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FOOD POLICY, EXTERNAL SHOCKS AND INCOME DISTRIBUTION IN BANGLADESH:

A MULTI-MARKET ANALYSIS

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1. OBJECTIVES

Increased production of high yielding variety (HYV) paddy and wheat have contributed to dramatic changes in foodgrain markets in Bangladesh over the past two decades. Foodgrain production has doubled over the past 20 years, while marketed quantities have increased by a factor of six. Private rice and wheat markets have grown just as fast. At the same time, price volatility has fallen considerably. Seasonal price fluctuations have dropped in half because production growth has centered on a second major rice crop, the boro crop. Year to year price variations have likewise diminished since multiple harvests enable farmers to respond rapidly to production shortfalls. Typically in recent years, below-normal production in one crop triggers compensating increases in the next, thus moderating year-to-year price fluctuations (Chowdhury 1992, Goletti 1993).

More recently, adoption of new trade and domestic pricing policies of foodgrains has coincided with significant changes in world markets and in food aid flows that have altered the behavior of foodgrain markets in Bangladesh. Private foodgrain imports are now allowed, since July 1992 for wheat and since July 1993 for rice. Private importers have responded by bringing in substantial quantities of wheat, in the range of 300 to 600 thousand tons per year. At the same time, food aid has fallen precipitously, from 1.2 million tons in 1991/92 to 700 thousand tons in 1993/94. World grain markets are changing as well. The conclusion of the recent GATT negotiations brings with it the prospect of cereal subsidy removal and a consequent realignment of international foodgrain prices.

Given these changes, government and donors are attempting to re-evaluate their role in Bangladesh's foodgrain markets as well as the likely consequences of interventions in a new and changing environment. In particular, they are interested in evaluating a series of questions. Given growing domestic foodgrain markets, how much will production shocks affect year-to-year price volatility in the future? Given larger production, how much impact will government procurement have on domestic prices? What impact will private wheat imports have on producer incentives and on consumption? What are the likely consequences of declining food aid on prices and consumption of vulnerable groups? What are the likely consequences of a major increase in world foodgrain prices?

Answering these questions requires an analytical framework that takes into consideration interactions between production, household consumption and incomes, domestic and world prices, and trade policy. The objective of this study is to provide such an analytical framework, a multi-market model of the Bangladesh food economy, and to use this model to provide insights into these questions. Perhaps more important, the model presented here is designed to be flexible and easily adapted so as to enable further analysis of these issues as policies and world market conditions change, and as new data become available.

In particular, the study aims to evaluate the impact of production shocks, government policy and changes in world market conditions on domestic foodgrain prices and consumption, with a focus on the effects on poor households. Among the simulations included are model runs of the effects of production shocks, government procurement, imports (both food aid and commercial imports), and changes in world prices.

Chapter 2 briefly describes the multi-market model used for the analysis. Model simulations of various external shocks and policy changes are presented in Chapter 3. Conclusions and policy implications are found in Chapter 4.

Details of the model and the data base are found in the appendices. Appendix 1 describes the data base used for the model, while Appendix 2 provides a detailed exposition of the model's structure and underlying assumptions. A user's guide for operating the model is found in Appendix 3 and the computer code for the model is given in Appendix 4.

2. MODELING FOOD MARKETS IN BANGLADESH

A number of econometric analyses of rice markets in Bangladesh have explored the determinants of government procurement and the interactions between policies and market prices (e.g. Ahmed and Bernard 1989; Shahabuddin 1991; Goletti, Ahmed and Chowdhury 1991; Ahmed, Chowdhury and Ahmed 1993; and Chowdhury 1994). Major shifts in domestic rice prices and policies have occurred in the last two years. However, this period is too short to enable rigorous econometric analysis of the impact of various policy instruments on prices and consumption of vulnerable groups using time-series methods. Therefore, this report complements the earlier work on foodgrain markets in Bangladesh in building a simple multi-market model that allows the analyst to "hold all other things constant" when evaluating the likely domestic impact of production shocks, government procurement, trade policies, and shifts in world markets.

Analyzing the impact of policy and external shocks on agricultural commodities requires taking into account effects on supply, demand, trade and incomes. Moreover, interactions between commodities on both the supply and demand side make it important to conduct the analysis in a multi-commodity framework. This is especially true in analyzing food markets in Bangladesh, where rice and wheat markets are closely linked.

This chapter presents the basic structure of a multi-market model for Bangladesh food markets.[1] Sources of data for the model and a more detailed description of the model equations are given in Appendices 1 and 2.

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[1] The multi-market approach used here derives from Braverman and Hammer (1986).

MODEL STRUCTURE

In general, the multi-market model estimates the likely impact of various exogenous shocks on the supply, demand and prices of major food commodities. Twelve commodities are included in the model (rice, wheat, pulses, fruits and vegetables, potatoes, fish, meat and eggs, milk, edible oils, onions, spices, and other foods, fuel, and all other nonfoods). The primary focus of the analysis in this report, however, is on the major foodgrains (rice and wheat). In order to analyze the effects of external shocks and policies on income distribution and poverty, five separate household groups are specified: urban poor, urban nonpoor, rural landless, rural small farms and rural large farms (Table 1).

Domestic production of agricultural commodities is either taken as exogenous or modeled as a function of rural prices and a supply shifter, according to the specification of the model user. Non-agricultural production is fixed exogenously.

Consumption of both urban and rural households is a function of household income and consumer prices. (For rural households, their consumer price is equal to the producer price). Agricultural incomes are determined by quantities produced and their prices.

Two major sets of parameters influence the behavior of the model: supply elasticities and demand parameters. Supply elasticities are taken from Mahmud et. al. (1993). The demand parameters are derived from econometric estimates by Goletti (1993). Levels of these parameters are found in the GAMS computer code in Appendix 4.

The method by which prices are obtained varies according to whether the commodity is freely traded or not (i.e. traded with government controls on quantities or non-traded). For traded goods, the domestic price level is determined by world prices and the exchange rate. Net imports adjust so that total supply equals demand. For goods subject to import controls and for non-traded goods, net imports are fixed exogenously, and the model

Table 1 — Household Groups in Bangladesh, 1988-89

	Number of Households	Population		Per HH Expenditure	Per capita Expenditure
	(millions)	(millions)	(percent)	(Taka/month)	(Taka/month)
Urban Poor	0.95	5.82	5.6	2279	371
Urban Non-Poor	1.41	7.40	7.1	4986	950
Rural Landless	8.38	39.29	37.8	1819	388
Rural Marginal	4.98	28.23	27.1	2411	425
Rural Large Farm	3.08	23.27	22.4	3988	528
Urban Total	2.36	13.21	12.7	3900	695
Rural Total	16.43	90.79	87.3	2405	435
Total	18.79	104.00	100.0	2592	468

Source: Household Expenditure Survey, 1988-1989 (BBS 1991).

solves for the consumer price that clears the market, equating supply and demand. Rural prices are linked to urban consumer prices by a fixed marketing margin.

By equating supply and demand, the model determines new equilibrium prices for goods which are not freely traded and new levels of trade for freely traded goods. For the freely traded goods, world markets set domestic prices to which local producers and consumers respond.

This distinction between freely traded goods and goods that are subject to quantitative restrictions is particularly important in analyzing rice and wheat markets in Bangladesh. Up until mid-1992 for wheat and mid-1993 for rice, the levels of imports of these commodities were determined by the government of Bangladesh in conjunction with food aid donors. Market-clearing domestic price levels in the pre-liberalization trade regime were thus determined by total domestic supply (production plus the net release of grain from government stocks, food aid and other imports) and domestic demand. By contrast, in the recently liberalized grain markets post-1993, market prices will increasingly be linked to border prices (i.e. world market prices adjusted for transport costs and quality differentials) as private traders use market signals to determine the levels of imports, and potentially exports, of grain. A key aspect of the model is its adaptability in simulating these different price formation mechanisms, as is outlined in the users' guide to the model in Appendix 3.

3. MODEL SIMULATIONS

In this section, four sets of simulations using the multi-market model are presented.[2] The first set of simulations examines the effects of positive production shocks and government paddy procurement policy. Simulation 1 models the effects of an increase in the boro paddy harvest by 10 percent. In simulation 2, procurement of paddy is increased from 100 to 500 thousand tons. Simulation 3 then looks at the effects of an increase in government procurement with liberalized foreign trade of rice and wheat. The second set of simulations illustrates the role of imports in Bangladesh food markets, examining the impact of a cut in food aid (simulation 4) and an offsetting increase in commercial imports (simulation 5).

The third set of simulations are designed to analyze the influence of changing world market prices in the context of liberalized trade in rice and wheat. Simulation 6 shows the effects of liberalization of imports of rice and wheat with no change in world prices. Three other simulations model the effects of a 20 percent increase in the world price of rice (simulation 7), the world price of wheat (simulation 8), and in the world prices of both rice and wheat (simulation 9). Finally, simulation 10 models the effects on food markets of an exchange rate devaluation.

The simulations reported here show the effects of these changes with respect to the situation in Bangladesh for the 1991/92 crop (fiscal) year. Both rice and wheat imports are exogenous in simulations 1,2,4 and 5. In simulations 4 and 6 - 10, rice and wheat

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[2] The simulations presented here are results of runs using the annual version of the multi-market model. Equations for a seasonal version of the model are given in Appendix 2.

imports are made endogenous, reflecting the situation after the liberalization of grain trade in 1992 and 1993.

SIMULATION 1: INCREASED BORO PADDY HARVEST

In Simulation 1, a ten percent increase in yields for the boro harvest of paddy is modeled (Table 2). Since boro production accounted for only 37.4 percent of the total annual harvest in 1991/92, the immediate impact of the yield increase (before price changes are taken into account) is an increase in annual domestic production of rice by 3.7 percent. Increased rice production leads to a decline in producer prices of rice by 4.2 percent, however, so that total production increases by only 2.1 percent.

Because wheat is a close substitute for rice, lower rice prices tend to reduce wheat demand and cause a drop in wheat prices of 8.9 percent to equilibrate the wheat market. With the exception of large farmers, all household groups benefit in this scenario due to lower prices of rice and wheat. Low income, food deficit households see the largest gains in real incomes: 1.5 percent for the urban poor and 1.3 percent for the rural landless. Calorie consumption of the urban poor increases by 41 calories per person per day due mainly to a 7.8 percent increase in their wheat consumption in response to lower market prices for wheat. Real incomes of large farmers decline, however, as the decline in rice prices offsets the increase in rice production.

SIMULATION 2: INCREASED GOVERNMENT PROCUREMENT OF RICE

Increased government procurement is one method for supporting farm prices, improving incentives for production and raising farmer incomes. In simulation 2, government procurement of rice is increased by 400 thousand tons with no change in offtake. (Implicitly, government stocks increase by the full amount of the additional

Table 2 — Production and Procurement Simulation Results (percent change versus base)

	Simulation 1	Simulation 2	Simulation 3
	Increased Rice Production	Government Procurement	Government Procurement with Liberalized Trade
Production			
Rice	2.09	1.13	1.19
Wheat	-5.52	4.04	2.44
Consumer Price			
Rice	-4.19	3.04	3.19
Wheat	-8.90	6.70	4.03
Imports/Base Consumption			
Rice	0.00	0.00	-0.25
Wheat	0.00	0.00	2.73
Rice Consumption			
Urban Poor	3.47	-2.38	-2.59
Urban NonPoor	1.47	-1.02	-1.16
Rural Landless	2.75	-1.82	-2.12
Rural Small Farm	1.34	-0.60	-0.92
Rural Large Farm	2.28	-1.52	-1.42
Total	2.18	-1.37	-1.56
Wheat Consumption			
Urban Poor	7.76	-5.49	1.80
Urban NonPoor	-4.02	2.83	3.32
Rural Landless	-0.75	0.68	3.90
Rural Small Farm	-1.56	0.82	2.07
Rural Large Farm	-7.91	5.94	6.21
Total	-2.15	1.57	3.68
Real Incomes			
Urban Poor	1.49	-1.10	-1.00
Urban NonPoor	0.77	-0.59	-0.51
Rural Landless	1.29	-0.93	-0.83
Rural Small Farm	0.81	-0.23	-0.18
Rural Large Farm	-0.05	0.95	0.92
Total	0.76	-0.22	-0.18
Calories from Foodgrains (absolute change kcal/person/day)			
Urban Poor	41	-28	-21
Urban NonPoor	10	-7	-8
Rural Landless	32	-21	-17
Rural Small Farm	15	-6	-8
Rural Large Farm	22	-13	-11

Source: Model simulations

procurement.) The result of the withdrawal of 400 thousand tons of rice from the market is a 3.0 percent increase in the rice price. Because the increase in rice prices leads to increased demand for wheat, the wheat price also rises, by 6.7 percent. Production of rice and wheat increase by 1.1 and 4.0 percent, respectively, in response to higher prices.

Real incomes of large farmers who produce significant surpluses of rice and wheat rise by 0.95 percent in this scenario. Small farmers are only marginally affected, given their approximate self-sufficiency in food grains. Both the urban poor and rural landless suffer, however, from the increase in grain prices, with calorie consumption from grains falling by 28 and 21 calories per person per day for the urban poor and rural landless, respectively.

SIMULATION 3: INCREASED PROCUREMENT WITH LIBERALIZED IMPORTS

The above simulation reflects the impact of procurement with rice and wheat imports determined by government policy. With liberalized imports of foodgrains, procurement has smaller effects on real incomes and foodgrain calorie consumption. If market prices are near border prices for imports or exports, changes in domestic demand or production tend to be offset by changes in private net imports, so that total supply and domestic prices are unchanged.

Given current market conditions in 1994, rice is essentially a non-traded good, with its domestic price too high for profitable exports (the domestic price is above export parity) and too low for profitable imports (the domestic price is below import parity). This situation is modeled in simulation 3, where a procurement of 200,000 tons of rice with liberalized trade in foodgrains still has approximately the same effect on the price of rice as in simulation 2, raising the rice price by 3.2 percent. Unlike in simulation 2, however, wheat prices rise only to the border price (an increase of 4.0 percent), and the increase in

demand for wheat is met with imports, which rise by 2.7 percent of base wheat consumption.

Simulation 3 approximates the world market situation of 1994. However, if world market prices rise such that rice becomes an exportable good or if world market prices fall enough so that rice imports into Bangladesh become privately profitable, then an increase in procurement will have only minimal effects on market prices (apart from possible effects on markets that are not well integrated with the rest of the Bangladeshi rice market). In this case, increased procurement will tend to result only in a change in net imports with no change in domestic prices.

SIMULATIONS 4 AND 5: REDUCTIONS IN FOOD AID

In simulation 4, a 200 thousand ton cut in food aid wheat imports and distribution is modeled. In addition, the value of the decline in food aid is subtracted from incomes of the rural landless.

The resulting increase in market wheat prices (10.4 percent) spurs an increase in production by 6.2 percent (Table 3). Total market supply of wheat thus falls by only 5.7 percent. Higher wheat prices also lead to a small shift in demand towards rice which raises rice prices by 0.4 percent. The rural landless suffer a loss in real incomes of 0.7 percent and see their calorie consumption from grains drop by 17 calories per person per day. Urban households, particularly the urban poor, are also adversely affected because of higher wheat prices, with a 0.6 percent drop in real incomes and a 28 calorie per person per day fall in calories from grains.

If the decline in food aid is offset by private imports, or equivalently, if food aid is sold in open market operations with no distribution of the revenues to the rural poor, the effects on grain prices and real incomes are much smaller (Simulation 5). The decline in

Table 3 — Simulations 4 and 5, Reduced Food Aid

	Simulation 4	Simulation 5
	Lower Food Aid	Lower Food Aid w/ Commercial Imports
Production		
Rice	0.15	-0.07
Wheat	6.19	-0.20
Consumer Price		
Rice	0.39	-0.19
Wheat	10.35	-0.33
Imports/Base Consumption		
Rice	0.00	0.00
Wheat	-8.10	0.00
Rice Consumption		
Urban Poor	-0.01	0.18
Urban NonPoor	0.16	0.06
Rural Landless	0.32	-0.26
Rural Small Farm	0.82	-0.04
Rural Large Farm	-0.75	0.07
Total	0.15	-0.07
Wheat Consumption		
Urban Poor	-22.03	0.63
Urban NonPoor	-0.64	-0.07
Rural Landless	-9.12	0.06
Rural Small Farm	-3.55	-0.13
Rural Large Farm	0.88	-0.50
Total	-5.70	-0.08
Real Incomes		
Urban Poor	-0.64	0.10
Urban NonPoor	-0.42	0.07
Rural Landless	-0.70	-0.36
Rural Small Farm	-0.22	0.02
Rural Large Farm	0.37	-0.09
Total	-0.26	-0.11
Calories from Foodgrains (absolute change, kcal/cap/day)		
Urban Poor	-28	2
Urban NonPoor	1	1
Rural Landless	-17	-3
Rural Small Farm	4	-1
Rural Large Farm	-10	0

Source: Model simulations.

incomes of the rural landless as a result of the loss of the value of food aid transfers reduces their market demand for rice, contributing to a slight decline in rice prices (by 0.2 percent). As a group, the rural landless are only marginally affected by the loss of food aid, but this average obscures the fact that the subset of households who were recipients of the food aid suffered declines in real incomes. Lower grain prices convey slight benefits to urban households and small losses for large farmers.

SIMULATION 6: IMPACTS OF IMPORT LIBERALIZATION FOR RICE AND WHEAT

Simulation 6 shows the effects of an import liberalization for rice and wheat. With free trade, wheat prices rise by 4.0 percent to the import parity price (Table 4). Rice prices, within the fob-cif band both before and after liberalization, rise by only 0.4 percent.

Given the small effects on market prices, the effects on production, consumption and incomes are likewise small. Declining wheat consumption by urban poor and rural landless households entails a drop in calories from foodgrains by 13 and 8 calories per person per day, respectively. Thus, the immediate effects of the liberalization are small, given that wheat prices were close to import parity before the liberalization and that neither rice imports nor exports are profitable for private traders given world market prices.

SIMULATIONS 7 - 9: IMPACTS OF HIGHER WORLD PRICES

Simulations 7 - 9 model the effects of higher world prices of rice and wheat with liberalized trade in these commodities (Table 5). Simulations 7 and 8 show the effects of a twenty percent increase in the world prices of rice and wheat, respectively. Simulation 9 models the effects of a simultaneous twenty percent increase in world prices of both of these commodities.

Table 4 — Simulation 6, Liberalized Foreign Trade in Rice and Wheat

	Simulation 6
	Liberalized Trade
Production	
Rice	0.16
Wheat	2.44
Consumer Price	
Rice	0.44
Wheat	4.03
Imports/Base Consumption	
Rice	-0.25
Wheat	-2.78
Rice Consumption	
Urban Poor	-0.25
Urban NonPoor	-0.05
Rural Landless	-0.05
Rural Small Farm	0.21
Rural Large Farm	-0.41
Total	-0.08
Wheat Consumption	
Urban Poor	-8.51
Urban NonPoor	0.06
Rural Landless	-3.11
Rural Small Farm	-1.12
Rural Large Farm	0.88
Total	-1.83
Real Incomes	
Urban Poor	-0.32
Urban NonPoor	-0.20
Rural Landless	-0.28
Rural Small Farm	-0.09
Rural Large Farm	0.22
Total	-0.09
Calories (absolute change, kcal/cap/day)	
Urban Poor	-13
Urban NonPoor	0
Rural Landless	-8
Rural Small Farm	0
Rural Large Farm	-5

Source: Model simulations.

Table 5 — Simulations 7, 8 and 9, Higher World Grain Prices with Liberalized Trade

	Simulation 7	Simulation 8	Simulation 9
	20 Percent increase in World Price of Rice	20 Percent Increase in World Price of Wheat	20 Percent Increase in World Price of Rice and Wheat
Production			
Rice	2.27	0.49	2.27
Wheat	2.44	14.49	14.49
Consumer Price			
Rice	6.18	1.32	6.18
Wheat	4.03	24.83	24.83
Imports/Base Consumption			
Rice	-5.47	-0.25	-4.68
Wheat	8.93	-16.78	-8.30
Rice Consumption			
Urban Poor	-5.01	-0.44	-4.44
Urban NonPoor	-2.32	0.15	-1.75
Rural Landless	-4.26	0.70	-2.91
Rural Small Farm	-2.08	1.84	-0.17
Rural Large Farm	-2.48	-1.82	-3.54
Total	-3.09	0.27	-2.31
Wheat Consumption			
Urban Poor	13.89	-42.37	-30.52
Urban NonPoor	6.85	-1.01	4.60
Rural Landless	11.85	-18.41	-8.04
Rural Small Farm	5.53	-7.23	-2.08
Rural Large Farm	12.15	3.19	12.65
Total	9.87	-11.15	-2.63
Real Incomes			
Urban Poor	-1.72	-1.65	-2.78
Urban NonPoor	-0.85	-1.08	-1.60
Rural Landless	-1.43	-1.44	-2.38
Rural Small Farm	-0.26	-0.52	-0.65
Rural Large Farm	1.69	1.04	2.25
Total	-0.26	-0.52	-0.65
Calories from Foodgrains (absolute change, kcal/cap/day)			
Urban Poor	-27	-58	-79
Urban NonPoor	-15	0	-12
Rural Landless	-25	-33	-53
Rural Small Farm	-16	9	-7
Rural Large Farm	-18	-23	-33

Source: Model simulations.

With a twenty percent increase in the world price of rice and free trade, Bangladesh becomes a rice exporter, with the decline in net imports equal to 5.5 percent of base consumption.[3] Domestic rice prices rise by 6.2 percent in this scenario, while wheat prices remain at import parity, 4.0 percent above the base level. The increase in rice prices shifts consumer demand toward wheat. Wheat consumption rises by 9.9 percent while rice consumption falls by 3.1 percent. In response to higher producer prices, rice and wheat production also increase slightly (2.3 and 2.4 percent, respectively). Wheat imports also increase by 8.9 percent of base consumption.

Real incomes of food deficit households decline in this simulation. Real incomes of the urban poor fall by 1.7 percent and those of the rural landless fall by 1.4 percent. Although the shift towards wheat helps mitigate the effects on calorie consumption, grain calorie consumption falls by 27 and 25 calories per person per day for the urban poor and rural landless, respectively. Real incomes of rural large farm households rise by 1.7 percent, though the increase in rice prices leads to a decline in their calorie consumption of foodgrains by 18 calories per person per day.

A 20 percent rise in the world price of wheat with free trade has larger effects on domestic prices since wheat prices are at import parity both before and after the change in world prices (Simulation 8). The domestic price of wheat rises by 24.8 percent (the rise is slightly greater than 20 percent since domestic wheat prices in the base year (1991-92) were slightly below import parity). Imports as a share of base consumption fall by 16.8 percent while domestic production of wheat rises by 14.5 percent.

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[3] In the base year, 1991-92, rice imports were equal to 0.25 percent of domestic consumption. With a 5.47 percent decline in net imports as a share of base consumption, rice exports are equal to 5.22 percent of base consumption.

Higher wheat prices lead to a large shift out of wheat by the urban poor, reducing their wheat consumption by 42.4 percent and their total grain calorie consumption by 58 calories per capita per day. Large farmers see a 1.0 percent gain in real incomes, due to higher prices for their grain output.

With free trade and higher world prices in both rice and wheat, rice prices rise 6.2 percent to the new export parity and wheat prices rise 24.8 percent to the new import parity. Rice exports are equal to 4.4 percent of base rice consumption and wheat imports fall by 8.3 percent of base wheat consumption. Real incomes fall sharply in this scenario for the urban poor (2.8 percent) and the rural landless (2.4 percent), while rural large farm households enjoy a 2.3 percent gain in real incomes. Calorie consumption from grain falls by 79 calories per capita per day for the urban poor and 53 calories per capita per day for the rural landless.

SIMULATION 10: IMPACTS OF AN EXCHANGE RATE DEVALUATION

In simulation 9, a 10 percent exchange rate devaluation is modeled, with free trade in rice and wheat (Table 6). Consumer prices of wheat rise by 14.4 percent, slightly more than the amount of the devaluation since wheat prices were slightly below border prices in the base year. Rice prices are little affected since rice is a non-traded good both before and after the devaluation.

Higher prices of wheat and other traded goods lead to reductions in demand for these commodities and a drop in imports. Wheat imports fall by 22.2 percent of base consumption. Real incomes fall for all households, though the decline for large farmers is minimal. For the rural landless and small farmers there is a large decline in calories deriving from grain, 69 and 62 calories per capita per day, respectively. In part this is offset by increased calorie consumption from other food.

Table 6 — Simulation 10, Exchange Rate Devaluation

	Simulation 10
	10 Percent Devaluation
Production	
Rice	0.03
Wheat	8.57
Consumer Price	
Rice	0.09
Wheat	14.43
Imports/Base Consumption	
Rice	-0.25
Wheat	-21.95
Rice Consumption	
Urban Poor	4.64
Urban NonPoor	3.23
Rural Landless	-1.14
Rural Small Farm	-3.23
Rural Large Farm	-2.43
Total	-0.22
Wheat Consumption	
Urban Poor	-24.85
Urban NonPoor	-8.42
Rural Landless	-24.58
Rural Small Farm	-9.08
Rural Large Farm	-21.76
Total	-18.63
Real Incomes	
Urban Poor	-2.76
Urban NonPoor	-2.60
Rural Landless	-2.43
Rural Small Farm	-1.59
Rural Large Farm	-0.15
Total	-1.67
Calories from Foodgrains	
Urban Poor	10
Urban NonPoor	23
Rural Landless	-69
Rural Small Farm	-62
Rural Large Farm	1

Source: Model simulations.

It must be emphasized, however, that the assumption that non-agricultural incomes do not change is especially harsh in this simulation. Some non-agricultural income is related to production of tradable goods and would be expected to increase with the devaluation. Moreover, linkage effects of increased production of tradables will have some positive effects on non-tradables. Thus the declines in real incomes shown here may be overstated or even reversed for some households. Simulating the response of non-agricultural output and incomes would be best accomplished in a general equilibrium model. The simulation does highlight, however, the importance of a shift in relative prices of rice and wheat resulting from a devaluation, and points to the direction of effects on consumption and trade.

4. CONCLUSIONS

The changing structure of grain markets in Bangladesh brought about by long-term trends in production and more recently, the liberalization of imports of rice and wheat, has resulted in important changes in the determination of grain prices in Bangladesh. Domestic prices of rice and wheat are now linked with world market prices through the possibility of private trade in these grains. Changes in world prices and levels of food aid in this context will have important implications for real incomes and food consumption of Bangladeshi households, particularly low-income households.

Prior to the liberalization, changes in world prices of grain influenced food markets in Bangladesh only indirectly, by affecting the cost of imports for the government and to some extent the availability of food aid. The amount of grain released in the domestic economy, in terms of food aid or net offtake of government stocks, figured into the determination of market prices.

In the post-liberalization world, changes in world prices have the potential to have major effects on household incomes and consumption. With Bangladesh's liberalized trade regime, higher world prices for rice and wheat lead to growth of rice exports and increases in wheat imports, but potentially large negative effects on calorie consumption and real incomes of the urban poor and rural landless. Increased demand for labor in a growing economy may mitigate negative effects of increased world grain prices, should they occur, but there still remains a significant role for targeted programs to increase real incomes and food consumption of the poor.

The model presented in this report provides a tool for analyzing the complex interactions between world prices, trade, domestic production, domestic prices, and household incomes and consumption. Further work is needed, particularly on the refinement of estimates of demand parameters for various household groups and estimates of agricultural supply parameters. Analyses of food policy must also be updated as domestic production, world prices and other factors change.

With the increasing reliance of markets for the determination of prices and levels of trade in foodgrains in Bangladesh, timely analysis of the impacts of changes in world market conditions, production shocks and government policies will become increasingly important. Taking into account the interactions across commodities in food markets and the effects on various household groups, particularly the poor, are an essential aspect of this analysis.

APPENDIX 1: BASE DATA FOR THE MULTI-MARKET MODEL

Because of data limitations, two different approaches are used in estimating supply, demand, and prices of commodities in the multi-market model. For rice, wheat, potatoes, edible oils, and onions, production and trade data form the basis for total supply, and household consumption is calculated as a residual. For the other commodities, published production estimates are considerably more uncertain, and consumption data from the Household Expenditure Survey of 1988-1989 form the basis for estimates of demand. Here, the value of production is calculated as a residual.

PRODUCTION

National production data for rice, wheat, potatoes, edible oils, and onions for the annual model are for the 1991/92 crop year from BBS (1993, pages 251-263) and Ministry of Food (1993). Production of the other crops is derived as a residual from estimates of value of consumption.

For rice, wheat, pulses, fruits and vegetables, potatoes, edible oils, onions, and spices and sugar, crop production is disaggregated by rural household group using the share of area operated as calculated from the 1983/84 Agricultural Census, (BBS, 1986, volume II, pages 111-112). For fish, a constant production per capita is assumed across rural household groups. For meat and milk, the shares of area operated for rice and wheat are used to allocate production across households. Production of other food, fuel, and non-food is not distributed across household groups.

CONSUMPTION

For rice, wheat, potatoes, edible oils, and onions, total quantity consumed (C_i) is calculated as the residual quantity of production plus imports, less changes in stock and other non-consumption end uses. For the other commodities, "quantity" consumed is calculated as estimated value of consumption, divided by implicit prices paid by urban and rural households.

The breakdown of consumption per household is based on data from the 1988-1989 Household Expenditure Survey, market prices for 1989 and 1991, and marketing margins for each crop. Shares of value of consumption are estimated from the HES data from 1989 and population growth rates. Using the adjusted HES shares of urban and rural value of consumption and urban and rural prices, it is possible to calculate total quantities consumed in each area and thus total value of consumption. The HES derived value shares can then be used to estimate value of consumption and quantities consumed for each household group.

Value of consumption of commodity i by household h in 1988-89 is calculated from the HES data using reported population and the value of food consumption per capita by household group. The share of each household group in total value of consumption of each commodity (v_{ih}) then is calculated using the HES 1988-89 figure for value of consumption per household group ($V89_{ih}$) updated to 1991 with an estimated growth rate of population of each household group:[4]

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[1] The assumed population growth rates are 2.0 percent per year for total population, 7.0 percent per year for urban households and 1.23 percent per year (calculated as a residual) for rural households.

$$v_{ih} = V89_{ih} * (1 + g_h) / VTHES_i \tag{1}$$

where $VTHES_i$, the HES-derived estimate of the value of total consumption in 1991 is defined as

$$VTHES_i = \sum V89_{ih} * (1 + g_h). \tag{2}$$

The value shares for urban and rural households, V_{iu} and v_{ir}, are then the sum of the value shares (v_{ih}) for urban and rural households, respectively. Assuming these value shares estimated from the 1989 HES data and population growth rates are valid for 1991, then:

$$V_{iu} = PC_i * UC_i / VT_i \tag{3}$$

and

$$v_{ir} = PP_i * RC_i / VT_i, \tag{4}$$

UC_i and RC_i are quantities consumed by urban and rural households, respectively, and VT_i is the total value of consumption of commodity i in 1991.

Dividing v_{iu} by v_{ir} gives:

$$v_{iu}/v_{ir} = (PC_i * UC_i) / (PP_i * RC_i). \tag{5}$$

Given that $UC_i + RC_i = C_i$, it is possible to solve for RC_i in terms of known variables:

$$RC_i = C_i / [1 + (v_{iu}/v_{ir})(PP_i/PC_i)]. \tag{6}$$

Finally, solving sequentially for UC_i and then VT_i, the quantity consumed by each household is found using the value share V_{ih}.

PRICES

For wheat, pulses, fruits and vegetables, potatoes, edible oils, and onions, rural producer prices are production-weighted averages of producer prices across crops using data from BBS (1993). Producer prices for rice are weighted averages of producer prices for the three harvests using data from Ministry of Food (1993). For fruits and vegetables, meat, dairy and other food, the rural producer price is set at 1.00 (Appendix Table 1.1). For most crops, marketing margins are from Mahmud, et. al. (1993, pages A14-A15). Marketing margins for wheat derive from Chowdhury (1992). Urban consumer prices are calculated from the producer prices and the estimated average marketing margin.

Appendix Table 1.2 gives the base data for the variables reported in the simulation results in chapter 3.

Appendix Table 1.1 — Prices and Marketing Margins

	Producer Price	Consumer Price	Marketing Margin
Rice	9.241	11.699	0.266
Wheat	6.413	8.819	0.375
Pulses	11.535	14.996	0.300
Fruits, Vegetables	5.933	8.900	0.500
Potatoes	3.315	4.641	0.400
Fish	1.000	1.400	0.400
Meat	1.000	1.400	0.400
Milk	1.000	1.400	0.400
Oils	12.279	15.963	0.300
Onions and Spices	19.354	25.160	0.300
Sugar	1.000	1.250	0.250
Other Food Crops	1.000	1.000	0.000
Fuel	1.000	1.000	0.000
Non-Food	1.000	1.000	0.000

Sources: BBS (1993); Ministry of Food (1993); Chowdhury (1993); Mahmud, Rahman, and Zohir (1993); and author's calculations.

Appendix Table 1.2 — Base Data, 1991-1992

Production	
Rice	18.182
Wheat	1.065
Consumer Price	
Rice	11.699
Wheat	8.819
Imports/Base Consumption	
Rice	0.249
Wheat	2.778
Rice Consumption	
Urban Poor	0.710
Urban NonPoor	1.112
Rural Landless	5.471
Rural Small Farm	4.316
Rural Large Farm	4.075
Total	15.683
Wheat Consumption	
Urban Poor	0.105
Urban NonPoor	0.163
Rural Landless	1.051
Rural Small Farm	0.697
Rural Large Farm	0.453
Total	2.468
Real Incomes	
Urban Poor	42.117
Urban NonPoor	137.456
Rural Landless	296.438
Rural Small Farm	243.282
Rural Large Farm	252.234
Total	971.527
Calories (absolute change, kcal/cap/day)	
Urban Poor	1029
Urban NonPoor	1267
Rural Landless	1440
Rural Small Farm	1541
Rural Large Farm	1691

Source: Bangladesh Multi-Market Model.

APPENDIX 2: MODEL EQUATIONS

This annex documents the equations of the two versions of the Bangladesh multi-market model, the annual model and the seasonal model. The annual model is somewhat simpler and is presented first. Equations of the seasonal model, including a discussion of the estimation and calibration of the base data, follow.

EQUATIONS OF THE ANNUAL MODEL

Supply, Demand and Incomes in the Annual Model

In the annual model, domestic production of commodity i, X_i, is either fixed exogenously or modeled as a function of the base level of production XO_i and domestic producer prices PP_j:

$$X_i = XO_i * (1 + \sum \epsilon^s_{i,j} * [PP_j/PPO_j - 1])$$

The elasticities of supply, $\epsilon^s_{i,j}$, determine the price-responsiveness of production to changes in the prices of the output and competing activities.

Household consumption of commodity i is a function of prices faced by the household and household income (Y_h). For urban households, consumption is determined

by consumer prices (equation 2). Rural household consumption is determined by producer prices for agricultural commodities produced in rural areas (equation 3).[5]

$$UC_{i,uh} = UCO_{i,uh} * (1 + \sum_j \epsilon^D_{i,j,uh} * [PC_j/PCO_j - 1] + \eta_{i,uh} * [Y_{uh}/YO_{uh} - 1])$$

$$RC_{i,rh} = RCO_{i,rh} * (1 + \sum_j \epsilon^D_{i,j,rh} * [PP_j/PPO_j - 1] + \eta_{i,rh} * [Y_{rh}/YO_{rh} - 1])$$

Total consumption of each commodity i, CD_i, is simply the sum of the demands by all households:

$$CD_i = \sum_{uh} UC_{i,uh} + \sum_{rh} RC_{i,rh}$$

Production of non-agricultural goods is fixed (exogenous) in the model. Non-agricultural incomes for each household, $YNAG_h$, are assumed to change only according to a change in the consumer price of non-agricultural goods.

---

5 In most of the simulations, a logarithmic formulation is used instead of the percentage change equations above (equations 1,2 and 3). The equations are as follows:

$$X_i = XO_i * \prod_j (PP_j/PPO_j)^{\epsilon^S_{i,j}} \quad \textbf{(1a)}$$

$$UC_{i,uh} = UCO_{i,uh} * \prod_j (PC_j/PCO_j)^{\epsilon^D_{i,j,uh}} * (Y_{uh}/YO_{uh})^{\eta_{i,uh}} \quad \textbf{(2a)}$$

$$RC_{i,rh} = RCO_{i,rh} * \prod_j (PP_j/PPO_j)^{\epsilon^D_{i,j,rh}} * (Y_{rh}/YO_{rh})^{\eta_{i,rh}} \quad \textbf{(3a)}$$

$$YNAG_h = YNAGO_h * PC_{NA}/PCO_{NA},$$

Agricultural income for household h is then simply the sum of the gross value of production of each crop times the share of value added in production by household h, VA_{ih}, times the share of production by household h, w_{ih}. In the model, w_{ih} for urban households is assumed to be zero.

$$YAG_h = \sum PP_i * X_i * VA_{ih} * w_{ih}$$

Prices

For tradable goods, the border price is determined as the world price in dollars converted to taka by the exchange rate and adjusted for tariffs and taxes.

$$PM_i = PW_i * ER * (1 + tm_i)$$

The world price of tradable goods, PW_i, is exogenous.

The consumer price for tradable goods is then determined by the border price and marketing costs, $imarg_i$. For goods for which import quotas are binding or for which the government holds a monopoly on trade, $imarg_i$ is endogenous, and includes the implicit subsidies to consumers or rents accruing to the government or traders:

$$PC_{it} = PM_{it} * (1 + imarg_i)$$

Producer prices are related to consumer prices by a marketing margin, $marg_i$, which is fixed for all commodities.

$$PC_i = PP_i * (1 + marg_i)$$

Market Clearing

Given the base levels of consumption, production, incomes and prices, the model solves for new values of all endogenous variables so that total supply equals total demand for each commodity.

$$X_i * (1 - loss_i) = C_i - M_i$$
$$+ GOVPROC_i + GOVIMP_i - OFFTAKE_i + CHPRSTK_i$$

where government procurement, ($GOVPROC_i$), plus government imports, ($GOVIMP_i$), less government distribution ($OFFTAKE_i$) are equal to change in government stocks.[6] These components of the change in government stocks, along with the change in private stocks, are exogenous. For freely traded tradable goods, domestic prices are determined by world prices and the exchange rate (equations 7 and 9), and net imports M_i are endogenous. For "non-tradable goods," net imports are very small relative to total supply and are fixed exogenously. Domestic prices of non-tradables adjust to clear the markets.

For goods for which external trade is completely controlled by the government, imports are fixed exogenously (i.e. they are a policy instrument of the government) and the marketing costs on tradables, $imarg_i$, is made endogenous to reflect rents in addition to normal marketing costs.[7]

In the above basic version of the annual model, non-agricultural incomes and world prices are fixed, and the model solves for changes in market prices, household incomes,

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[6] Note that M_i denotes total imports, i.e. M_i includes government imports.

[7] Rents arise when the amount of government imports is fixed below the level of imports that would be demanded by private importers. These rents are captured either by recipients of the imported good at below-market prices or by individuals within the distribution system.

and household expenditures. Variations of this simplest version of the model are discussed below.

THE SEASONAL MODEL

The seasonal model differs from the annual model in three major ways: the use of an average annual income in the demand equations, a central role for the change in private stocks, and the imposition of an exogenous seasonality pattern to the price data. Moreover, the base data for seasonal consumption by household is in itself generated from the base data for the annual model.

Household incomes for use in the consumption function are redefined as the average household yearly income ($YHAVE_h$):

$$YHAVE_h = Y_h + YL_h$$

where Y_h is the household's current season's income and YL_h is the household's income from the past three seasons. YL_h is thus determined from the base data or from the model solution values of earlier periods. In this way, although production and agricultural incomes are highly seasonal, consumption is spread out throughout the year. Agricultural income in the current period, YAG_h, remains endogenous, while non-agricultural income $YNAG_h$ is fixed.

Change in private stock is fixed at the base level, and is calculated as a residual from production plus net imports less consumption and change in government stocks. In contrast to the annual model, for which the change in private stocks (measured on a year to year basis) is generally fixed at zero, change in private stocks in the seasonal model is fixed at the base levels calculated from equation 10 above.

The base data for rice and wheat prices in the seasonal model derive directly from the national wholesale rice and wheat prices and thus follow historical seasonal patterns. For non-grains, price seasonality is imposed on the base data using the pattern observed in national wholesale rice prices. Since each period's solution is calculated relative to the base data, prices in the model generally follow historical seasonal price movements.

Base consumption is calculated from the household consumption equation using the seasonal values of prices and incomes. The intercept of the consumption equation, $\alpha'_{i,h,t}$, is calculated from the annual data for 1991-92 using the following formula:

$$\alpha'_{i,h,t} = \alpha_{i,h,t} * length\ (t)/12$$

where

$$\ln UC_{i,uh} = \ln \alpha_{i,uh} + \sum_j \beta_{i,j,uh} \ln PC_j + \eta_{i,uh} \ln Y_{uh} \qquad (13)$$

and

$$\ln RC_{i,rh} = \ln \alpha_{i,rh} + \sum_j \beta_{i,j,rh} \ln PP_j + \eta_{i,rh} \ln Y_{rh} \qquad (14)$$

and length (t) is the number of months in season t. The base level of household consumption in season t is then calculated by substituting $\alpha'_{i,h,t}$ for $\alpha_{i,h}$ in equations (13) and (14) and using the seasonal values for PC_j, PP_j and Y_h.

APPENDIX 3: USER'S GUIDE TO THE BANGLADESH MULTI-MARKET MODEL

The Bangladesh multi-market model is written in GAMS (General Algebraic Modeling System), a programming language designed especially for modeling applications. Although this user's guide covers some of the basic features of GAMS, the central focus is the multi-market model, itself. The complete GAMS code for the Bangladesh multi-market model is found in Appendix 4.

BASIC STRUCTURE OF THE GAMS PROGRAM

The GAMS program for the Bangladesh multi-market model contains the following seven major parts:[8]

1) definition of sets,

2) data (including declaration of parameter names and assignment of initial values),

3) declaration of variable names,

4) equations (declaration of equation names and the equations, themselves),

5) initialization of variables and model closure,

6) model definition and solve statement, and

7) computation of output statistics.

The concept of sets is crucial to understanding and using GAMS. In GAMS, sets correspond to the indices in the algebraic symbols for variables or parameters. For example, for the variable X_i, the variable X is defined over the set I. In the GAMS computer code, the set I, along with the elements of the set must be defined, generally at

---

[8] This breakdown of the major parts of a GAMS program is adapted from that in the GAMS user's guide, Brooke, Kendrick and Meeraus (1988).

the beginning of the program. This set notation allows a compact representation of the equations of the model.

In the multi-market model, the major sets are the set I of commodities, the set H of households and the set TP of time periods. Subsets are also defined for the first two of these sets, including the subset IT, the subset of tradable commodities.

In the data section of the GAMS code, parameter names are defined, and data is input and assigned to parameters. Some algebraic manipulation of the data may be done in calculating values of the parameters that correspond to the initial base data, a process termed "calibration".

The names and dimensions of variables then are declared. In GAMS, variables are arrays included in the model equations, whose values may change during a model simulation. They differ from parameters in that parameters are fixed at the time the model is solved and do not change in the model solution process.

Following the declaration of variable names, each equation of the model is also named and its dimension is declared before the equation itself is specified. For example, in the Bangladesh multi-market model, the equation defining the calculation of import prices is declared as PMDEF(I). Subsequently, the equation is defined as:

$$PMDEF(IT)..\quad PM(IT) =E= PW(IT) * ER * (1+TM(IT)); \tag{15}$$

Here PM, PW and TM are the import price in Taka, the world price in dollars, and the import tariff, respectively; ER is the exchange rate. The index IT indicates that the equation PMDEF applies to all members of the subset IT.

Before the model is solved, initial levels of variables are assigned to aid GAMS in finding a solution to the system of equations. Variables in the model may also be made exogenous at this point by fixing the variables at a given level. By making an appropriate

number of variables exogenous, the number of remaining endogenous variables is reduced to equal the number of independent equations, thus "closing" the model.

The model itself is then named and the equations which define the model are explicitly specified. (Only equations that are included in the GAMS model statement are used in the model; equations that are defined but not included in the model statement are ignored.) The solve statement directs GAMS to solve the model using a subroutine (MINOS) and non-linear programming (NLP):

```
SOLVE BANGMM1 MAXIMIZING OMEGA USING NLP ;
```

GAMS requires than an objective function be specified and be either maximized or minimized in the solution process. Thus, an objective function, OMEGA, is also specified in one of the equations of the model, and is maximized in the solution process. Given the structure of the Bangladesh model where there is a unique solution to each simulation, the specification of the objective function is irrelevant.[9]

Finally, output statistics from the solution of the model are computed and displayed. These statistics may also be written to another computer file.

PRICE FORMATION IN THE BANGLADESH MULTI-MARKET MODEL

A key aspect of modeling agricultural and food markets in Bangladesh is the specification of how price formation takes place for each of the commodities. The model permits three basic choices: non-tradable goods with fixed imports and endogenous

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[9] In fact, one useful check on the model is to run the same simulation with alternative objective functions. If the model is specified correctly, changing the objective function should make no difference to the final model solution.

domestic prices, freely traded tradable goods with endogenous imports and domestic prices linked to world prices, and tradable goods constrained by import controls, with exogenous imports, endogenous domestic prices and endogenous margins between the border and domestic markets. Each of these three options involves a different treatment of import marketing margins and imports, as well as affecting the composition of the subset of tradable products, IT (Appendix Table 3.1).

Non-tradable goods are excluded from the set IT.[10] Imports are fixed at their base levels[11] and the import margin, (IMARG), is not used in the model since it is only found in the equation for the consumer price of tradable goods. With trade fixed, changes in demand and domestic supply result in changes in domestic consumer and producer prices, rather than changes in trade.

---

[10] In GAMS, goods are specified as tradable goods by declaring them as members of the subset IT of the set of commodities I. This can be done by including the name of the commodity in the list of elements of the set IT, at the beginning of the program where the set IT is defined. Alternatively, membership in the set IT can be specified later in the program using the following syntax:

```
IT("RICE") = YES ;
IT("WHEAT") = NO ;
```

The first line specifies rice as a member of the set IT; the second line excludes wheat from membership in the set IT.

[11] Variables in the model are fixed at an exogenous level using the following syntax, which in this case, fixes the level of wheat imports at 100:

```
M.FX("WHEAT") = 100 ;
```

Variables which are specified earlier in the program as fixed may be made endogenous by resetting the upper and lower bounds to plus and minus infinity, respectively, thus allowing the variable to take on any value:

```
M.LO("WHEAT") = -INF;
M.UP("WHEAT") = +INF;
```

Appendix Table 3.1 — Model Specifications for Tradable and Nontradable Commodities

	Set	Trade (M)	Import Margin (IMARG)
Non-tradable	not IT	M.FX	not used
Tradable, no restrictions	IT	endogenous	IMARG.FX
Tradable, quantity constrained	IT	M.FX	endogenous

Both freely traded tradable goods and tradable goods constrained by quantitative restrictions are modeled as members of the set IT. For freely traded tradable goods, the import margin IMARG (the percentage marketing margin between the border price and the consumer price) is fixed exogenously, thus directly linking world prices to domestic prices. Changes in demand and domestic supply result in changes in imports, with prices fixed at world price levels adjusted for marketing costs. For tradable goods for which the quantity of imports is determined by the government (e.g. wheat until mid-1992 and rice until mid-1993), the quantity of imports is exogenous and the import marketing margin, which includes the value of economic rents (excess profits) associated with the quantitative restrictions, is made endogenous.

RUNNING POLICY SIMULATIONS

Running a simulation with the model involves changing the levels of exogenous variables and in some instances, parameters or equations, and using GAMS to solve for the levels of all endogenous variables in the model. Generally, these changes in the levels of exogenous variables are made in the closure section of the model.

A production shock can be simulated by fixing the exogenous level of production at a level different from that in the base data. Changes in other exogenous variables such as world prices or government procurement can be modeled in a similar way. Note that for freely traded tradable goods, a shift in domestic production has no effect on the domestic price of the good, since this price is linked directly to the world market price. In an analogous way, a shift in the world price of a tradable good constrained by import

restrictions has no effect on domestic prices since total domestic supply and demand are unchanged if imports remain at their initial level.[12]

In the multi-period model, changes in the levels of exogenous variables in any of the periods of the simulation will potentially alter the model solution for the given period and subsequent periods, as well. Of particular importance in the multi-period model is the behavior of changes in stocks.

SAMPLE SIMULATION CLOSURES

The following simulation closures, used to generate some of the main simulations shown in this paper, illustrate the use of the model.

Simulation 1: Boro Rice Harvest Up 10 Percent (Annual Model)

```
it("rice") = yes;
it("wheat") = yes;
imarg.lo("rice") = -inf; imarg.up("rice") = +inf;
imarg.lo("wheat") = -inf; imarg.up("wheat") = +inf;
m.fx("rice") = m.l("rice");
m.fx("wheat") = m.l("wheat");
x0("rice") = x0("rice") + .1 * 6.804 ;
```

In simulation 1, both wheat and rice are modeled as tradable goods constrained by import restrictions. Thus import margins (which include implicit rents) are endogenous. Imports of both rice and wheat are fixed exogenously at their historical levels. Yields for the boro rice harvest are increased by 10 percent over its base 1991/92 level by raising the base production level X0("rice"). Given that the production variable X("rice") represents annual production of rice (18,182 tons) out of which only 6804 tons was

---

12 The change in world prices does affect the amount of rents generated, however. If household incomes are modeled to include rental incomes, domestic prices of tradable goods with import restrictions will be affected since the change in household incomes will alter demand.

harvested from the boro crop, the increase in the base production level X0 is less than 10 percent. In the model solution, with rice and wheat imports fixed, the increase in rice production leads to an increase in total supply of rice, reducing the rice price.

Simulation 2: Increased Rice Procurement

```
it("rice") = yes;
it("wheat") = yes;
imarg.lo("rice") = -inf;   imarg.up("rice") = +inf;
imarg.lo("wheat") = -inf;  imarg.up("wheat") = +inf;
m.fx("rice") = m.l("rice");
m.fx("wheat") = m.l("wheat");
govproc.fx("rice") = govproc.l("rice") + 0.4 ;
```

In simulation 2, imports of both rice and wheat are again fixed, with the marketing margin between port and wholesale (consumer price) flexible. Government procurement of rice is set at a level 400 thousand tons greater than in the base data. In the model solution, the withdrawal of the procured paddy from the market (with no increase in offtake from government stocks) raises domestic rice prices and leads to shifts in demand for rice, wheat and other commodities.

Simulation 4 : Reduction in food aid wheat

```
it("rice") = no;
it("wheat") = no;
m.fx("rice") = m.l("rice");
m.fx("wheat") = m.l("wheat") - 0.200;
govimp.fx("wheat") = govimp.l("wheat") - 0.200 ;
offtake.fx("wheat") = offtake.l("wheat") - 0.200 ;
* initial wheat offtake is 1.259 million tons
faid.fx("wheat","noland") = faid.l("wheat","noland") - 0.200 ;
** subtract food aid income from rural poor households
** check that faid0("wheat","noland") is initialized
```

In simulation 4, food aid wheat is reduced by 200 thousand tons by simultaneously reducing total imports (M), government imports (GOVIMP) and government distribution

(OFFTAKE). Since levels of both wheat and rice imports are exogenous (fixed), domestic grain prices adjust with changes in the level of demand and total supply.[13]

In order to model the loss of implicit income of rural poor households due to the decline in food aid (assumed to have been previously used for direct distribution to households), the equation defining incomes of households is modified to include the value of the food aid transfer (YFAID), which is defined as:

$$YFAID(RH) = SUM(I, FAID(I,RH) * PP(I)) \quad (16)$$

Simulation 7: Liberalized Grain Prices with Twenty Percent Increases in the World Price of Wheat

```
it("rice") = yes;
it("wheat") = yes;
* rice is non-tradable with free trade and no change in world prices
m.fx("rice") = 0 ;
imarg.lo("rice") = -inf; imarg.up("rice") = +inf;

imarg.fx("wheat") = (1449)/(155*39) + .24 ;
** imarg = (port to wholesale margin)/(world price * erate) + milling cost
** port to wholesale data from MRZ p.A-14;
** milling cost from 42% margin Chowdhury'93,p.74 - 1109
** transport costs from Rahman'93
m.lo("wheat") = 0 ; m.up("wheat") = +inf ;

pw0("rice") = pw.l("rice") * 280/310 ;
* calculate fob rice price from cif rice price
pw.fx("rice") = pw0("rice") * 1.0 ;
pw.fx("wheat") = pw.l("wheat") * 1.2 ;
```

---

[13] Note that rice and wheat are here modeled as nontradables, as they are no longer members of the set "IT". In terms of price formation, this is an equivalent formulation to that used in simulations 1 and 2 above, where rice and wheat are tradables but import marketing margins are endogenous. The only difference is that for rice and wheat, the variables PW (world price), PM (border price of imports) and IMARG (marketing margin on imports) are not included in the GAMS listing for values of model variables. In both cases, however, these variables are fixed.

It should be noted that if implicit rents on imports were modeled as accruing to households as income, then it would be necessary to include rice and wheat as members of the set "IT". See Dorosh and Bernier (1994).

In simulation 7, trade in rice and wheat are liberalized and their world prices are increased exogenously by 20 percent. Such an increase would have no effect on prices if the quantities of rice and wheat imports were fixed at the base level (and if rents are not modeled as a component of household income).

Here, (net) imports of wheat are made endogenous and the import marketing margin (IMARG) is held fixed. For rice, the domestic price is within the f.o.b. - c.i.f. band, so rice is non-traded. Imports are set to zero and the marketing margins are made endogenous.

In running simulations with free trade, it is important to check that if an export (import) parity price is used to set the domestic price of rice or another tradable that the model solution indeed gives a result of positive exports (imports). If this condition is not met, the good should be modeled as a non-traded good. Likewise, if a good is modeled as a non-traded good, the domestic price in the solution of the model should be between the export and import parity. If not, the good should be modeled as a traded good. In the above example, modeling wheat prices at import parity does in fact result in positive wheat imports and modeling rice as a non-traded good does in fact result in a rice price within the f.o.b. - c.i.f band.

Simulation 9: Liberalized Grain Prices with Twenty Percent Increases in World Prices of Rice and Wheat

```
it("rice") = yes;
it("wheat") = yes;
  m.lo("rice") = -inf ;  m.up("rice") = 0 ;
  imarg.fx("rice") = -1286/10864  ;
* imarg("rice") based on mktg costs wholesale to port of 1286 Tk/MT
*  and fob price of 10864 Tk/Mt = 280$/MT * 38.8 Tk/$

imarg.fx("wheat") = (1449)/(155*39) + .24 ;
** imarg = (port to wholesale margin)/(world price * erate) + milling cost
** port to wholesale data from MRZ p.A-14;
** milling cost from 42% margin Chowdhury'93,p.74 - 1109
** transport costs from Rahman'93
```

```
 m.lo("wheat") = 0 ; m.up("wheat") = +inf ;
 pw0("rice") = pw.l("rice") * 280/310 ;
* calculate fob rice price from cif rice price
 pw.fx("rice") = pw0("rice") * 1.2 ;
 pw.fx("wheat") = pw.l("wheat") * 1.2 ;
```

In simulation 9, trade in rice and wheat again are liberalized. Unlike simulation 7, world prices of both rice and wheat are increased exogenously by 20 percent. Net imports of both commodities are made endogenous and the import marketing margins (IMARG) are held fixed. For rice, this margin is negative, since for an export commodity the wholesale price is less than the price at the port (f.o.b. price). In addition, the world price of rice is adjusted to reflect an f.o.b. price rather than a c.i.f. price.

Checking the consistency conditions outlined above confirms that with rice prices at export parity the model solution gives positive rice exports and that with wheat prices at import parity there are positive wheat imports.

APPENDIX 4: GAMS COMPUTER CODE FOR THE BANGLADESH MULTI-MARKET MODEL

```
$TITLE BANGLADESH MULTI-MKT MODEL       BANG1.GMS      6/28/94
$OFFSYMLIST OFFSYMXREF
* Simulation 9: Trade liberalization with higher world prices of rice and
*     wheat
 SET I      COMMODITIES    /RICE          1 RICE
                            WHEAT         2 WHEAT
                            PULSES        3 PULSES
                            FRTVEG        4 FRUITS AND VEGS
                            POTATO        5 POTATOES
                            FISH          6 FISH
                            MEAT          7 MEAT AND EGGS
                            MILK          8 MILK
                            OILS          9 EDIBLE OILS
                            ONION         10 ONIONS AND SPICES
                            SUGAR         11 SUGAR,SPICES,SALT
                            OTHFOOD       12 OTHER FOOD
                            FUEL          13 FUEL - KEROSENE
                            NONFOOD       14 NON-FOOD EXC FUEL
                            FERT          15 FERTILIZER /

   IC(I)    COMMODITIES CONSUMED BY HOUSEHOLDS
              /RICE,WHEAT,PULSES, FRTVEG, POTATO, FISH, MEAT
               MILK, OILS, ONION, SUGAR, OTHFOOD, NONFOOD/
   IP(I)    FOOD COMMODITIES PRODUCED DOMESTICALLY
              /RICE,WHEAT,PULSES, FRTVEG, POTATO, FISH, MEAT
               MILK, OILS, ONION, SUGAR, OTHFOOD /
   JP(I)    FOOD COMMODITIES PRODUCED DOMESTICALLY PLUS INPUTS
              /RICE,WHEAT,PULSES, FRTVEG, POTATO, FISH, MEAT
               MILK, OILS, ONION, SUGAR, OTHFOOD, FERT/
   IT(I)    COMMODITIES TRADED
              /RICE,WHEAT,PULSES,MEAT,
               MILK, OILS, SUGAR, OTHFOOD /

     H                HOUSEHOLDS       / URB1    URBAN POOR
                                         URB2    URBAN NON-POOR
                                         NOLAND  RURAL LANDLESS
                                         SMFARM  SMALL FARMERS
                                         LGFARM  LARGE FARMERS /
     UH(H)            URBAN HOUSEHOLDS / URB1,URB2 /
     RH(H)            RURAL HOUSEHOLDS / NOLAND, SMFARM, LGFARM /
;

     ALIAS (I,J) ;
     ALIAS (IC,JC) ;
*PARAMETERS

PARAMETER
   TM(I)      IMPORT TARIFF                                  (UNITY)
   EY(H,I)    INCOME ELAST OF DEMAND FOR HOUSEHOLD H         (UNITY)
   ED(I,J,H)  PRICE ELASTICITY OF DEMAND FOR HOUSEHOLD H     (UNITY)
```

```
   AGSHARE(I,H) SHARE OF AGR INCOME PER HOUSEHOLD          (UNITY)
   totcons  total value of consumption                   (bn taka)
   pcwt(i)  weights for consumer price index               (unity)
   CHKPROD(I)   CHECK FOR PRODUCTION DATA
   LOSS(I)  LOSSES FACTOR                                  (UNITY)
   VA(I,H)  VALUE ADDED BY ACTIVITY BY HOUSEHOLD           (UNITY)
   CALKG(I) CALORIES PER KG OF COMMODITY I          (KCALS PER KG)
   CAL(H,I)  CALORIES FROM COMMODITY I                     (KCALS)
   CALO(H,I) INITIAL CALORIES FOR COMMODITY I              (KCALS)
   POP(H)    POPULATION OF HOUSEHOLD H                  (MILLIONS)
*DUMMIES TO HOLD INITIAL DATA
   MARGO(I)  DOMESTIC MARKETING MARGIN                     (UNITY)
   PCO(I)    CONSUMER (URBAN) PRICE                  (Taka per kg)
   PPO(I)    PRODUCER (RURAL) PRICE                  (Taka per kg)
   PMO(I)    IMPORT PRICE                            (Taka per kg)
   PWO(I)    WORLD PRICE                             ($ per ton)
   IMARGO(I)  MARKETING MARGIN ON IMPORTS OR EXPORTS       (UNITY)
   XO(I)     PRODUCTION                                 ('000 TONS)
   CO(I)     TOTAL CONSUMPTION                          ('000 TONS)
   HCO(H,I)  CONSUMPTION BY HOUSEHOLD H                 ('000 TONS)
   MO(I)     IMPORTS (NEGATIVE EXPORTS)                 ('000 TONS)
   IVTGOVO(I) INVESTMENT AND GOV SPENDING                (Bn taka)
   YHO(H)    HOUSEHOLD INCOME                            (Bn taka)
   YHAGO(H)  HOUSEHOLD AGRICULTURE INCOME                (Bn taka)
   YHNAGO(H) HOUSEHOLD NON-AGRICULTURAL INCOME           (Bn taka)
   ERO       REAL EXCHANGE RATE BASE                  (Taka per $)
   CHPRSTKO(I)  CHANGE IN PRIVATE STOCKS                ('000 TONS)
   GOVIMPO(I)   GOVERNMENT IMPORTS                      ('000 TONS)
   GOVPROCO(I)  GOVERNMENT DOMESTIC PROCUREMENT         ('000 TONS)
   OFFTAKEO(I)  DISTRIBUTION FROM GOVT STOCK            ('000 TONS)
   YFAIDO(H)  FOOD AID IMPLICIT INCOME BY HOUSEHOLD      (Bn taka)
   FAIDO(I,H) FOOD AID BY COMMODITY TO HOUSEHOLDS       ('000 TONS)
*BASE DATA

SCALAR
ERO     EXCHANGE RATE    (Taka PER DOLLAR)   / 40.0 /
YO      NATIONAL INCOME          (Bn taka)
YAGO    AGRICULTURAL INCOME      (Bn taka)
YNAGO   NON-AGRICULTURAL INCOME  (Bn taka)
```

TABLE HCO(H,I) INPUT AS VALUE (BN TAKA)

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
URB1	8.3053	0.9213	1.0485	1.8631	0.2774	2.4251
URB2	13.0062	1.4409	2.3609	5.5206	0.6585	7.6350
NOLAND	50.5589	6.7370	5.6022	11.8780	1.4126	13.1400
SMFARM	39.8827	4.4725	4.3194	8.5168	1.0172	9.8671
LGFARM	37.6572	2.9019	4.2423	7.2245	1.0168	8.2488

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
URB1	0.8341	0.3724	0.5239	0.3507	2.0016	3.1380
URB2	5.0606	2.3586	1.3321	0.9469	5.1033	10.5129
NOLAND	4.9858	2.5608	3.0096	1.9489	13.2809	18.5617
SMFARM	4.7068	2.3025	2.1555	1.4238	9.3461	14.2820
LGFARM	4.9538	2.5648	2.1015	1.2338	7.9860	12.6365

+	FUEL	NONFOOD	FERT
URB1	0.0000	10.1703	
URB2	0.0000	49.2650	
NOLAND	0.0000	94.2308	
SMFARM	0.0000	77.2558	
LGFARM	0.0000	90.9755	

TABLE ZZH(*,H) BASE LEVEL HOUSEHOLD INCOME (BN TAKA)

	URB1	URB2	NOLAND	SMFARM	LGFARM
YHO	42.117	137.456	296.438	243.282	252.234
YHAGO					
YHNAGO					

TABLE PRODH(H,I) PRODUCTION BY HOUSEHOLD

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
URB1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
URB2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NOLAND	0.3576	0.0209	0.0286	0.1079	0.0271	0.7561
SMFARM	5.0052	0.2932	0.4006	1.5099	0.3797	10.5823
LGFARM	12.8192	0.7509	1.0260	3.8671	0.9725	27.1032

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
URB1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
URB2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NOLAND	0.3709	0.1845	0.0091	0.0063	0.4204	0.0000
SMFARM	5.1910	2.5818	0.1271	0.0886	5.8839	0.0000
LGFARM	13.2951	6.6125	0.3256	0.2269	15.0698	0.0000

TABLE ZZ(*,I) DIVERSE PARAMETERS AND INITIAL VALUES

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
PCO	11.6993	8.8189	14.9959	8.8995	4.6410	1.4000
PPO	9.2411	6.4130	11.5353	5.9330	3.3150	1.0000
PWO	300	150	100	100	100	100
XPROD	18.1820	1.0651	1.4552	5.4849	1.3793	38.4416
CONS	15.6834	2.4683	1.4552	5.4849	1.2414	38.4416
IVTGOV	0	0	0	0	0	0
IMPORTS	0.0390	1.5250	0.0000	0.0000	0.0000	0.0000
TM	0	0	0	0	0	0
EM	99999	99999	99999	99999	99999	99999
LOSS	0.1	0.1	0	0	0.1	0
CHPRSTK	0.5	0	0	0	0	0
GOVIMP	0.0390	1.5250	0	0	0	0
GOVPROC	0.9396	0.0766	0	0	0	0
OFFTAKE	-0.75928	-1.58634	0	0	0	0

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
PCO	1.4000	1.4000	15.9632	25.1599	1.2500	1.0000
PPO	1.0000	1.0000	12.2793	19.3538	1.0000	1.0000
PWO	100	100	100	100	100	100
XPROD	18.8570	9.3788	0.4618	321.7700	36.2969	59.1311
CONS	18.8570	9.3788	0.7080	289.5930	36.2969	59.1311
IVTGOV	0	0	0	0	0	0
IMPORTS	0.0000	0.0000	0.2463	0.0000	0.0000	0.0000
TM	0	0	0	0	0	0
EM	99999	99999	99999	99999	99999	99999
LOSS	0	0	0	0.1	0	0
CHPRSTK	0	0	0	0	0	0
GOVIMP	0	0	0	0	0	0
GOVPROC	0	0	0	0	0	0
OFFTAKE	0	0	0	0	0	0

+	FUEL	NONFOOD
PCO	1.0000	1.0000
PPO	1.0000	1.0000
PWO	100	100
XPROD	0.0000	321.8974
CONS	0.0000	321.8974
IVTGOV	0	0
IMPORTS	0	0
TM	0	0
EM	99999	99999
LOSS	0	0
CHPRSTK	0	0
GOVIMP	0	0
GOVPROC	0	0
OFFTAKE	0	0

TABLE VA(I,H) VALUE ADDED COEFFICIENT BY ACTIVITY (UNITY)

	URB1	URB2	NOLAND	SMFARM	LGFARM
RICE	0.72	0.72	0.72	0.72	0.72

WHEAT	0.75	0.75	0.75	0.75	0.75
PULSES	0.83	0.83	0.83	0.83	0.83
FRTVEG	0.75	0.75	0.75	0.75	0.75
POTATO	0.76	0.76	0.76	0.76	0.76
FISH	0.83	0.83	0.83	0.83	0.83
MEAT	0.73	0.73	0.73	0.73	0.73
MILK	0.73	0.73	0.73	0.73	0.73
OILS	0.79	0.79	0.79	0.79	0.79
ONION	0.68	0.68	0.68	0.68	0.68
SUGAR	0.70	0.70	0.70	0.70	0.70
OTHFOOD	0.73	0.73	0.73	0.73	0.73

;

TABLE ES(I,J) ELASTICITY OF SUPPLY (UNITY)

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
RICE	0.375	0.000	0.000	0.000	0.000	0.000
WHEAT	0.000	0.610	0.000	0.000	0.000	0.000
PULSES	0.000	0.000	0.110	0.000	0.000	0.000
FRTVEG	0.000	0.000	0.000	0.100	0.000	0.000
POTATO	0.000	0.000	0.000	0.000	0.100	0.000
FISH	0.000	0.000	0.000	0.000	0.000	0.200

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
MEAT	0.100	0.000	0.000	0.000	0.000	0.000
MILK	0.000	0.100	0.000	0.000	0.000	0.000
OILS	0.000	0.000	0.160	0.000	0.000	0.000
ONION	0.000	0.000	0.000	0.050	0.000	0.000
SUGAR	0.000	0.000	0.000	0.000	0.150	0.000
OTHFOOD	0.000	0.000	0.000	0.000	0.000	0.100

+	FUEL	NONFOOD
FUEL	0.000	0.000
NONFOOD	0.000	0.000

```
* INCOME ELASTICITIES OF DEMAND BY HOUSEHOLD    (UNITY)
TABLE EY(H,I)
              RICE    WHEAT   PULSES   FRTVEG   POTATO     FISH
URB1         0.505    0.060    0.620    0.945    0.945    0.920
URB2         0.080    0.135    0.055    0.300    0.300    0.345
NOLAND       0.755   -0.660    0.875    1.150    1.150    0.815
SMFARM       0.640   -1.000    1.270    0.890    0.890    0.290
LGFARM       0.030   -0.190    0.300    0.140    0.140    0.400

   +          MEAT     MILK     OILS    ONION    SUGAR  OTHFOOD
URB1         2.370    0.920    0.970    1.015    0.740
URB2         0.620    0.345    0.420    0.360    1.000
NOLAND       2.110    0.815    0.815    0.645    1.645
SMFARM       0.510    0.290    1.460    0.610    1.920
LGFARM       0.990    0.400    0.400    0.190    0.530
  ;

* Urban Poor (1st and 2nd quartiles)
TABLE EDU1(I,J)   ELASTICITY OF DEMAND URBAN POOR     (UNITY)
              RICE    WHEAT   PULSES   FRTVEG   POTATO     FISH
RICE        -0.890    0.040    0.190   -0.055   -0.055   -0.040
WHEAT        3.670   -2.640   -0.870   -0.900   -0.900   -0.995
PULSES       0.675   -0.315   -0.830    0.930    0.930   -0.280
FRTVEG      -0.960   -0.015    0.155   -1.145   -1.145    0.350
POTATO      -0.960   -0.015    0.155   -1.145   -1.145    0.350
FISH         0.010    0.310    0.295    0.490    0.490   -1.220
MEAT         0.170    0.220   -0.375   -0.710   -0.710   -0.815
MILK         0.010    0.310    0.295    0.490    0.490   -1.220
OILS        -0.180   -0.060   -0.265    0.135    0.135   -0.250
ONION       -0.350    0.050    0.130    0.495    0.495   -0.670
SUGAR        0.275   -0.065   -0.465    0.115    0.115   -0.650
OTHFOOD

   +          MEAT     MILK     OILS    ONION    SUGAR  OTHFOOD
RICE         0.040   -0.040    0.150    0.020    0.035
WHEAT        0.140   -0.995    0.265    0.785    0.480
PULSES       0.010   -0.280   -0.435   -0.350   -0.025
FRTVEG       0.440    0.350   -0.245   -0.095    0.565
POTATO       0.440    0.350   -0.245   -0.095    0.565
FISH         0.060   -1.220   -0.560    0.020   -0.335
MEAT         0.635   -0.815    0.560    1.125   -0.735
MILK         0.060   -1.220   -0.560    0.020   -0.335
OILS         0.190   -0.250   -0.695    0.125    0.025
ONION       -0.125   -0.670   -0.315   -0.320    0.090
SUGAR       -0.245   -0.650    1.110    0.460   -1.275
OTHFOOD

  ;

* Urban Non-Poor (3rd and 4th quartiles)
TABLE EDU2(I,J) ELASTICITY OF DEMAND URBAN NON-POOR  (UNITY)
              RICE    WHEAT   PULSES   FRTVEG   POTATO     FISH
```

RICE	-0.440	-0.025	-0.090	0.080	0.080	-0.075
WHEAT	1.185	0.040	-0.285	-0.530	-0.530	0.055
PULSES	0.410	0.265	-1.280	0.690	0.690	-0.275
FRTVEG	-0.210	-0.035	-0.165	-0.385	-0.385	0.155
POTATO	-0.210	-0.035	-0.165	-0.385	-0.385	0.155
FISH	0.345	0.365	0.080	0.450	0.450	-1.115
MEAT	1.295	-1.060	-0.160	0.495	0.495	0.110
MILK	0.345	0.365	0.080	0.450	0.450	-1.115
OILS	0.530	-0.165	0.400	0.080	0.080	-0.065
ONION	0.540	-0.015	0.105	-0.005	-0.005	-0.195
SUGAR	0.175	0.115	0.100	0.030	0.030	0.610
OTHFOOD						
FUEL						
NONFOOD						

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
RICE	-0.235	-0.075	0.155	0.230	0.320	
WHEAT	0.120	0.055	0.005	-0.450	-0.290	
PULSES	0.445	-0.275	-0.330	-0.270	0.285	
FRTVEG	0.365	0.155	0.200	-0.315	0.080	
POTATO	0.365	0.155	0.200	-0.315	0.080	
FISH	-0.155	-1.115	0.020	0.025	-0.350	
MEAT	-0.605	0.110	-0.125	-0.265	-0.315	
MILK	-0.155	-1.115	0.020	0.025	-0.350	
OILS	-0.255	-0.065	-0.595	-0.350	0.005	
ONION	-0.065	-0.195	0.125	-1.145	0.290	
SUGAR	-0.710	0.610	-0.670	-0.170	-0.470	
OTHFOOD						
FUEL						
NONFOOD						

;

* Adjust sugar elasticity to give non-negative eii for fourth q

* Rural Landless (1st and 2nd quartiles)

TABLE EDR1(I,J) ELASTICITY OF DEMAND RURAL LANDLESS (UNITY)

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
RICE	-0.800	0.015	-0.010	-0.030	-0.030	0.095
WHEAT	2.620	-1.110	0.045	-0.240	-0.240	0.515
PULSES	0.015	0.140	-0.855	0.935	0.935	-0.525
FRTVEG	-0.325	0.055	0.190	-1.475	-1.475	0.005
POTATO	-0.325	0.055	0.190	-1.475	-1.475	0.005
FISH	-0.465	0.445	-0.345	0.200	0.200	-1.630
MEAT	-0.265	0.565	0.165	-0.570	-0.570	0.480
MILK	-0.465	0.445	-0.345	0.200	0.200	-1.630
OILS	-0.200	-0.110	0.020	-0.005	-0.005	-0.020
ONION	-0.060	0.375	-0.055	0.185	0.185	0.020
SUGAR	0.415	-0.290	0.435	0.665	0.665	-0.655
OTHFOOD						
FUEL						
NONFOOD						

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
RICE	-0.140	0.095	0.080	0.115	-0.075	
WHEAT	-0.615	0.515	-0.095	-0.280	-0.175	
PULSES	0.070	-0.525	-0.540	-0.590	0.465	
FRTVEG	0.185	0.005	0.150	-0.230	0.290	
POTATO	0.185	0.005	0.150	-0.230	0.290	
FISH	1.485	-1.630	-0.455	0.040	-0.090	
MEAT	-6.145	0.480	0.615	0.885	2.150	
MILK	1.485	-1.630	-0.455	0.040	-0.090	
OILS	-0.120	-0.020	-1.100	0.095	0.620	
ONION	0.160	0.020	-0.385	-1.010	0.120	
SUGAR	0.280	-0.655	0.360	-0.510	-2.340	
OTHFOOD						
FUEL						
NONFOOD						

* Rural Small Farmers (3rd quartile)
TABLE EDR2(I,J) ELASTICITY OF DEMAND SMALL FARMERS (UNITY)

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
RICE	-0.550	0.000	0.020	0.020	0.020	0.160
WHEAT	1.310	-0.490	0.360	-0.470	-0.470	0.420
PULSES	-0.040	-0.210	-1.000	0.690	0.690	-0.280
FRTVEG	-0.160	0.130	0.240	-1.000	-1.000	-0.040
POTATO	-0.160	0.130	0.240	-1.000	-1.000	-0.040
FISH	0.030	0.060	-0.390	0.220	0.220	-1.130
MEAT	0.270	0.280	1.070	-0.280	-0.280	0.650
MILK	0.030	0.060	-0.390	0.220	0.220	-1.130
OILS	-0.130	-0.090	0.080	0.020	0.020	-0.140
ONION	0.200	0.390	-0.110	0.140	0.140	-0.040
SUGAR	-0.090	-0.640	1.100	-0.180	-0.180	-0.330
OTHFOOD						
FUEL						
NONFOOD						

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
RICE	-0.330	-0.330	0.100	0.140	-0.190	
WHEAT	0.400	0.400	-0.350	0.060	-0.250	
PULSES	0.760	0.760	-0.250	-0.950	0.020	
FRTVEG	0.300	0.300	-0.130	0.000	-0.210	
POTATO	0.300	0.300	-0.130	0.000	-0.210	
FISH	1.400	1.400	-0.090	-0.230	-0.170	
MEAT	-2.940	-2.940	-0.380	0.310	0.520	
MILK	1.400	1.400	-0.090	-0.230	-0.170	
OILS	0.310	0.310	-1.270	-0.250	0.020	
ONION	0.160	0.160	-0.050	-1.060	-0.240	
SUGAR	-0.070	-0.070	-0.330	0.160	-1.530	
OTHFOOD						
FUEL						
NONFOOD						

* Rural NonPoor (4th quartile)
TABLE EDR3(I,J) ELASTICITY OF DEMAND LARGE FARMERS (UNITY)

	RICE	WHEAT	PULSES	FRTVEG	POTATO	FISH
RICE	-0.390	-0.090	-0.030	0.100	0.100	0.000
WHEAT	1.880	-0.210	0.300	-0.770	-0.770	0.720
PULSES	0.440	-0.330	-0.840	0.760	0.760	-0.850
FRTVEG	0.120	0.050	0.220	-0.700	-0.700	0.140
POTATO	0.120	0.050	0.220	-0.700	-0.700	0.140
FISH	0.340	-0.550	-0.340	0.400	0.400	-1.260
MEAT	-0.010	-0.460	-0.140	-0.080	-0.080	0.530
MILK	0.340	-0.550	-0.340	0.400	0.400	-1.260
OILS	-0.020	0.000	0.150	-0.020	-0.020	-0.070
ONION	0.100	0.470	-0.160	-0.060	-0.060	-0.350
SUGAR	0.750	-0.160	0.780	-0.190	-0.190	-0.400
OTHFOOD						
FUEL						
NONFOOD						

+	MEAT	MILK	OILS	ONION	SUGAR	OTHFOOD
RICE	-0.200	0.000	0.260	0.070	0.260	
WHEAT	0.450	0.720	-0.490	0.300	-1.980	
PULSES	0.310	-0.850	-0.180	-0.170	0.560	
FRTVEG	0.140	0.140	-0.420	0.220	0.080	
POTATO	0.140	0.140	-0.420	0.220	0.080	
FISH	0.930	-1.260	-0.400	-0.110	0.600	
MEAT	-1.870	0.530	0.430	0.180	0.420	
MILK	0.930	-1.260	-0.400	-0.110	0.600	
OILS	0.100	-0.070	-0.900	0.000	0.360	
ONION	0.390	-0.350	0.110	-0.700	0.000	
SUGAR	-0.230	-0.400	-0.280	0.150	-0.960	
OTHFOOD						
FUEL						
NONFOOD						

```
ED(I,J,"URB1") = EDU1(I,J) ;
ED(I,J,"URB2") = EDU2(I,J) ;
ED(I,J,"NOLAND")= EDR1(I,J) ;
ED(I,J,"SMFARM") = EDR2(I,J) ;
ED(I,J,"LGFARM") = EDR3(I,J) ;
PC0(I) = ZZ("PC0",I) ;
PP0(I) = ZZ("PP0",I) ;
parameter homogchk(i,h), engelchk(h), hhconval(h), ed0(i,j,h), edchk1(i,h),
 edchk2(i,h), engel1(h) ;
ed0(i,j,h) = ed(i,j,h) ;
homogchk(i,h) = sum(j,ed(i,j,h)) + ey(h,i) - ed(i,"potato",h) -
ed(i,"milk",h);
display homogchk ;
display ed ;
** corrections to cross-price elasticities for disaggregation of commodities
** note that hc0 still contains values at this point in the program
ed(i,"frtveg",h) = ed0(i,"frtveg",h) *
hc0(h,"frtveg")/(hc0(h,"frtveg")+hc0(h,"potato")) ;
ed(i,"potato",h) = ed0(i,"frtveg",h) *
hc0(h,"potato")/(hc0(h,"frtveg")+hc0(h,"potato")) ;
ed("frtveg","frtveg",h) = ed("frtveg","frtveg",h) + ed("frtveg","potato",h) ;
ed("potato","potato",h) = ed("frtveg","frtveg",h) ;
ed("frtveg","potato",h) = 0 ; ed("potato","frtveg",h) = 0 ;
ed(i,"meat",h) = ed0(i,"meat",h) * hc0(h,"meat")/(hc0(h,"meat")
     + hc0(h,"milk"));
ed(i,"milk",h) = ed0(i,"meat",h) * hc0(h,"milk")/(hc0(h,"meat")
     + hc0(h,"milk"));
ed("meat",j,h) = ed("fish",j,h) ;
ed("meat","meat",h) =
ed("meat","meat",h)+ed("meat","milk",h)+ed("meat","fish",h) ;
ed("fish","fish",h) = ed("meat","meat",h) ;
ed("milk","milk",h) = ed("meat","meat",h) ;
ed("meat","milk",h) = 0; ed("milk","meat",h) = 0;
ed("fish","milk",h) = 0; ed("milk","fish",h) = 0;
ed("fish","meat",h) = 0; ed("meat","fish",h) = 0;
ey(h,"meat") = ey(h,"fish") ;

* check homogeneity of degree 0
* edchk1(i,h) = ed(i,"frtveg",h)+ed(i,"potato",h) - ed0(i,"frtveg",h) ;
* edchk2(i,h) = ed(i,"meat",h) + ed(i,"milk",h) - ed0(i,"meat",h) ;
* display edchk1, edchk2 ;
homogchk(i,h) = sum(j,ed(i,j,h)) + ey(h,i) ;
display homogchk ;
```

```
* check Engel's Law
hhconval(h) = sum(i,hc0(h,i)) ;
engel1(h) = sum(i,hc0(h,i)*ey(h,i)/hhconval(h)) ;
ey(h,"othfood") = (1 - engel1(h))
    /((hc0(h,"othfood")+hc0(h,"fuel")+hc0(h,"nonfood"))/hhconval(h));
ey(h,"fuel") = ey(h,"othfood") ;
ey(h,"nonfood") = ey(h,"othfood") ;
ed("othfood","othfood",h) = -ey(h,"othfood") ;
ed("fuel","fuel",h) = -ey(h,"fuel") ;
ed("nonfood","nonfood",h) = -ey(h,"nonfood") ;
engelchk(h) = sum(i,hc0(h,i)*ey(h,i)/hhconval(h)) ;
display engelchk ;
display ed, ey ;
* Note that symmetry is not imposed

TM(I) = ZZ("TM",I) ;
IMARGO(I) = .1 ;
PMO(I) = PCO(I)/(1+IMARGO(I)) ;
PWO(I) = PMO(I)/(ERO*(1+TM(I))) ;
PWO("RICE") = .325 ;
PMO("RICE") = PWO("RICE")*(ERO*(1+TM("RICE"))) ;
IMARGO("RICE") = PCO("RICE")/PMO("RICE") - 1;
PWO("WHEAT") = .155 ;
PMO("WHEAT") = PWO("WHEAT")*(ERO*(1+TM("WHEAT"))) ;
IMARGO("WHEAT") = PCO("WHEAT")/PMO("WHEAT") - 1;
* PWO(I) = ZZ("PWO",I)/1000 ;
* PMO(I) = PWO(I)*(ERO*(1+TM(I))) ;
* IMARGO(I) = (PCO(I)/PMO(I) - 1)$PMO(I);
* XO(I) = ZZ("XPROD",I) ;
XO(I) = SUM(H,PRODH(H,I)) ;
XO("SUGAR")=ZZ("XPROD","SUGAR") ;
XO("OTHFOOD")=ZZ("XPROD","OTHFOOD") ;
XO("NONFOOD")=ZZ("XPROD","NONFOOD") ;
CHKPROD(I) = XO(I) - ZZ("XPROD",I);
DISPLAY XO, CHKPROD ;
MO(I) = ZZ("IMPORTS",I) ;
IVTGOVO(I) = ZZ("IVTGOV",I) ;

CHPRSTKO(I)= ZZ("CHPRSTK",I) ;
GOVIMPO(I) = ZZ("GOVIMP",I) ;
GOVPROCO(I) = ZZ("GOVPROC",I) ;
OFFTAKEO(I)= -ZZ("OFFTAKE",I) ;
* MARG(I) = ZZ("MARGIN",I) ;
MARGO(I) = (PCO(I)/PPO(I) - 1)$PPO(I) ;
LOSS(I) = ZZ("LOSS",I) ;
```

```
* ASSUME NO AGRIC PRODUCTION FOR URBAN HOUSEHOLDS

AGSHARE(I,UH) = 0 ;
AGSHARE(I,H) = (PRODH(H,I)/XO(I))$XO(I) ;
DISPLAY AGSHARE ;
YHO(H) = ZZH("YHO",H) ;
YHAGO(H) = SUM(I,PRODH(H,I)*PPO(I)*VA(I,H)) ;
* YHAGO(H) = SUM(I,PRODH(H,I)*PPO(I))
*               - PRODH(H,"FERT")*PPO("FERT") ;

FAIDO(I,H) = 0 ;
* FAIDO("WHEAT","NOLAND") = GOVIMPO("WHEAT") ;
* DELETE ABOVE LINE FOR STANDARD (NON-FOOD AID) MODEL
YFAIDO(RH) = SUM(I, FAIDO(I,RH)*PPO(I)) ;
YFAIDO(UH) = SUM(I, FAIDO(I,UH)*PCO(I)) ;
YHNAGO(H) = YHO(H) - YHAGO(H) - YFAIDO(H) ;
YAGO = SUM(H, YHAGO(H)) ;
YNAGO = SUM(H, YHNAGO(H)) ;
YO = YAGO + YNAGO + SUM(H,YFAIDO(H)) ;
DISPLAY YFAIDO, YHNAGO, YHAGO, YHO ;
DISPLAY MARGO, YAGO, YO ;
DISPLAY PMO, PCO, IMARGO, TM, PWO ;

hcO(uh,ic) = hcO(uh,ic)/pcO(ic) ;
hcO(rh,ic) = hcO(rh,ic)/ppO(ic) ;
* CO(I) = ZZ("CONS",I) ;
CO(I) = SUM(H,HCO(H,I)) ;
totcons = sum(ic, pcO(ic)*( hcO("urbl",ic)+hcO("urbl",ic))
 + ppO(ic)*(hcO("noland",ic)+hcO("smfarm",ic)+hcO("lgfarm",ic)));
pcwt(ic) = ( pcO(ic)*( hcO("urbl",ic)+hcO("urbl",ic))
 + ppO(ic)*(hcO("noland",ic)+hcO("smfarm",ic)+hcO("lgfarm",ic)) )
       / totcons ;
* population figures are estimates for 1991-92 from sam worksheet
pop("urbl") = 7.124; pop("urb2") = 9.064; pop("noland") = 40.758 ;
pop("smfarm") = 29.286 ; pop("lgfarm") = 24.137 ;
calkg("rice") = 3.3 ;  calkg("wheat") = 3.2 ;
calO(h,i) = (calkg(i)*hcO(h,i)*1000000/365)/pop(h)  ;
* units: (kcal/g)*(10^12 g/year)*(1/365 years/day)/(10^6 persons)

display totcons, pcwt ;
```

```
*CALIBRATION OF PARAMETERS
*DEFINITION OF MODEL - VARIABLES
 VARIABLES

*PRICE BLOCK
   PC(I)     CONSUMER (URBAN) PRICE                        (Taka per kg)
   PP(I)     PRODUCER (RURAL) PRICE                        (Taka per kg)
   PM(I)     IMPORT (EXPORT) PRICE                         (Taka per kg)
   PW(I)     WORLD PRICE                                     ($ per ton)
   IMARG(I)  MARKETING MARGIN ON IMPORTS OR EXPORTS              (UNITY)
   pindex    consumer price index                            (unity)
   MARG(I)   DOMESTIC MARKETING MARGIN                          (UNITY)
*COMMODITY FLOWS
   X(I)      PRODUCTION                                      ('000 TONS)
   C(I)      TOTAL CONSUMPTION                               ('000 TONS)
   HC(H,I)   HOUSEHOLD CONSUMPTION                           ('000 TONS)
   IVTGOV(I) INVESTMENT AND GOVERNMENT SPENDING              (Bn taka)
   M(I)      IMPORTS (NEGATIVE EXPORTS)                      ('000 TONS)
   CHPRSTK(I)  CHANGE IN PRIVATE STOCKS                      ('000 TONS)
   GOVIMP(I)  GOVERNMENT IMPORTS                             ('000 TONS)
   GOVPROC(I) GOVERNMENT DOMESTIC PROCUREMENT                ('000 TONS)
   OFFTAKE(I)  DISTRIBUTION FROM GOVT STOCK                  ('000 TONS)
*INCOMES, ETC.
   Y         NATIONAL INCOME                                 (Bn taka)
   YH(H)     HOUSEHOLD INCOME                                (Bn taka)
   YHAG(H)   HOUSEHOLD AGRICULTURAL INCOME                   (Bn taka)
   YHNAG(H)  HOUSEHOLD NON-AGRICULTURAL INCOME               (Bn taka)
   YFAID(H)  HOUSEHOLD IMPLICIT FOOD AID INCOME              (Bn taka)
   FAID(I,H) FOOD AID BY COMMODITY TO HH                     ('000 TONS)
   ER        EXCHANGE RATE                                ('000 Taka per $)
   CHFSAV    CHANGE IN FOREIGN SAVINGS                        (MN DOLLARS)
*OBJECTIVE FUNCTION
   OMEGA     OBJECTIVE FUNCTION                              (Bn taka) ;
* PC.LO(I) = .01; PP.LO(I) = .01 ; PM.LO(IM) =.01;
```

```
* MODEL DEFINITION - EQUATIONS
 EQUATIONS
*PRICE BLOCK
   PMDEF(I)       DEFIN OF IMPORT (EXPORT) PRICE     (Taka per kg)
   PPDEF(I)       DEFIN OF PRODUCER PRICE            (Taka per kg)
   PCDEF(I)       DEFIN OF CONSUMER PRICE            (Taka per kg)
*COMMODITY FLOWS
   XDEF(I)           PRODUCTION EQUATION                ('000 TONS)
   CONDEF(I)         CONSUMPTION EQUATION               ('000 TONS)
   HCONDEF(H,I)      HOUSEHOLD CONSUMPTION EQUATION     ('000 TONS)
   RHCONDEF(H,I)     RURAL HOUSEHOLD CONSUMPTION EQN    ('000 TONS)
   EQUIL(I)          EQUILIBRIUM EQUATION               ('000 TONS)
*INCOMES,ETC.
   YDEF              INCOME EQUATION                      (Bn taka)
   YHDEF(H)          HOUSEHOLD INCOME EQUATION            (Bn taka)
   YHAGDEF(H)        AG INCOME EQUATION                   (Bn taka)
   RHYFADEF(H)       RURAL FOOD AID INCOME EQN            (Bn taka)
   UHYFADEF(H)       URBAN FOOD AID INCOME EQN            (Bn taka)
   FSAVEQ            FOREIGN SAVINGS CONSTRAINT  (MILLION DOLLARS)
*OBJECTIVE FUNCTION
   OBJ               OBJECTIVE FUNCTION

*MODEL DEFINITION - PRICE BLOCK

 PMDEF(IT)..   PM(IT) =E= PW(IT)*ER*(1 + TM(IT)) ;
 PPDEF(IC)..    PP(IC) =E= PC(IC) / (1 + MARG(IC)) ;
 PCDEF(IT)..   PC(IT) =E= PM(IT) * (1 + IMARG(IT));
** PCDEF DETERMINES CONS PRICE OF TRADED GOODS
** IF IMPORTS ARE FIXED, IMARGS ARE ENDOGENOUS AND INCLUDE RENTS

 XDEF(IP)..    X(IP) =E= X0(IP) *
                      PROD(JP,(PP(JP)/PP0(JP))**ES(IP,JP)  );
 CONDEF(IC)..   C(IC) =E= SUM(H, HC(H,IC)) ;
 HCONDEF(UH,IC)..  HC(UH,IC) =E= HC0(UH,IC)
                      * prod(JC,(PC(JC)/PC0(JC))**ED(IC,JC,UH)  )
                      * (YH(UH)/YH0(UH))**EY(UH,IC) ;
 RHCONDEF(RH,IC)..  HC(RH,IC) =E= HC0(RH,IC)
                      * prod(JC,(PP(JC)/PP0(JC))**ED(IC,JC,RH)  )
                      * (YH(RH)/YH0(RH))**EY(RH,IC) ;
 YHDEF(H)..     YH(H) =E= YHAG(H)
                        + YHNAG(H)*pc("nonfood")/pc0("nonfood")
                        + YFAID(H) ;
 YHAGDEF(H)..    YHAG(H) =E= SUM(IP, AGSHARE(IP,H)*PP(IP)*X(IP)*VA(IP,H) ) ;
 RHYFADEF(RH)..  YFAID(RH) =E= SUM(I, FAID(I,RH)*PP(I) ) ;
 UHYFADEF(UH)..  YFAID(UH) =E= SUM(I, FAID(I,UH)*PC(I) ) ;
 FSAVEQ..      CHFSAV =E=
            SUM(IT,PW(IT)*M(IT)) - SUM(IT,PW0(IT)*M0(IT))
    + PW("NONFOOD")*M("NONFOOD") -PW0("NONFOOD")*M0("NONFOOD");

*MARKET CLEARING
 EQUIL(IC)..   X(IC)*(1-LOSS(IC)) =E= C(IC)+IVTGOV(IC) - M(IC)
      + GOVPROC(IC) + GOVIMP(IC) - OFFTAKE(IC) + CHPRSTK(IC) ;
```

```
 OBJ..          OMEGA =E= YH.L("URB1") ;
* OBJ..          OMEGA =E= 10 ;

*MODEL SETUP - INITIALIZATION
PC.L(I)=PC0(I); PP.L(I)=PP0(I); PW.L(I)=PW0(I); PM.L(I)=PM0(I) ;
X.L(I)=X0(I); C.L(I)=C0(I); M.L(I)=M0(I) ; MARG.L(I) = MARG0(I) ;
IVTGOV.L(I) = IVTGOV0(I) ;
* OMEGA.L = YH0("URB1") ;
OMEGA.L = 10;
* YAG.L = YAG0; YNAG.L = YNAG0; Y.L = Y0 ;
YH.L(H) = YH0(H) ; YHNAG.L(H)=YHNAG0(H); YHAG.L(H)=YHAG0(H) ;
HC.L(H,I) = HC0(H,I) ;
PP0("FERT") = 1; PP.L("FERT") = 1;
IMARG.L(I) = IMARG0(I) ;
er.l = er0 ; CHFSAV.L = 0 ;
FAID.L(I,H) = FAID0(I,H) ;    YFAID.L(H) = YFAID0(H) ;
pindex.l = sum(ic,pcwt(ic)*pc.l(ic)/pc0(ic) ) ;
display pc.l,pc0, pindex.l;

parameter  wt(h,i)   consumer price index weight  (unity)
           totexp(h) total household expenditure  (unity) ;
totexp(h) = sum(ic,pc.l(ic)*hc.l(h,ic)) ;
wt(h,ic) = pc.l(ic)*hc.l(h,ic)/totexp(h) ;
totexp(rh) = sum(ic,pp.l(ic)*hc.l(rh,ic)) ;
wt(rh,ic) = pp.l(ic)*hc.l(rh,ic)/totexp(rh) ;
display totexp,wt ;

*CLOSURE
CHPRSTK.FX(I)= CHPRSTK0(I) ;
GOVIMP.FX(I) = GOVIMP0(I) ;
GOVPROC.FX(I)= GOVPROC0(I) ;
OFFTAKE.FX(I)= OFFTAKE0(I) ;
IVTGOV.FX(I) = IVTGOV0(I) ;
YHNAG.FX(H) = YHNAG0(H) ;
MARG.FX(I) = MARG0(I) ;
X.FX("NONfood") = X.L("NONfood") ;
M.FX(I) = M0(I) ;
M.LO(IT)=-INF; M.UP(IT)=+INF;
M.LO("NONFOOD")=-INF; M.UP("NONFOOD")=+INF;
pw.fx("nonfood") = pw0("nonfood") ;
IMARG.FX(I) = IMARG0(I) ;
PW.FX(I) = PW.L(I);
FAID.FX(I,H) = FAID.L(I,H) ;
 ER.FX = ER0 ;
 PC.FX("nonfood") = PC.L("nonfood") ;
** if tradable and fixed imports, then imarg must be variable
** if tradable and endogenous imports, then imarg (=mktg margin) is fixed
** if non-tradable and fixed imports, imarg does not enter model

* Simulation 9: Free Trade in Rice and Wheat, 20 percent higher PW wheat,rice
it("rice")=yes;
it("wheat")=yes;
```

```
m.lo("rice") = -inf ;  m.up("rice") = 0 ;
imarg.fx("rice") = -1286/10864  ;
* imarg("rice") based on mktg costs wholesale to port of 1286 Tk/MT
*  and fob price of 10864 Tk/Mt = 280$/MT * 38.8 Tk/$

imarg.fx("wheat") = (1449)/(155*39) + .24 ;
** imarg = (port to wholesale margin)/(world price * erate) + milling cost
** port to wholesale data from MRZ p.A-14;
** milling cost from 42% margin Chowdhury'93, p.74
** 1109 transport from Rahman'93
  m.lo("wheat") = 0 ;  m.up("wheat") = +inf ;
  pw0("rice") = pw.l("rice") * 280/310 ;
* calculate fob rice price from cif rice price
  pw.fx("rice") = pw0("rice") * 1.2 ;
  pw.fx("wheat") = pw.l("wheat") * 1.2 ;

  OPTIONS ITERLIM=200, LIMROW=0, LIMCOL=0 ;
*  OPTIONS ITERLIM=1, LIMROW=20, LIMCOL=20 ;
*  OPTIONS SOLPRINT=OFF ;

** NOTE THAT SOME TRADABLE GOODS SHOW M0=0 IN BASE DATA, SO
**  "TRADE" EQN DOES NOT FIX PW FOR THESE GOODS

* MODEL 1 FIXES REAL NON-AG INCOMES (DEFLATED BY PC("NON-AG")
* and fixes pc("non-ag") using simple ("no macro") closure

MODEL BANGMM1  MODEL /
  PPDEF, PCDEF, PMDEF, CONDEF, YHAGDEF, XDEF,
  HCONDEF, rhcondef, YHDEF, FSAVEQ,
  RHYFADEF, UHYFADEF,
  EQUIL, OBJ / ;

 SOLVE BANGMM1 MiniMIZING OMEGA USING NLP;
display pc.l ;
 SOLVE BANGMM1 MaxiMIZING OMEGA USING NLP;
display pc.l ;
```

```
PARAMETER  PCGR(I,*) CONSUMER PRICE CHANGE   (PERCENT)
           PPGR(I,*) PRODUCER PRICE CHANGE   (PERCENT)
           PWGR(I,*) WORLD PRICE CHANGE      (PERCENT)
           XGR(I,*)  PRODUCTION CHANGE       (PERCENT)
           CGR(I,*)  CONSUMPTION CHANGE      (PERCENT)
           CHGR(H,I,*) HOUSEHOLD CONSUMPTION CHANGE (PERCENT)
           MGR(I,*)  TRADE CHANGE AS PCT OF BASE CONS (PERCENT)
           YGR(H)    INCOME CHANGE           (PERCENT) ;
parameter  cpi(h)    consumer price index         (unity)
           realygr(h)   real income change        (unity) ;
cpi(uh) = sum(ic,wt(uh,ic)*pc.l(ic)/pc0(ic) ) ;
cpi(rh) = sum(ic,wt(rh,ic)*pp.l(ic)/pp0(ic) ) ;
PCGR(I,"CONS PRICE") =100*(PC.L(I)/PC0(I) - 1)$PC0(I);
PPGR(I,"PROD PRICE") =100*(PP.L(I)/PP0(I) - 1)$PP0(I);
PWGR(I,"WRLD PRICE") =100*(PW.L(I)/PW0(I) - 1)$PW0(I);
XGR(I,"PROD") =100*(X.L(I)/X0(I) - 1)$X0(I) ;
CGR(I,"CONS") =100*(C.L(I)/C0(I) - 1)$C0(I) ;
CHGR(H,I,"HHCONS") = 100*(HC.L(H,I)/HC0(H,I) - 1)$HC0(H,I) ;
* MGR(I,"TRADE") =100*(M.L(I)/M0(I) - 1)$M0(I);
MGR(I,"TRADE") =100*((M.L(I)-M0(I))/C0(I))$C0(I);
YGR(H) = 100*(YH.L(H)/YH0(H) - 1) ;
realygr(h) = 100*( (yh.l(h)/cpi(h)) / yh0(h) - 1 ) ;
cal(h,i) = (calkg(i)*hc.l(h,i)*1000000/365)/pop(h)  ;
DISPLAY PCGR,PPGR,PWGR,XGR,CGR,CHGR,MGR,YGR,IMARG.L,cpi,realygr, pw.l ;
DISPLAY CHFSAV.L, ER.L, pindex.l ;
display yhag.l, yhag0, yhnag.l, yhnag0, yh.l, yh0, yfaid.l, yfaid0,
   cal, cal0 ;

**PUT CODE**

FILE SOL /'C:\bangla\BANG1_9.PRN'/ ;
PUT SOL ;
SOL.PC = 5 ;
* COMMA DELIMITED FORMAT
* IMPORT FILE INTO LOTUS USING "NUMBERS" OPTION
PUT // ;
PUT /, PUT ' ','Consumer Price', PUT // ;
LOOP(I, PUT I.TL, PC.L(I):11:5, PUT/ ) ;
PUT /, PUT ' ','Import Margin', PUT // ;
LOOP(IT, PUT IT.TL, IMARG.L(IT):11:5, PUT/ ) ;
PUT ' ','Production', PUT // ;
LOOP(I, PUT I.TL, XGR(I,"PROD"):11:3, PUT/ ) ;
PUT /, PUT ' ','Household Consumption', PUT // ;
LOOP(I, PUT I.TL, PUT / ;
  LOOP(H, PUT H.TL, CHGR(H,I,"HHCONS"):11:3, PUT/)  ) ;
PUT /, PUT ' ','Real Income', PUT // ;
LOOP(H, PUT H.TL, REALYGR(H):11:3, PUT/ ) ;
PUT /, PUT ' ','CPI', PUT // ;
LOOP(H, PUT H.TL, CPI(H):11:3, PUT/ ) ;
PUT /, PUT ' ','Consumption', PUT // ;
LOOP(I, PUT I.TL, CGR(I,"CONS"):11:3, PUT/ ) ;
PUT /, PUT ' ','Trade', PUT // ;
```

```
LOOP(I, PUT I.TL, MGR(I,"TRADE"):11:3, PUT/ ) ;
PUT /, PUT ' ','Calories', PUT // ;
LOOP(I, PUT I.TL, PUT / ;
  LOOP(H, PUT H.TL, cal(H,I):11:3, PUT/)  ) ;
```

END OF PUT CODE

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