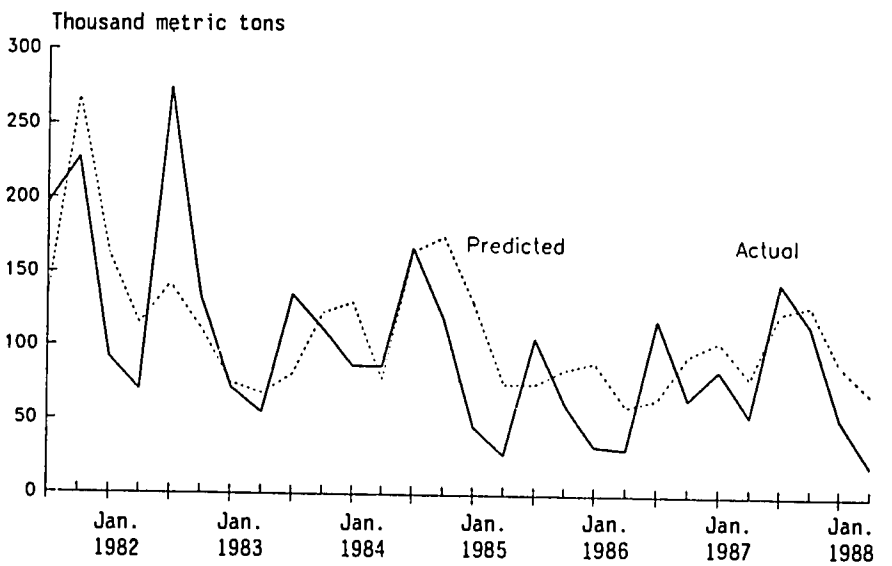
Note: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

Figure 1--Actual and predicted seasonal rice prices (in real terms)



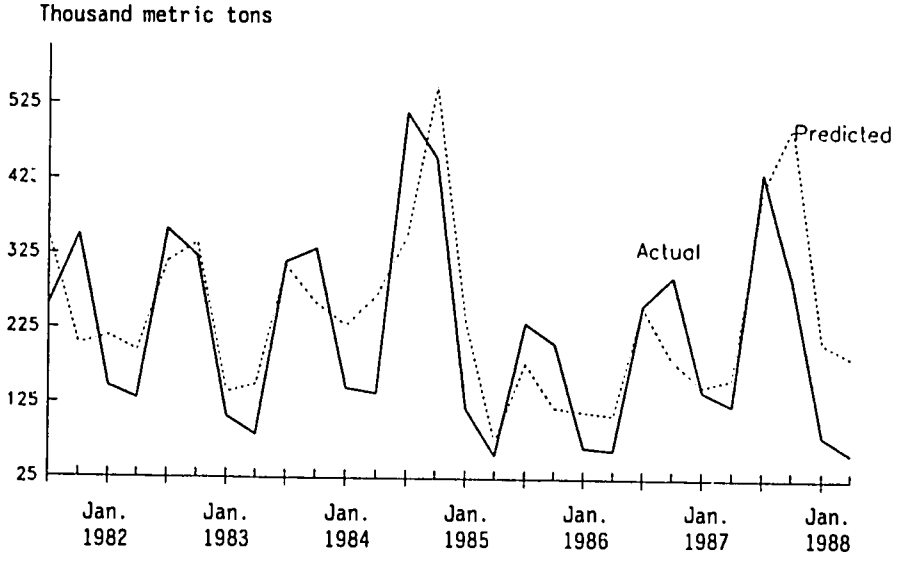
Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

Figure 2--Actual and predicted values of the ration (monetized) distribution of rice



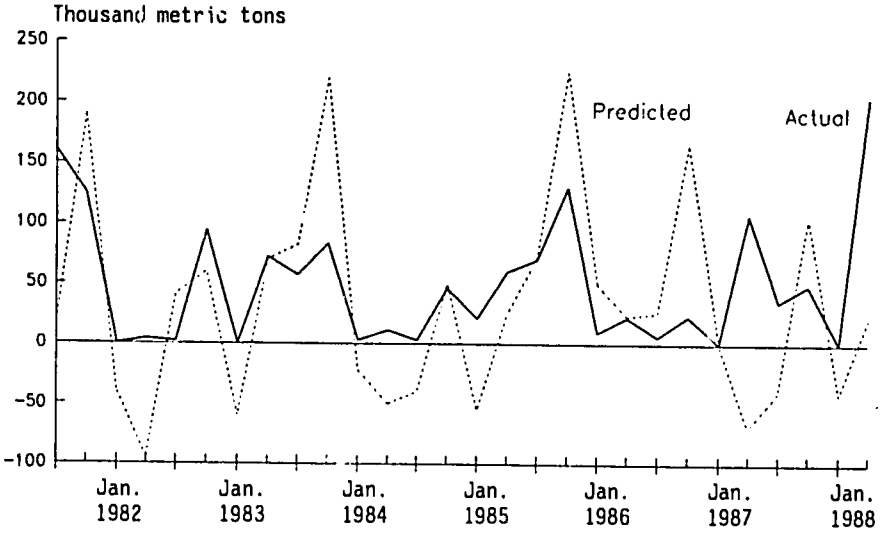
Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

Figure 3--Actual and predicted values of the ration (monetized) distribution of wheat



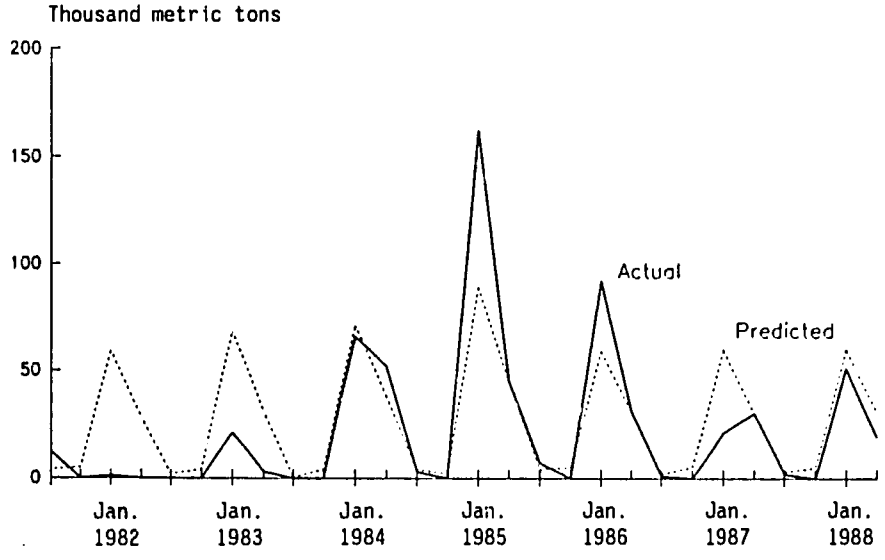
Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

Figure 4--Actual and predicted values of the domestic procurement of rice



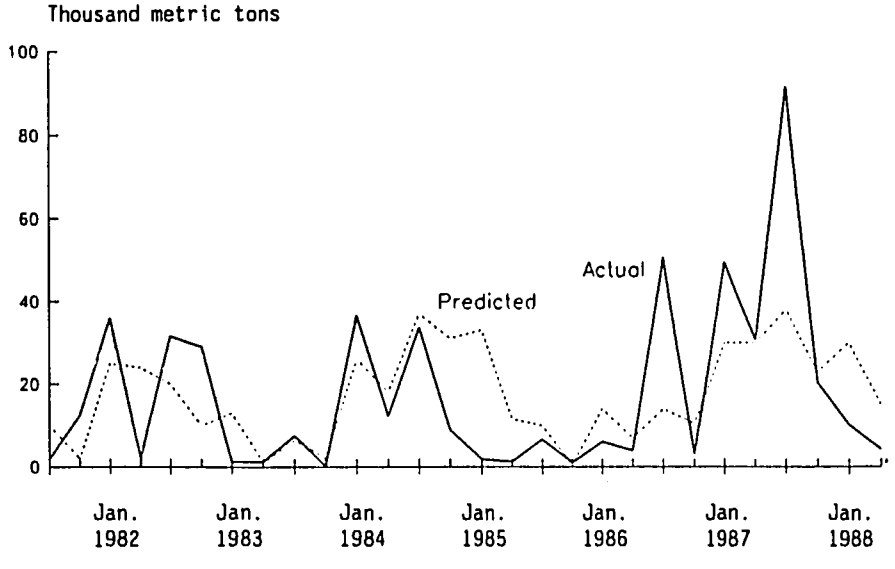
Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

Figure 5--Actual and predicted values of the domestic procurement of wheat



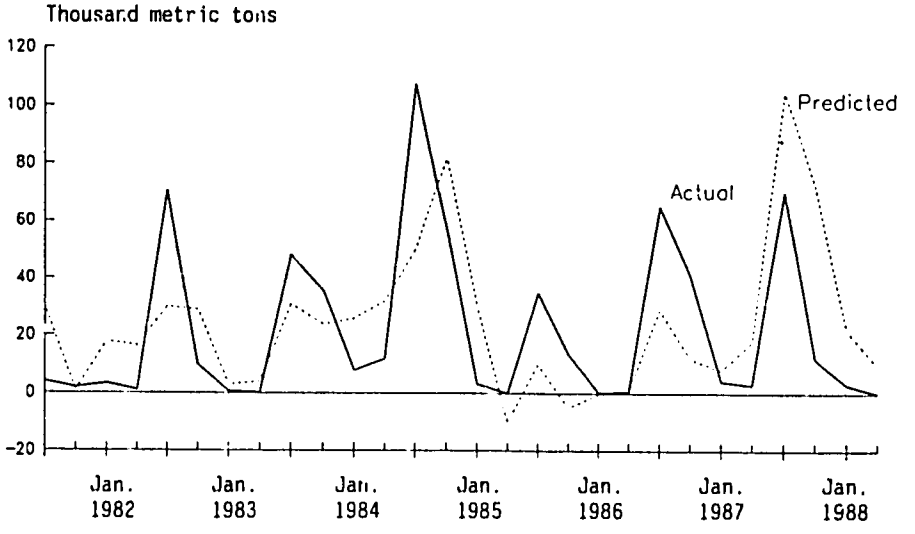
Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

Figure 6--Actual and predicted values of the open market sales of rice



Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

Figure 7--Actual and predicted values of the open market sales of wheat



Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

3. APPLICATION OF THE MODEL

The exercise is built on the analysis of rice price stabilization carried out by Ahmed and Bernard (1989). The target prices, both annual and seasonal, were derived following the Ahmed-Bernard approach. However, the targeted quantities were estimated in a manner consistent with the disaggregated model, which takes seasonal factors explicitly into account. In particular, the implications for the policy instruments associated with the two principal modes of stabilization, domestic procurement and open market sales of foodgrain, were analyzed on a seasonal basis.

FIXING OF TARGET PRICES FOR 1989/90

Following the four-step procedure suggested by Ahmed and Bernard (1989), the target annual as well as floor and ceiling prices were derived for 1989/90. The results are summarized in Table 3. (The application of the procedure in deriving the set of target prices is elaborated in Appendix 2.)

Table 3--Projected annual target, floor, and ceiling prices of rice, 1989/90

	Prices
	Taka per maund
Annual target price	373
Floor (procurement) price	345
Ceiling (open market sales) price	401
World price[a]	386
Cost of production[b]	
High-yielding variety aman	234
High-yielding variety boro	272

Source: Author's calculations.

[a] Estimated as the World Bank projected 1990 world price of rice of US$250 per metric ton plus US$20 shipping plus 12 percent transportation cost at the wholesale border and official exchange rates.

[b] For the derivation of the cost of production figures for high-yielding varieties of aman and boro rice, see Quazi Shahabuddin, "Pricing of Public Foodgrains in Bangladesh: Some Tentative Suggestions for 1989-90" (paper prepared for the IFPRI Food Policy Project in Bangladesh, Washington, D.C. 1989).

Fixing the procurement price of rice at taka (Tk) 345 per maund (md) for 1989/90 means an increase of about 7 percent over what prevailed in 1988/89. (One maund is equal to 37.3 kilograms.) A comparison of the procurement price with the domestic cost of production indicates that this price would provide a considerable incentive to farmers, as the difference between the procurement price and the cost of production of both high-yielding variety aman and boro is quite large. However, the cost of cultivation does not include the opportunity cost of the land.

Under the current pricing mechanism (based on Title III of Public Law 480), open market sale and ration prices are linked to the procurement price in a fixed manner. Therefore if the procurement price is inappropriate, it will create problems with the open market sales and ration distribution. At present, it is believed that the procurement price is one of the sources of the current anomalies or operational complications with the open market sales and ration price, as it does not appear to bear a consistent relation with the market price. If there is a substantial difference between the procurement price and the market price, it may either cause instability in the government's budget or render the procurement program ineffective. Price stabilization involves the containment of both interyear and intrayear (seasonal) price fluctuations, and when the procurement price is fixed both must be taken into consideration. In fact, the procurement price should be based on the following considerations: expected condition of the crop, market price regime, cost of production, and world prices (Ahmed 1988). The approach used here to fix the procurement (floor) and subsequently the ceiling (open market sale) prices for 1989/90 is based on these considerations.[2]

ESTIMATION OF THE TARGETED PROCUREMENT AND DISTRIBUTION FOR 1989/90

The principal policy instruments at the disposal of the government to combat the seasonal fluctuations in prices are domestic procurement in the harvest seasons and open market sales of foodgrains in the lean seasons. The multiseason model estimated with disaggregated data can be used to project the required amounts of domestic procurement and distribution in the different seasons consistent with the price targets fixed earlier.[3] A summary of the results is presented in Table 4.

Table 4 shows that the total domestic procurement of rice required to support a harvest season price of Tk 345 per md is 430,000 metric tons. (All tons in this report are metric tons.) The distribution of this procurement by season reveals an interesting pattern. Most of the procurement takes place in season II (230,000 tons) and season IV

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[2] For a detailed discussion of this theme, see the report on the IFPRI Food Policy Project in Bangladesh of May 10, 1990.

[3] The reduced form matrix of the model used to solve the model is presented in Appendix 3.

(110,000 tons), which represent the aman and boro harvests, respectively, and is accompanied by seasonal dips in prices. The procurement of 37,000 tons of rice would also help support the harvest prices in July and August, which are included in season I. The season III procurement of 70,000 tons represents lagged procurement from the aman harvest, which occurred in the previous season. The procurement of the total aman harvest thus amounts to 300,000 tons. The domestic procurement of wheat, as expected, takes place mostly in seasons III and IV, which correspond roughly to the harvesting seasons of wheat.

There is almost no seasonality in the ration (monetized) distribution of foodgrains. The offtake of both rice and wheat is more or less uniformly distributed over the different seasons. The effectiveness of ration rice and the offtake of wheat as instruments to stabilize seasonal prices therefore appears to be somewhat weak. The main stated objective of the statutory and modified rationing program is to provide subsidized foodgrains to the urban and rural poor. Thus, the price stabilization effect is not of primary concern for the policymakers. It may be noted, however, that the offtake of rice and wheat together accounts for about 60 percent of the total PFDS distribution and about 7 percent of the total market supply of foodgrains, a level that definitely has an overall cushioning effect on the market prices for rice in Bangladesh.

Table 4--Projected domestic procurement, ration offtake, and open market sales of foodgrains by seasons, 1989/90, base scenario

	Seasons				
	I	II	III	IV	Total
	(1,000 metric tons)				
Domestic procurement of rice (QRP_t)	37	230	70	101	438
Domestic procurement of wheat (QRW_t)	6	8	63	36	113
Ration distribution of rice (monetized) (MRD_t)	52	71	72	59	254
Ration distribution of wheat (monetized) (MWD_t)	189	225	107	145	666
Open market sales of rice ($OMSR_t$)	21	7	17	6	51
Open market sales of wheat ($OMSW_t$)	69	16	2	3	90

Source: Author's calculations.

Notes: The values of exogenous variables assumed in the model to project these quantities of domestic procurement and distribution are shown in Appendix 4.

I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

The open market sales of rice display pronounced seasonality: they are confined mostly to season I (which includes the lean months of September and October) and season III (March and April), which are both characterized by seasonal peak prices. The total amount of open market sales is, however, rather low. This pattern is not surprising given that with a bumper aman harvest, 1989/90 was an exceptionally good crop year, reducing the need for government intervention to arrest the rise in prices, although some seasonality even in a good crop year cannot be ruled out.

It is interesting to look at the seasonal prices and opening stocks of foodgrains that are most likely to prevail once the price stabilization program is put into operation. These are shown in Table 5. It is readily observed from Table 5 that the predicted seasonal prices follow a distinct seasonal pattern of high prices in the lean seasons (I and III) and low prices in the harvesting seasons (II and IV). In addition, they are reasonably consistent with the target floor and ceiling prices of Tk 345 per md and Tk 401 per md, as fixed earlier. The weighted average of the seasonal prices of Tk 354 per md falls short, however, of the target annual price of Tk 373 per md.

Table 5 also shows that the level of the opening stock of foodgrains in the different seasons is consistent with the price stabilization program. The opening stock hardly displays any seasonal variations (except in season IV) with an average level of around 1 million tons for 1989/90, of which the shares of wheat and rice are 70 percent and 30 percent respectively. This result, however, does little to highlight the issues associated with maintaining or estimating the optimal foodgrain stock in Bangladesh, for which a separate study under the IFPRI Food Policy Project is under way.

Table 5--Seasonal rice prices and opening stock of foodgrains

	Seasons				
	I	II	III	IV	Average
Seasonal rice price (taka/maund)	392	342	371	345	354
Opening stock (1,000 metric tons)					
Rice	269	210	329	300	277
Wheat	669	746	660	780	714
Total	938	956	989	1,080	991

Source: Author's calculations.

Note: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

ALTERNATIVE SCENARIO

An alternative scenario was simulated to demonstrate how the model would perform in a "bad" crop year.[4] In particular, it addressed what volume of (monetized) ration distribution, domestic procurement, and open market sales of grains would have been consistent with the price stabilization policy had the domestic production of rice been 15 million tons instead of the 18.5 million tons expected in 1989/90.[5] The results are presented in Table 6.

It is readily observed that under the alternative scenario the total domestic procurement of rice is about 200,000 tons as compared with the 450,000 tons required earlier (base scenario) to support the harvest prices in 1989/90. The open market sales of grains, on the other hand, register sharp increases, as expected, going from about 150,000 tons to about 300,000 tons. The monetized ration offtake also picks up considerably--by about 700,000 tons--augmenting market supplies and thereby cushioning the shock of the shortfall in domestic production in a bad crop year.

Table 6--Projected domestic procurement, ration offtake, and open market sales of foodgrains by season, 1989-90, alternative scenario

	Seasons				
	I	II	III	IV	Total
	(1,000 metric tons)				
Domestic procurement of rice (QRP_t)	35	132	7	--	174
Domestic procurement of wheat (QWP_t)	8	12	68	40	128
Ration distribution of rice (monetized) (MRD_t)	105	138	124	96	463
Ration Distribution of wheat (monetized) (MWD_t)	276	387	200	230	1,093
Open market sales of rice ($OMSR_t$)	31	25	31	20	107
Open market sales of wheat ($OMSW_t$)	84	48	20	21	173

Source: Author's calculations.

Note: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

[4] The set of exogenous variables assumed for the alternative scenario is presented in Appendix 4.

[5] Because of a severe shortfall in production, both the annual and seasonal prices for new targets were set (ceiling and floor) for this scenario using the Ahmed-Bernard approach discussed earlier (for details see Appendix 2).

The seasonal prices and opening stocks of foodgrains for the alternative scenario are shown in Table 7. Whereas prices in the harvest seasons (II and IV) are mostly consistent with the target floor price (Tk 375 per md) prices in the lean seasons (I and III) are way below the price earlier fixed as the ceiling (Tk 435 per md). As a result the average annual price also falls far short of what was targeted for this scenario (Tk 405 per md). In a bad crop year, the price expectations and stocking decisions of traders play a prominent role, particularly during the lean seasons.[6] A failure explicitly to incorporate such factors in this model may have been partly responsible for its poor predictive performance in a bad crop year, especially during the lean season.

SEASONAL ELASTICITIES: A DIGRESSION

It is sometimes useful to look at the magnitudes of the elasticities, as they tend to capture the underlying relations between prices and quantities in a straightforward way. These are presented in Table 8. From the point of view of price stabilization, the elasticity of the market price with respect to the market supply of rice is an important indicator, because it shows the degree of government intervention through open market sales and domestic procurement of grains during the lean and harvest seasons, respectively. This elasticity is observed to be -1.04 in the pre-aman season (I) and -2.25 in the aman harvest season (II). The implication is that whereas an augmentation of the market supply by 1 percent, presumably through open market sales of grains, would lower the market price by about 1 percent in the lean seasons, the diversion of market supplies through public procurement of 1 percent would increase the market price by more than 2 percent in the harvest seasons. Thus, the intensity of government intervention in bringing about given changes in prices has to be much greater in the lean seasons as compared with the harvest seasons. The average seasonal elasticity is computed to be -1.02, which is much lower than the -1.94 based on parameters estimated with annual data by Ahmed and Bernard.

The responsiveness of public procurement of rice to changes in domestic production seems low, as reflected in the average seasonal elasticity of 0.67. There is some seasonal variation in the estimate, ranging from 0.56 in the aman season to 0.93 in the boro season.[7] It seems that public procurement is influenced more by the market price than by the procurement price, given the average seasonal elasticities

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[6] This point is well-documented in the literature dealing with traders' anticipatory price behavior. For a discussion on these in the context of seasonal variation in rice prices in Indonesia and the Philippines see Goldman (1974) and Bouis (1983).

[7] Boro harvests thus seem to offer greater potential for public procurement than do aman harvests, at least from the point of view of production.

Table 7--Seasonal rice prices and opening stock of foodgrains, alternative scenario

	Seasons				
	I	II	III	IV	Average
Seasonal rice price (taka per maund)	400	369	392	371	377
Opening stock (1,000 metric tons)					
Rice	269	318	425	382	348
Wheat	669	934	901	998	876
Total	938	1,252	1,326	1,380	1,224

Source: Author's calculations.

Note: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

Table 8--Seasonal elasticities of some selected variables

Elasticities	Seasonal Values				Average Value
	I	II	III	IV	
Elasticity of the market price with respect to the market supply of rice	-1.04	-2.25	-0.11	-0.79	-1.02
Elasticity of the market price with respect to income	1.17	1.56	0.32	0.46	0.91
Elasticity of domestic rice procurement with respect to production	1.00	0.56	0.26	0.93	0.67
Elasticity of domestic rice procurement with respect to the market price of rice	-13.50	-3.93	-36.00	-16.61	-9.39
Elasticity of domestic rice procurement with respect to the procurement price of rice	4.05	1.14	11.57	5.06	2.89
Elasticity of open market sales of rice with respect to market price of rice	3.90	13.00	6.50	19.50	7.80
Elasticity of open market sales of rice with respect to the open market sales price of rice	-0.70	-2.30	-1.00	-2.80	-1.17
Elasticity of open market sales of wheat with respect to the market price of rice	1.00	2.25	20.0	25.7	2.57
Elasticity of open market sales of wheat with respect to the open market sales price of wheat	-1.29	-3.14	-22.0	-44.0	-3.38

Source: Author's calculations.

Note: No adjustments have been made for the unequal duration of the different seasons as defined in this exercise.

I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

of -9.4 and 2.9, respectively. An increase in the market price of 1 percent would lead to a decrease in public procurement by about 9 percent, whereas an increase in the procurement price by 1 percent is likely to raise public procurement by about 3 percent.

Open market sales of rice seem to be responsive to changes in the market price, with an average seasonal elasticity of 7.8; the implication is that a 1 percent increase in the market price would lead to about an 8 percent increase in open market sales. The magnitude of this elasticity is observed to be lower in the pre-aman season (3.9) as compared with the pre-boro season (6.5).[8] The open market sale of rice, on the other hand, is observed to be much less responsive to changes in the open market sale price, with an average seasonal value of only -1.2.

This asymmetry of response is not as pronounced in the case of open market sales of wheat, with an average seasonal elasticity of 2.6 and -3.4 for market price and open market sales price, respectively. Viewed from a different angle, the open market sales of rice are much more responsive to changes in the market price than the open market sales of wheat. An increase in the open market sale price, on the other hand, is likely to have a greater negative impact on open market sales of wheat than of rice. Thus the success of open market sales as an instrument of price stabilization in the lean season also depends on the composition of the offtake.

In general, the magnitude of the estimated seasonal price elasticities (with values greater than one) of both domestic procurement and open market sales indicates that these public operations are quite responsive to changes in prices, a pattern that augurs well for the success of any price stabilization program in Bangladesh.

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[8] Open market sales thus seem to have greater potential in the pre-boro season (III) than in the pre-Aman season (I), at least from the demand side.

4. CONCLUDING OBSERVATIONS

The case for government intervention to stabilize the price of rice rests on some structural features of the Bangladesh foodgrain market.[9] The low price elasticities of demand and supply, the high elasticity of the marketable surplus of rice with respect to production, the random shocks to production emanating from natural factors, and, finally, excessive speculation by private traders even in a competitive market in the periods preceding severe shortages (perceived and not necessarily real) all contribute to the pronounced instability in rice prices in Bangladesh.

Bangladesh has been using several public policy instruments to achieve the objectives of PFDS, such as imports of foodgrains to meet the shortfall in domestic production, maintenance of stocks, open market sales of grains, and domestic procurement of rice. In formulating these policies, however, the government has not followed a consistent framework that involves setting a target price range that would achieve stabilization and ascertaining the concomitant requirements of imports, stocks, and quantities to be sold in the lean seasons and procured in the harvest seasons. As a result, the system has been largely ineffective in maintaining the stability of market prices.[10]

This study contributes to the development of a consistent framework for stabilizing prices in Bangladesh. It involves a shift from the current practice of quantity planning to that of price-based planning of the food system. This change does not mean abandoning the quantity targets. In fact, it allows the quantity targets to be derived from the price targets with some consistency. It is also emphasized here that, although the primary focus of this study was to develop a disaggregated model for price stabilization, that model still builds on the analysis of Ahmed and Bernard (1989) by suggesting an integrated framework wherein quantity targets are derived in a consistent fashion from the targeted floor and ceiling prices.

The scope for further refinement of the model's structure by incorporating variables or specifications to account for such factors as traders' expectations of prices and stocking decisions is recognized. However, such a refinement may unduly complicate the model's structure, and season-specific data limitations could make it very difficult to put this kind of modeling exercise into practice. Moreover, an important

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[9] For a detailed discussion on this point see Ahmed (1990).

[10] Between 1976/77 and 1984/85, the annual prices showed variations of -17.3 percent to 41.3 percent, while seasonal prices varied from a low of 13.8 percent in 1980/81 to a high of 37.8 percent in the following years (Ahmed and Bernard 1989).

point is that the development of a model for price stabilization designed to improve food policy planning in the Food Planning and Monitoring Unit should be guided by the need for operational simplicity, albeit without unduly sacrificing predictive power.

In this study disaggregation was defined on a seasonal basis, and not spatially. This approach was prompted by the findings in the Ahmed and Bernard (1989) study indicating that the Bangladeshi rice markets are not segmented, a condition that implies that price analysis at the aggregate level is valid. At the same time, it should be recognized that even though the markets are not segmented, the degree of integration (the extent and rapidity with which price signals are transmitted from one market to another) is low at some market locations and at certain times of the year. For that reason the government cannot be sure that procurement or open market sales in only a few centers will automatically influence prices in all markets.[11]

No attempt was made here to estimate the costs and benefits associated with the suggested price stabilization program. Given that the measurement of benefits, particularly economy-wide and intangible ones, is difficult, the degree of price stability representing the quantum of benefits to society may be accepted. The problem then becomes one of ascertaining how the social cost can be minimized to achieve this objective. Minimization of that cost requires keeping an optimal stock of foodgrains and maintaining very efficient operations (Ahmed 1990).

Finally, it should be emphasized that although the fixing of target prices and projection of quantities through a modeling exercise introduces some realism and rationality into food policy planning, erratic behavior by factors that are difficult to identify do influence seasonal prices. Some degree of flexibility in both the procurement and open market sales programs is necessary to counter these erratic factors, which derive from, for example, stock decisions of private traders or sudden spurts in public expenditures. These deviations may cause prices in the harvest seasons in turn to deviate from normal patterns.

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[11] The Ahmed and Bernard (1989) study identifies, on the basis of their analysis of intermarket links and regional prices, the regions where greater than normal efforts may be required for successful procurement in different seasons.

APPENDIX 1: NATURE AND SOURCES OF THE DATA

This appendix briefly discusses the nature and sources of the data used in the model. (The data set is presented at the end of this Appendix in Tables 9, 10, and 11.) The data related to the monthly distribution by categories under the PFDS were collected from the Food Planning and Monitoring Unit, Ministry of Food, for the period 1972/73 to 1987/88. Those data were converted into seasonal figures corresponding to the different seasons:

Season I: July-October
Season II: November-February
Season III: March-April
Season IV: May-June

This way of defining the seasons conflicts somewhat with the ideal basis for defining the seasons, corresponding to seasonal price shifts, presented below:

		Seasonal Indexes of Monthly Prices
Season I:	September-October (pre-aman)	102.50, 103.81
Season II:	November-February (aman)	96.65, 91.31, 95.6, 99.44
Season III:	March-April (pre-boro)	104.73, 108.40
Season IV:	May-August (boro/aus)	101.26, 98.45, 99.0, 98.57

The latter approach to defining the seasons captures the two lean seasons (I and III), which are characterized by peak seasonal prices, and the two harvest seasons (II and IV), which are characterized by seasonal troughs in prices. However, since season IV cuts across a fiscal year, the months in seasons I and IV had to be adjusted to conform to the availability of data, as well as to facilitate presentation of the results by fiscal year.

The procurement and issue prices for both rice and wheat, with the effective dates for the different periods, were collected from Bangladesh Bureau of Statistics (BBS) Statistical Yearbooks, from Food Situation Reports published by Food Planning and Monitoring Unit, and from other sources at the Ministry of Food. These were distributed over

the different seasons using the effective dates for each price. Data on the monthly price of rice (coarse, wholesale variety) were compiled from the Directorate of Marketing, Government of Bangladesh. All these nominal prices were deflated by the indexes of the prices of manufactured consumer goods to convert them into real prices.

Data on foodgrain production, both rice and wheat and by variety, as well on income (GNP at constant 1972/73 prices) were available from the Bangladesh Bureau of Statistics Statistical Yearbooks annually by fiscal year (July-June). These data were converted into seasonal figures by the following procedure.

Estimates of the quantities of rice harvested each month were derived on the basis of the historical percentages of crops harvested each month in the World Bank study on food policy issues in Bangladesh (World Bank 1979). It gave the following monthly percentages for the three rice crops, aus, aman, and boro:

July	35 percent of aus	January	5 percent of aman
August	55 percent of aus	February	no harvest
September	10 percent of aus	March	no harvest
October	3 percent of aman	April	10 percent of boro
November	50 percent of aman	May	65 percent of boro
December	42 percent of aman	June	25 percent of boro

These monthly percentages were then applied to the yearly production of aus, aman, and boro rice as published in the Bangladesh Bureau of Statistics Statistical Yearbooks to derive estimates of the rice harvested each month, which were then distributed over different seasons as defined earlier. For wheat, the harvest season was identified as the months of March, April, and May, each of which was assumed to account for one-third.

These monthly percentages of crops harvested provide the following seasonal shares (as defined in this paper) for the different rice crops harvested in Bangladesh:

Season I	100 percent of aus plus 3 percent of aman
Season II	97 percent of aman
Season III	10 percent of boro
Season Iv	90 percent of boro

Alternatively, the following pattern of seasons for harvesting the major rice crops by variety could have been used to capture the recent changes in the harvesting period induced by the dissemination of high-yielding variety technology:

Local aus	July-August
High-yielding variety aus	August-September
Local transplant aman	December-January
Local broadcast aman	November-December
High-yielding variety aman	January-February
Local boro	April-May
High-yielding variety boro	June-July

With this information, the data on yearly production of rice available from Bangladesh Bureau of Statistic by different crop variety could be distributed over the different seasons as follows:

Season I	100 percent aus (local and high-yielding variety plus 50 percent of high-yielding variety boro)
Season II	100 percent of aman (local and high-yielding variety)
Season III	50 percent of local boro
Season IV	50 percent of local boro plus 50 percent of high-yielding variety boro

The annual figures on GNP (at constant 1972/73 prices) collected from the Bangladesh Bureau of Statistics Statistical Yearbooks were distributed over the different seasons in the following way. It was assumed that income originating from agriculture was proportional to the seasonal production of rice, while nonagricultural income could be distributed uniformly over the different seasons, since there is hardly any basis for deriving its seasonal shares. In other words,

$$Y_{it} = m_{it}a_tY_t + (n_i/12)(1 - a_t)\ Y_t,$$

where

Y_{it} = seasonal income i in year t,
m_{it} = seasonal share of rice in total production in year t,
Y_t = annual GNP at constant 1972/73 price,
a_t = share of the agricultural sector in total GNP, and
n_i = number of months in season i.

Table 9--Selected variables of the data set for the disaggregated model: public market operations

Year	Season	MRD	OMSR	NRD	MWD	OMSW	NWD	QRP	MPR	QWP	MPW
		Variables									
		(1,000 metric tons)									
1972/73	I	238.170	4.315	12.810	786.204	0	101.731	0	239.846	0	859.789
	II	119.933	0.040	1.222	478.887	0	55.468	0	118.907	0	651.448
	III	26.950	0	0.007	344.292	0	16.744	0	37.603	0	653.480
	IV	25.477	0	0.004	426.385	0	22.495	0	0	0	309.971
1973/74	I	30.312	0	0	613.518	0	28.245	0	83.336	0	744.947
	II	47.108	0	0	463.218	0	14.187	72.157	0	0	272.368
	III	24.139	0	0.0030	242.858	0	5.489	0	0	0	254.075
	IV	23.745	0	0.0030	257.550	0	5.405	0	0	0	363.835
1974/75	I	44.029	0	1.249	579.869	0	58.669	0	35.570	0	587.421
	II	32.298	0	1.878	466.403	0	58.227	100.613	39.635	0	645.350
	III	50.406	0	0.164	201.906	0	23.861	0	63.010	0	280.498
	IV	52.145	0	0.334	194.802	0	19.158	28.546	132.119	0	616.894
1975/76	I	183.942	0	0.079	529.812	0	20.878	38.619	172.771	0	519.329
	II	169.364	0	1.227	319.915	0	61.092	463.432	155.493	0	423.797
	III	65.921	0	3.023	56.778	0	93.813	1.016	14.228	0	17.277
	IV	76.910	10.347	1.244	52.026	0.987	42.991	0	51.831	0	133.135
1976/77	I	213.917	21.432	0.874	174.161	7.875	30.816	8.130	76.222	0	131.102
	II	198.964	10.834	0.218	153.163	10.279	67.091	227.651	33.537	0	195.129
	III	153.452	0.209	0.574	74.908	7.804	41.246	72.157	0	3.048	43.700
	IV	148.963	0.185	0.388	101.715	0.969	13.299	9.146	85.369	0	260.172
1977/78	I	231.046	0.077	0.092	434.981	5.301	54.851	3.048	226.634	0	769.339
	II	162.184	0	0.101	309.805	0.232	99.783	463.432	71.141	0	193.097
	III	107.133	0	0.117	121.468	0	89.177	41.668	6.097	4.065	155.493
	IV	98.858	0.006	0.403	116.742	0.003	35.754	39.635	0	7.114	242.895
1978/79	I	202.344	0.093	1.090	299.824	24.754	22.602	88.418	0	2.032	591.486
	II	170.533	0	0.002	307.512	16.640	69.385	172.771	20.326	0	413.634
	III	91.618	0.166	0.003	141.841	8.283	105.266	42.684	20.326	35.570	0
	IV	103.837	0.136	0.034	181.176	12.674	65.171	2.032	16.260	14.228	102.646

(continued)

Table 9, continued

Year	Season	MRD	OMSR	NRD	MWD	OMSW	NWD	QRP	MPR	QWP	MPW
		Variables									
		(1,000 metric tons)									
1979/80	I	268.444	0.589	0.032	458.176	83.693	153.639	0	514.247	0	1,047.805
	II	213.868	0	0.004	357.507	37.991	149.548	170.738	146.347	0	275.417
	III	120.217	0	0.044	158.253	0.121	115.865	7.114	46.749	91.467	275.417
	IV	92.164	0	0.004	144.211	0.022	77.931	49.798	15.244	34.554	487.824
1980/81	I	173.143	0	0.014	248.722	0.019	114.016	281.515	9.146	28.456	752.062
	II	132.817	0	0.114	244.305	0.075	87.655	460.383	55.896	0	56.912
	III	73.078	0	0.119	186.011	0	135.172	65.043	20.326	29.472	78.255
	IV	70.483	0	0.112	150.361	0	115.163	47.766	0	120.939	116.874
1981/82	I	195.968	1.778	1.001	255.922	4.006	48.714	160.575	0	12.195	519.329
	II	227.583	12.522	0.259	349.952	1.868	114.074	125.004	19.309	0	31.505
	III	92.256	35.865	0.495	147.431	3.346	126.652	0	44.717	1.016	296.759
	IV	69.945	1.983	1.011	130.631	0.984	77.789	4.065	84.352	0	237.814
1982/83	I	273.579	31.546	0.017	358.008	70.468	70.971	2	210	0	581
	II	132.747	29.207	0.004	322.143	9.791	195.556	94	61	0	632
	III	71.994	1.341	0.002	107.051	0.587	144.852	0	45	21	30
	IV	54.754	1.326	0.002	83.273	0.105	77.664	72	0	-3	281
1983/84	I	134.985	7.474	3.813	315.048	47.967	50.589	57	17	0	597
	II	112.884	0.951	0.481	333.270	35.478	207.133	83	59	0	416
	III	87.389	36.511	0.122	146.142	7.754	185.873	3	72	66	367
	IV	86.889	12.225	0.367	138.888	11.855	92.593	11	37	52	504
1984/85	I	166.581	33.564	0.216	515.412	107.324	238.112	3	346	3	544
	II	118.783	8.914	0.170	455.116	57.301	374.610	46	227	0	1,084
	III	45.930	1.834	0.085	119.257	3.141	191.857	21	98	162	257
	IV	27.092	1.284	1.464	55.721	0.001	115.882	60	24	45	0
1985/86	I	105.649	6.591	51.738	234.003	34.944	61.654	70	12	7	437
	II	62.299	1.099	23.531	206.909	13.479	233.014	130	9	0	138
	III	32.738	5.988	0.844	67.243	0.247	166.728	9	14	92	278
	IV	31.232	3.883	0.785	63.307	0.324	77.184	22	0	31	310

(continued)

Table 9, continued

Year	Season	MRD	OMSR	NRD	MWD	OMSW	NWD	QRP	MPR	QWP	MPW
		Variables									
		(1,000 metric tons)									
1986/87	I	118.606	50.468	6.668	259.109	65.127	67.569	6	23	1	525
	II	65.331	3.068	0.789	296.813	40.814	291.495	23	56	0	214
	III	84.758	49.445	8.370	143.199	4.115	206.162	0	81	21	329
	IV	54.161	30.593	0.041	124.294	2.861	92.387	107	100	30	439
1987/88	I	145.330	91.467	5.081	437.009	70.124	172.771	35	300	2	872
	II	115.858	20.326	0	295.743	12.195	378.063	49	168	0	962
	III	52.847	10.163	0	84.352	3.048	137.200	0	34	51	248
	IV	21.342	4.065	0	59.961	0	110.776	204	81	19	246

Sources: Bangladesh Bureau of Statistics, Statistical Yearbook (Dhaka: BBS, various years); Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and Directorate of Agricultural Marketing, unpublished data.

Notes: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).
MRD = Ration distribution (monetized channels) of rice,
OMSR = Open market sales of rice,
NRD = Public distribution of rice through non=monetized channels,
MWD = Ration distribution (monetized channels) of wheat,
OMSW = Open market sales of wheat,
NWD = Public distribution of wheat through non=monetized channels,
QRP = Domestic procurement of rice,
MPR = Import of rice,
QWP = Domestic procurement of wheat, and
MPW = Import of wheat.

Table 10--Selected variables of the data set for the disaggregated model: foodgrain supply, income, and population

Year	Season	OSR	OSW	QR	QW	ZR	ZW	MSR	MSW	Y	POP
		Variables									
		(1,000 metric tons)								(Taka)	(millions)
1972/73	I	33.537	269.319	2,441	0	873.384	1,129.109	2,696.296	887.936	13,723	74.3
	II	27.440	178.868	5,419	0	146.347	830.317	5,540.196	534.356	20,724	74.73
	III	23.374	205.292	207	60	60.978	858.773	233.957	421.037	4,022	75.17
	IV	33.537	465.465	1,864	30	33.537	775.436	1,889.481	478.881	5,796	75.17
1973/74	I	9.146	260.172	3,003	0	92.483	1,005.120	3,033.312	641.763	15,748	76.4
	II	38.619	351.639	6,499	0	110.776	624.008	6,473.951	477.405	23,234	76.84
	III	60.978	111.793	222	73	60.978	365.868	246.142	321.347	4,237	77.29
	IV	34.554	116.874	1,998	36	34.554	480.709	2,021.748	298.956	6,216	77.29
1974/75	I	11.179	204.276	3,039	0	46.749	791.697	3,084.278	638.539	16,860	78.0
	II	4.065	103.662	5,820	0	144.314	749.013	5,753.562	524.631	22,843	78.45
	III	105.695	148.379	225	77	168.705	428.878	275.571	302.767	4,614	78.91
	IV	112.809	201.227	2,024	38	273.384	818.121	2,048.023	251.960	6,711	78.91
1975/76	I	214.439	546.769	3,440	0	425.829	1,066.098	3,585.402	550.691	18,843	79.9
	II	227.651	487.824	6,833	0	846.577	911.621	6,540.159	381.008	26,469	80.36
	III	604.698	461.400	229	143	619.943	478.677	296.928	293.592	5,238	80.83
	IV	540.671	353.672	2,058	71	592.502	486.807	2,146.503	167.005	7,313	80.83
1976/77	I	467.498	368.916	3,218	0	551.850	500.019	3,446.094	212.852	18,872	81.7
	II	299.808	284.564	6,698	0	560.997	479.693	6,680.365	230.534	17,707	82.18
	III	331.313	236.797	165	171	403.471	283.547	247.078	291.910	5,356	82.66
	IV	216.471	160.575	1,484	84	310.987	420.748	1,624.390	199.984	6,955	82.66
1977/78	I	136.184	285.580	3,326	0	365.868	1,054.919	3,554.167	495.134	20,007	83.7
	II	104.678	495.954	7,199	0	639.252	689.051	6,897.853	409.821	29,510	84.19
	III	448.188	259.156	224	230	495.954	418.715	289.582	436.580	6,035	84.68
	IV	372.982	202.243	2,015	113	412.617	452.253	2,074.632	258.385	8,011	84.68

(continued)

Table 10, continued

Year	Season	OSR	OSW	QR	QW	ZR	ZW	MSR	MSW	Y	POP
		Variables									
		(1,000 metric tons)								(Taka)	(millions)
1978/79	I	300.824	299.808	3,510	0	389.242	893.327	3,625.110	345.148	21,573	85.6
	II	160.575	535.590	7,206	0	353.672	949.224	7,203.764	393.538	30,703	86.1
	III	215.455	509.166	193	393	278.466	544.736	242.1035	612.821	6,417	86.6
	IV	156.510	273.384	1,736	193	174.803	390.259	1,837.975	437.794	8,240	86.6
1979/80	I	64.026	146.347	3,028	0	578.274	1,194.152	3,297.066	695.508	21,489	87.7
	II	297.775	492.905	7,084	0	614.861	768.322	7,127.133	545.047	31,043	88.21
	III	393.308	225.618	243	717	447.172	592.502	356.147	899.773	6,604	88.72
	IV	316.065	320.134	2,185	353	381.112	842.512	2,227.369	540.612	9,135	88.72
1980/81	I	238.830	554.839	3,172	0	529.492	1,335.418	3,363.643	334.301	23,464	89.9
	II	345.542	988.859	7,603	0	861.822	1,045.772	7,275.548	332.036	32,946	90.42
	III	684.986	699.214	259	720	770.355	805.942	267.154	1,011.711	7,228	90.95
	IV	648.399	581.323	2,330	355	696.165	819.137	2,352.830	499.584	9,791	90.95
1981/82	I	606.731	601.649	3,431	0	767.306	1,133.174	3,469.172	296.447	24,431	91.6
	II	548.802	800.844	2,883	0	693.116	832.349	6,998.360	914.414	7,264	92.67
	III	430.911	342.493	310	638	475.628	640.269	438.617	914.414	7,264	92.67
	IV	299.808	356.721	2,792	314	388.226	594.535	2,860.875	523.405	10,588	92.67
1982/83	I	338	277	3,242	0	550	858	3,545.11	499.448	25,323	93.6
	II	314	342	7,256	0	469	974	7,323.958	527.491	33,476	133
	III	433	433	942	734	478	484	1,015.338	965.491	7,371	94.69
	IV	283	214	3,142	361	355	498	3,126.082	519.043	11,461	94.69
1983/84	I	290	321	3,405	0	364	918	3,494.272	413.605	26,152	95.7
	II	188	491	7,571	0	330	907	7,601.717	575.881	35,195	96.26
	III	201	320	220	812	276	753	451.024	1,085.770	7,634	96.82
	IV	146	408	2,967	400	194	964	3,055.482	591.336	11,516	96.82
1984/85	I	90	710	2,974	0	439	1,257	3,171.362	857.849	26,280	98
	II	228	373	7,570	0	501	1,457	7,651.868	887.027	35,436	98.57
	III	353	593	385	981	472	1,012	411.850	1,133.256	8,223	99.14
	IV	424	687	3,463	483	508	732	3,432.841	609.605	12,635	99.14

(continued)

Table 10, continued

Year	Season	OSR	OSW	QR	QW	ZR	ZW	MSR	MSW	Y	POP
		Variables									
		(1,000 metric tons)								(Taka)	(millions)
1985/86	I	466	542	3,034	0	548	986	3,127.979	323.603	27,306	100.3
	II	341	625	8,152	0	480	763	8,108.930	453.402	38,298	100.8
	III	401	277	361	698	424	647	391.571	840.218	8,549	101.47
	IV	345	403	3,252	344	367	744	3,265.901	453.816	12,858	101.47
1986/87	I	298	594	3,379	0	327	1,120	3,548.763	390.806	29,764	102.5
	II	115	689	8,018	0	194	903	8,064.190	629.124	38,711	103.1
	III	108	216	376	731	189	566	518.574	1,063.478	9,132	103.7
	IV	49	207	3,383	360	256	676	3,360.795	549.543	13,917	103.7
1987/88	I	168	451	3,224	0	503	1,325	3,430.879	677.904	29,930	105
	II	249	571	7,459	0	466	1,533	7,546.184	686.002	35,710	105.6
	III	315	744	465	702	349	1.043	528.010	875.602	9,907	106.3
	IV	278	656	4,190	346	563	921	4,011.407	497.738	14,776	106.3

Sources: Bangladesh Bureau of Statistics, Statistical Yearbook (Dhaka: BBS, various years); Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and Directorate of Agricultural Marketing, unpublished data.

Notes: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).
OSR = Public opening stock of rice,
OSW = Public opening stock of wheat,
QR = Production of rice,
QW = Production of wheat,
ZR = Availability of rice in the government's stocks,
ZW = Availability of wheat in the government's stocks,
MSR = Market supply of rice,
MSW = Market supply of wheat,
Y = Real income, and
POP = Population.

Table 11--Selected variables of the data set for the disaggregated model: prices

Year	Season	Variables							
		PR	PPR	RPR	PPW	RPW	POMSR	POMSW	DFL
		(Taka per maund)							
1972/73	I	30.406	16.464	12.766	0	9.244	18.934	0	2.271
	II	28.652	20.475	12.072	0	8.757	23.546	0	2.398
	III	35.626	21.801	11.888	0	8.638	25.071	0	2.431
	IV	35.188	20.857	11.373	0	8.264	23.986	0	2.541
1973/74	I	26.745	16.452	10.383	0	9.312	18.920	0	3.221
	II	25.873	20.546	11.173	0	8.821	23.628	0	3.400
	III	35.576	21.087	11.022	0	8.701	24.250	0	3.447
	IV	36.613	20.174	13.320	0	13.875	23.200	0	3.603
1974/75	I	39.887	15.109	12.054	0	10.391	17.376	0	4.811
	II	41.905	22.630	11.418	0	9.843	26.025	0	5.079
	III	48.291	23.498	11.263	0	9.710	27.023	0	5.149
	IV	36.636	22.481	10.776	0	9.289	25.853	0	5.382
1975/76	I	38.462	28.936	13.870	17.218	11.957	33.276	19.800	4.181
	II	24.745	27.409	14.882	16.309	12.458	31.521	18.756	4.414
	III	23.656	27.037	19.440	16.088	15.641	31.093	18.501	4.475
	IV	22.047	25.867	18.598	15.392	14.964	29.747	17.700	4.677
1976/77	I	26.064	29.668	21.332	18.144	17.163	34.118	20.866	4.078
	II	24.206	28.161	20.206	17.187	16.258	32.385	19.765	4.305
	III	28.399	27.951	19.932	16.954	16.037	32.143	19.497	4.364
	IV	29.353	26.741	19.069	16.220	15.343	30.752	18.653	4.562
1977/78	I	33.606	27.938	19.923	18.320	16.030	32.129	21.068	4.366
	II	28.337	28.271	19.892	17.298	15.135	32.512	19.892	4.624
	III	28.452	25.945	19.065	15.724	13.758	29.836	18.083	5.087
	IV	24.820	24.391	17.924	14.782	14.782	28.010	17.000	5.411
1978/79	I	32.094	31.449	23.110	20.489	19.060	36.166	23.563	4.197
	II	29.099	27.753	20.394	18.081	16.820	31.916	20.794	4.756
	III	34.717	27.330	20.084	17.806	16.564	31.430	20.477	4.829
	IV	38.672	27.084	21.474	16.637	17.411	31.147	19.133	5.168

(continued)

Table 11, continued

Year	Season	Variables							
		PR	PPR	RPR	PPW	RPW	POMSR	POMSW	DFL
		(Taka per maund)							
1979/80	I	34.490	24.684	18.278	16.404	14.060	28.386	18.864	6.400
	II	29.990	26.299	18.261	16.388	14.047	30.244	18.846	6.406
	III	32.832	27.885	19.191	17.223	14.762	32.067	19.806	6.096
	IV	30.248	27.953	22.527	17.265	14.798	32.146	19.855	6.081
1980/81	I	25.842	26.961	21.727	17,445	14.273	31.005	20.062	6.305
	II	25.311	27.268	21.286	17.201	17.201	31.358	19.781	6.394
	III	27.960	26.495	21.347	16.654	16.654	30.469	19.152	6.604
	IV	26.442	26.232	22.664	16.489	17.388	30.167	18.962	6.671
1981/82	I	26.804	25.515	22.045	18.079	16.913	29.343	20.791	6.858
	II	30.838	25.868	22.837	17.222	17.222	29.748	19.805	7.199
	III	38.485	25.927	23.334	16.921	16.921	29.816	19.459	7.328
	IV	31.269	26.045	23.441	16.998	16.998	29.952	19.547	7.294
1982/83	I	31.925	24.807	24.938	17.626	17.496	28.529	20.270	7.658
	II	30.357	20.201	25.479	17.594	17.464	23.231	20.233	7.672
	III	32.068	13.575	27.022	17.454	18,747	15.612	20.072	7.734
	IV	29.810	26.639	26.512	17.125	18.393	30.635	19.694	7.883
1983/84	I	31.757	26.829	26.701	17.247	18.525	30.853	19.834	7.827
	II	34.866	30.590	30.000	18.508	21.250	35.178	21.284	7.293
	III	38.728	30.737	31.284	19.672	21.174	35.348	22.622	7.32
	IV	38.523	30.467	31.008	19.498	20.988	35.037	22.423	7.385
1984/85	I	39.612	31.563	29.837	18.762	20.195	36.298	21.576	7.675
	II	37.229	31.636	30.851	18.096	19.478	36.382	20.810	7.957
	III	37.036	32.092	31.970	19.768	20.378	36.906	22.733	8.195
	IV	32.190	32.250	32.127	19.865	20.478	37.087	22.844	8.155

(continued)

Table 11, continued

Year	Season	Variables							
		PR	PPR	RPR	PPW	RPW	POMSR	POMSW	DFL
		(Taka per maund)							
1985/86	I	32.581	31.888	31.767	19.642	20.248	36.671	22.588	8.247
	II	31.919	30.168	31.653	19.165	20.703	34.693	22.040	8.452
	III	35.193	29.377	31.036	19.585	20.161	33.784	22.523	8.68
	IV	33.937	29.511	30.964	19.296	21.112	33.938	22.190	8.81
1986/87	I	35.859	29.625	31.637	19.005	20.793	34.069	21.855	8.945
	II	36.700	30.790	31.744	19.068	20.863	35.409	21.929	8.915
	III	43.766	32.036	31.923	20.304	20.981	36.841	23.250	8.865
	IV	40.323	33.557	31.655	20.134	20.805	38.590	23.154	8.94
1987/88	I	39.132	32.885	31.537	19.731	21.046	37.818	22.691	9.122
	II	38.737	33.441	32.698	19.543	20.846	38.458	22.475	9.21
	III	39.803	33.011	33.547	21.436	21.221	37.963	24.651	9.33
	IV	34.403	32.489	33.270	21.097	20.886	37.362	24.261	9.48

Sources: Bangladesh Bureau of Statistics, Statistical Yearbook (Dhaka: BBS, various years); Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and Directorate of Agricultural Marketing, unpublished data.

Notes: I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).
PR = Market price of rice,
PPR = Procurement price of rice in real terms,
RPR = Ration price of rice in real terms,
PPW = Procurement price of wheat in real terms,
RPW = Ration price of wheat in real terms,
POMSR = Open market sale price of rice in real terms,
POMSW = Open market sale price of wheat in real terms, and
DFL = Deflator.

APPENDIX 2: FIXING OF TARGET PRICES FOR 1989/90 FOLLOWING THE AHMED-BERNARD APPROACH

The first step in the Ahmed and Bernard approach is to assess in advance the price of rice most likely to prevail in the coming year. Ahmed and Bernard (1989) formulated a four-equation price prediction model for this purpose. To predict the price of rice in 1989/90, this model was reestimated with the two-stage least squares method using more recent data covering the period from 1976/77 to 1987/88. The estimated structural equations are presented in Table 12. The predictive power of the estimated model was tested by examining how well the predicted prices fit actual past prices in the sample period; the results are shown in Figure 8. The computed Theil inequality coefficient of 0.053 also confirms that the model is reasonably corsistent with historical experience.

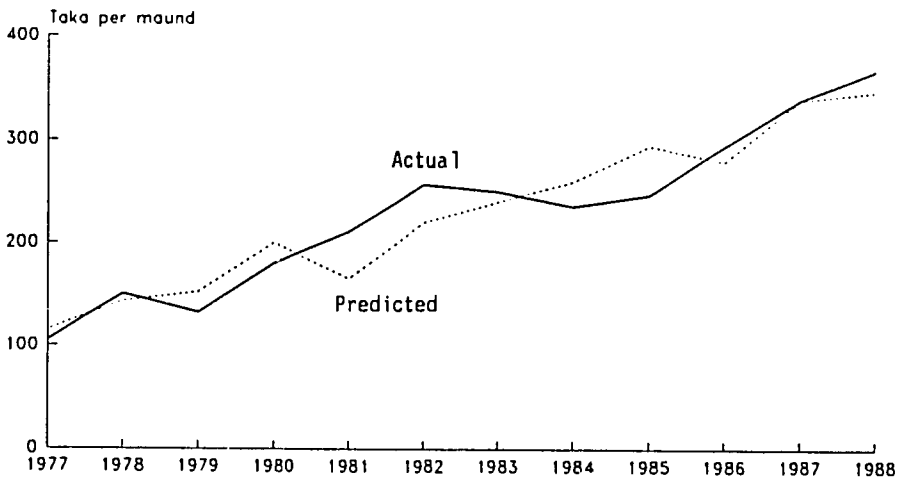
Table 12--Estimated equations for the price prediction model

Equations and Variables	Estimated Coefficients	t-value	R^2	D.W.
Price equation			0.85	1.68
Constant	41.231	2.18		
Income (Y_{t-1})	0.070	4.81*		
Market supply of rice (MSR_t)	-0.386	-1.60		
Wheat production (SW_t)	-0.364	-1.46		
Procurement equation			0.77	1.84
Constant	-34.986	-1.93		
Production of rice (QR_t)	0.320	2.88**		
Market price of rice (PR_t)	-0.672	-2.61**		
Procurement price (ADP_t)	0.487	1.17		
Opening stock of (OS_t) foodgrain	-0.161	-.76		
Ration equation			0.85	1.46
Constant	16.517	2.76**		
Market price of rice (PR_t)	0.617	4.27*		
Ration price ($ADPR_t$)	0.617	4.27*		
Availability of (Z_t) Government stock	0.085	1.09		

Source: Author's calculations

* Significant at the 1 percent level.
** Significant at the 5 percent level.

Figure 8--Actual and predicted annual prices of rice, 1977-88



Sources: Bangladesh Ministry of Food, Food Planning and Monitoring Unit, Food Situation Reports (Dhaka: Ministry of Food, various years); and author's calculations.

The following reduced form equation of the estimated model was solved given the set of exogenous variables (such as income, production of rice and wheat, opening stock, import of foodgrains, and administrative prices):[12]

$$PR_t = 1/1.497\ (21.352 + 0.070\ Y_{t-1} - 0.263\ QR_t + 0.187\ ADP_t + 0.463\ ADPR_t - 0.033\ Z_t - 0.364\ SW_t).$$

The predicted price of rice for 1989/90 was estimated as Tk 368.10/md. The next step was to check whether the predicted price was greater or less than the normal (trend) price for 1989/90. Since the predicted price was less than the normal price (estimated as the trend price in 1989/90) of Tk 388.91/md, the annual target price (ATP_t) was derived as follows (assuming a 4-percent band for the annual prices):

$$ATP_t = \text{normal (trend) price} * 0.96$$
$$= \text{Tk } 373.35/\text{md}.$$

The corresponding floor and ceiling prices were then derived by multiplying the annual target prices by the seasonal factors -0.925 for

[12] For a full description of the solution procedures and assumed values of the exogenous variables used to predict the price of rice for 1989/90, see Shahabuddin (1989).

the former and 1.075 for the latter.[13] The resulting floor and ceiling prices were calculated to be Tk 345.35 per md and Tk 401.35 per md, respectively.

The following iterative procedure was then adopted to confirm the results. Since the latest actual procurement price was used to estimate the predicted price for 1989/90, it was necessary to check whether the derived procurement price was consistent with the annual target price for 1989/90. Plugging the procurement price of Tk 345.35 per md into the reduced form equation, another predicted price of Tk 371.25 per md was obtained. Since this predicted price was again less than the normal one, it was still possible to opt, as per the prescribed decision rule, for the lower bound of the annual band. Hence the annual target price remained unchanged at Tk 373.35 per md, as did the procurement (floor) and ceiling prices.

It may be emphasized here that the above procedure for fixing the target prices assumed domestic production of foodgrains of 18.5 million tons (17.4 million tons of rice and 1.1 million tons of wheat) as originally targeted by the Ministry of Agriculture for 1989/90. However, target prices for alternative projections of foodgrain production, particularly rice, were also derived to serve as candidates for sensitivity analysis of the application of the disaggregated model. For example, because of the bumper aman harvest, domestic foodgrain production for 1989/90 is not projected to be 19.5 million tons (18.5 million tons of rice and 1 million tons of wheat). The corresponding predicted price of rice is estimated to be Tk 354.38 per md. Since this predicted price, as expected, is less than the normal price of Tk 389.00 per md calculated earlier, the lower bound of the normal price, that is, Tk 373.00 per md (Tk. 389 * 0.96) could be chosen as the annual target price. This choice would leave the corresponding floor and ceiling prices unchanged at Tk 345.00 per md and Tk 401.00 per md, respectively.

However, if the domestic production of rice were to fall to 16 million tons (with wheat production unchanged at 1 million tons) because of natural calamities, the corresponding predicted price of rice, using the reduced-form equation, is estimated to be Tk 390.55 per md, a lower level that is now greater than the estimated normal price for 1989/90. In this case the upper bound of the normal price would be chosen as the annual target price, that is, Tk 405.00 per md (Tk 389 * 1.04). The corresponding target floor and ceiling prices were calculated using the seasonal factors to be Tk 375.00 per md and Tk 435.00 per md, respectively.

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[13] This approach assumes that a 7.5 percent band in seasonal prices is consistent with private traders making normal profits in the Bangladesh rice markets. The IFPRI food policy project in Bangladesh is currently undertaking a marketing study to ascertain whether this assumption is realistic.

APPENDIX 3: THE REDUCED FORM OF THE MODEL

The system of structural equations of the model can be written in matrix form as $Ay = Bx$, where y is the column vector of the endogenous variables (market price of rice [PR]; ration distribution [monetized channels] of rice, per capita [MRD]; ration distribution [monetized channels] of wheat per capita [MWD]; domestic procurement of rice, per capita [QRP]; domestic procurement of wheat, per capita [QWP]; open market sales of rice, per capita [OMSR]; open market sales of wheat, per capita [OMSW]; market supply of rice, per capita [MSR]; market supply of wheat, per capita [MSW]; availability of rice in the government's stocks, per capita [ZR]; availability of wheat in the government's stocks [ZW]; public opening stock of rice, per capita [OSR]; and public opening stock of wheat, per capita [OSW]); x is the column vector of the exogenous variables (production of rice, per capita [QR]; production of wheat, per capita [QW]; public distribution of rice through nonmonetized channels, per capita [NRD]; public distribution of wheat through nonmonetized channels, per capita [NWD]; import of rice, per capita [MPR]; import of wheat, per capita [MPW]; real income, per capita [Y]; ration price of rice in real terms [RPR]; ration price of wheat in real terms [RPW]; procurement price of rice in real terms [PPR]; procurement price of wheat in real terms [PPW]; open market sales price of rice in real terms [POMSR]; open market sales price of wheat in real terms [POMSW]; and one-period lagged values for PR, QR, OSR, OSW, QRP, QWP, MPR, MPW, MRD, MWD, NRD, NWD, OMSR and OMSW); and A and B are the coefficient matrices of the set of endogenous and exogenous variables, respectively. The reduced form of the system can therefore be expressed as $y = Rx$, where $R = A^{-1}B$. The estimated matrix of the reduced form parameters is presented in Table 13. Using this matrix, it is easy to solve for the various endogenous variables in the model for different sets of variables that are exogenously specified.

Table 13--Estimated matrix of reduced form parameters

Exogenous Variables	Endogenous Variables												
	PR	MRD	MWD	QRP	QWP	OMSR	OMSW	MSR	MSW	ZR	ZW	OSR	OSW
C	3.718	0.339	2.636	3.75	-0.168	-0.671	-0.016	-4.082	2.788	3.75	-0.168	0	0
QR	-0.135	0.008	0.001	0.043	0.0001	-0.003	-0.022	0.962	-0.002	0.043	0.0001	0	0
QW	0.134	-0.003	0.033	-0.029	0.085	0.004	0.008	0.029	0.957	-0.029	0.085	0	0
NRD	-0.136	0.003	0.001	0.029	0.0001	-0.004	-0.002	0.97	-0.002	0.029	0.0002	0	0
NWD	0.14	-0.004	-0.001	-0.03	-0.0001	0.004	0.003	0.031	1.002	-0.03	-0.0001	0	0
MPR	-0.051	0.33	0.0004	0.011	0.0001	0.047	-0.001	0.366	-0.001	1.011	0.0001	0	0
MPW	0.067	-0.002	0.405	-0.014	-0.0001	0.002	0.073	0.015	0.478	-0.014	0.999	0	0
Y	0.022	-0.0005	-0.0002	-0.005	-0.00002	0.0006	0.0004	0.005	0.0002	-0.005	-0.00002	0	0
RPR	0.003	-0.023	-0.00002	-0.001	0	0.0001	0.0001	-0.023	0.00003	-0.001	0	0	0
RPW	-0.028	0.001	-0.201	0.006	0.00003	-0.001	-0.0005	-0.006	-0.201	0.006	0.00003	0	0
PPR	0.007	0.026	0.00005	0.08	0	0.004	0.0001	-0.049	0.0001	0.08	0	0	0
PPW	0.0006	0.00002	0.003	0.0001	0.009	-0.00001	0.0006	-0.0001	-0.004	0.0001	0.009	0	0
POMSR	0.0009	-0.00002	0	-0.0002	0	-0.0066	0.00002	-0.006	0.00001	-0.0002	0	0	0
POMSW	-0.006	0.0002	0.00005	0.001	0.00001	-0.0002	-0.044	-0.001	0.044	0.001	0.00001	0	0
PR(-1)	0.746	-0.018	-0.066	-0.161	-0.001	0.022	0.014	0.164	0.008	-0.161	-0.001	0	0
QR(-1)	0.001	0.004	0	0.013	0	0.001	0.00002	-0.008	0.00001	0.013	0	0	0
OSR(-1)	-0.078	0.227	0.001	-0.298	0.0001	0.031	-0.001	0.556	-0.001	0.702	0.0001	1	0
OSW(-1)	0.066	-0.002	0.41	-0.014	0.011	0.002	0.073	0.014	0.472	-0.014	1.011	0	1
QRP(-1)	-0.078	-0.227	0.001	-0.298	0.0001	0.031	-0.001	0.556	-0.001	0.702	0.0001	1	0
QWP(-1)	0.066	-0.002	0.41	-0.014	0.011	0.002	0.073	0.015	0.472	-0.014	1.011	0	1
MPR(-1)	-0.078	0.227	0.001	-0.298	0.0001	0.031	-0.001	0.556	-0.001	0.702	0.0001	1	0
MPW(-1)	0.066	-0.002	0.41	-0.014	0.011	0.002	0.073	0.014	0.472	-0.014	1.011	0	1
MRD(-1)	0.078	-0.227	-0.001	0.298	-0.0001	0.031	0.001	-0.556	0.001	-0.702	-0.0001	-1	0
MWD(-1)	-0.066	0.002	-0.41	0.014	-0.011	-0.002	-0.073	-0.014	-0.472	0.014	-1.011	0	-1
NRD(-1)	0.078	-0.227	-0.001	0.298	-0.0001	-0.031	0.001	-0.0556	0.001	-0.702	-0.0001	-1	0
NWD(-1)	-0.066	0.002	-0.41	0.014	-0.011	-0.002	0.073	-0.014	0.472	0.014	-1.011	0	-1
OMSR(-1)	0.078	-0.227	-0.001	0.298	-0.0001	-0.031	0.001	-0.556	0.001	-0.702	-0.0001	-1	0
OMSW(-1)	-0.066	0.002	-0.41	0.014	-0.011	-0.002	-0.074	-0.014	-0.472	0.014	-1.011	0	-1

(continued)

Table 13, continued

Source: Author's calculations.

Notes:

C = Constant,
QR = Production of rice, per capita,
QW = Production of wheat, per capita,
NRD = Public distribution of rice through non=monetized channels, per capita,
NWD = Public distribution of wheat though non=monetized channels, per capita,
MPR = Import of rice, per capita,
MPW = Import of wheat, per capita,
Y = Real income, per capita,
RPR = Ratio price of rice, per capita,
RPW = Ration price of wheat, per capita,
PPR = Procurement price of rice, in real terms,
PPW = Procurement price of wheat, in real terms,
POMSR = Open market sale price of rice in real terms,
POMSW = Open market sale price of wheat in real terms,
PR = Market price of rice,
MRD = Ration distribution (monetized channels) of rice, per capita,
MWD = Ration distribution (monetized channels) of wheat, per capita,
QRP = Domestic procurement of rice, per capita,
QWP = Domestic procurement of wheat, per capita,
OMSR = Open market sales of rice, per capita,
OMSW = Open market sales of wheat, per capita,
MSR = Market supply of rice, per capita,
MSW = Market supply of wheat, per capita,
ZR = Availability of rice in the government's stocks, per capita,
ZW = Availability of wheat in the government's stocks, per capita,
OSR = Public opening stock of rice, per capita, and
OSW = Public opening stock of wheat, per capita.

APPENDIX 4: VALUES OF THE VARIABLES USED IN THE MODEL SOLUTIONS, BASE AND ALTERNATIVE SCENARIOS FOR 1989/90

Table 14--Values of the variables used in the model solution, base scenario, 1989/90

Variables	Seasons I	II	III	IV	Total
Income (Y_t) 92,580	27,774	33,329	12,961	18,516	
Rice production (QR_t)	3.88	9.02	0.56	5.04	18.5
Wheat production (QW_t)	--	--	0.67	0.33	1.0
Public distribution (non-monetized) of rice (NRD_t)	0.02	0.04	0.01	0.01	0.08
Public distribution (non-monetized) of wheat (NWD_t)	0.18	0.36	0.09	0.09	0.72
Imports of rice (MPR_t)	--	--	--	--	--
Imports of wheat (MPW_t)	0.50	0.50	0.25	0.25	1.50
Ration price of rice (RPR_t)	39.47	39.47	39.47	39.47	--
Ration price of wheat (RPW_t)	25.26	25.26	25.26	25.26	--
Procurement price of rice (PPR_t)	33.96	33.96	33.96	33.96	--
Procurement price of wheat (PPW_t)	21.73	21.73	21.73	21.73	--
Open market sale price of rice ($POMSR_t$)	39.47	39.47	39.47	39.47	--
Open market sale price of wheat ($POMSW_t$)	25.26	25.26	25.26	25.26	--

Source: Author's calculations

Note: Income is valued in constant 1972-73 prices; all quantities are expressed in million metric tons and all prices in real terms (1969-70 level). The population for the period 1989 to 1990 is assumed to be 111.91 million, the number used to convert the quantities into per capita figures.

I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

Table 15--Values of the variables used in the model solution, alternative scenario, 1989/90

Variables	Seasons I	II	III	IV	Total
Income (Y_t) 89,070	26,721	32,065	12,470	17,814	
Rice production (QR_t)	3.15	7.31	0.45	4.09	15.00
Wheat production (QW_t)	--	--	0.67	0.33	1.00
Public distribution (non-monetized) of rice (NRD_t)	0.03	0.04	0.02	0.01	0.10
Public distribution (non-monetized) of wheat (NWD_t)	0.22	0.45	0.11	0.12	0.90
Imports of rice (MPR_t)	0.18	0.18	0.12	0.12	0.60
Imports of wheat (MPW_t)	0.84	0.84	0.36	0.36	2.40
Ration price of rice (RPR_t)	42.81	42.81	42.81	42.81	--
Ration price of wheat (RPW_t)	27.40	27.40	27.40	27.40	--
Procurement price of rice (PPR_t)	36.91	36.91	36.91	36.91	--
Procurement price of wheat (PPW_t)	23.62	23.62	23.62	23.62	--
Open market sale price of rice ($POMSR_t$)	42.81	42.81	42.81	42.81	--
Open market sale price of wheat ($POMSW_t$)	27.40	27.40	27.40	27.40	--

Source: Author's calculations.

Note: Income is valued in constant 1972-73 prices; all quantities are expressed in million metric tons and all prices in real terms (1969-70 level). The population for the period 1989 to 1990 is assumed to be 111.91 million, the number used to convert the quantities into per capita figures.

I is the pre-aman season (July-October), II the aman season (November-February), III the pre-boro season (March-April), and IV the boro season (May-June).

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