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THE CHANGING PUBLIC ROLE IN A RICE ECONOMY MOVING TOWARD SELF-SUFFICIENCY. THE CASE OF BANGLADESH

By

Francesco Goletti

International Food Policy Research Institute
1200 17th St., N.W.
Washington, D.C. 20036

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CHAPTER 1: SUMMARY

Bangladesh is moving in a sustained way towards rice self-sufficiency. Production of rice, the major food staple of the country, has grown at a rate of 2.7 percent in the 1980's versus a population growth of 2 percent. For a country characterized by chronic food deficit for a very long time, this is a remarkable accomplishment. Even though the country will continue to be importing wheat for the rest of the decade, the gap between foodgrain requirements of the population and production is narrowing over time. The process of growth has been increasingly stable over time, as shown by a declining coefficient of variation of deviations of rice production around trend from a value of 5.5 percent during the 1970's to 3.3 percent in the 1980's. The sustained growth of rice production and its stability are related to the introduction of high yielding varieties, mainly the Boro rice crop during the winter season, which has risen from 21 percent of total rice production in 1972/73 to 35 percent in 1989/90. It was found that the two main rice crops within one year, Aman and Boro, are negative correlated. This tendency to intra-year compensation implies also a more regular flow of production and a changed pattern of seasonality characterized by smoother price fluctuations.

The growth of production has been accompanied by an increasing reliance on the market process. A series of reforms in the foodgrain sector has removed numerous controls and actively promoted the development of markets. In some cases both an attempt to liberalization, and to privatization has been carried out. Both domestic and international trade of foodgrains and agricultural inputs have been largely opened to the private sector and numerous food subsidies have been eliminated.

This experience of growth of rice production and market development has been characterized by some positive aspects, such as a relatively stable foodgrain price environment and a declining incidence of poverty. Both inter-year and intra-year price variability have decreased substantially during the past two decades, with the coefficient of variation of domestic rice price around their trend declining from a value of 28.1 percent to about 7.5 percent. The decline in variability of domestic prices was partly, but not entirely, parallelled by decline in variability of border prices and international prices. Inter-year variability of domestic prices has declined much more than for international prices. However, that has not implied a complete isolation of international prices from domestic prices. Both domestic prices and border prices

of rice and wheat were found to be cointegrated, implying a long term relation between the series. The incidence of poverty and malnutrition also shows positive improvement, with the percentage of people having a diet less than 80 percent of the calorie requirement declining from about 50 percent in 1981/82 to about 30 percent in 1988/89 according to the Bangladesh Bureau of Statistics.

The degree of commercialization in the foodgrain sector has grown tremendously in the past two decades, from about 15 percent of total production in 1972 to about 50 percent in 1990; at the same time the ratio of public distribution in total marketed supply has decreased from about 78 in the 1970's to 36 percent in the 1980's. The country is now also in a better position of financing the imports of foodgrains. While the value of foodgrain imports represented about 54 percent of total foreign receipts in the Seventies, it declined to 22 percent in the Eighties.

At present, many of the reasons given in the past for the existence of the Public Foodgrain System seem to be less urgent. The changing environment characterized by sustained rice production and market liberalization call for a redefinition of the role of the Public Foodgrain System in the decade of the 1990's.

To this purpose, there is a need to understand the features of foodgrain markets in Bangladesh. The analysis conducted in this study shows that rice markets have exhibited a remarkable capacity of communicating signals of scarcity over time. Moreover, they have proved to be efficient processors of information, without destabilizing prices. The concern that markets may react in a very disordered way generating excessive price variability, once the government withdraws its stabilization policy, is not supported by the data.

Domestic markets have also proved to be fairly integrated spatially. Only a negligible number of segmented market links was found in a sample including weekly coarse rice prices for the 64 districts (zilas) of the country. In most of the remaining market links, prices exhibit long term stationary relations, even after common trends and seasonality are removed. About 60 percent of the magnitude of price shocks is transmitted on average among market links and it takes about 2.6 weeks. Road infrastructure was found to be one major structural determinant of market integration. The effects of price stabilization policy on market integration were found to be more complex. On one hand, stabilization policy has reinforced

comovement of prices at markets located in different district; on the other hand, it was found to slow down the dynamic process of price transmission.

Notwithstanding the encouraging developments in markets and production, still many problems remain. Poverty is widespread in the country, with too many people still lacking basic entitlement to food, even if the country is moving toward self-sufficiency in rice. The official estimates of extreme poverty are in the amount of 30 million in 1988/89. The government can assist these people through a set of well targeted distribution programs, such as subsidies, transfers, and employment schemes. Subsidies under the rationing scheme have come increasingly under attack in the most recent years, because of the large leakages to non beneficiaries. Direct transfers to the poor that are self-targeting, such as food for work programs and vulnerable group feeding programs have been indicated as more appropriate than broad programs, such as food subsidies and price stabilization.

In the past, price stabilization was viewed as a desirable goal of food policy. Both programs to support prices through domestic procurement during the harvest months and programs to put a downward pressure on prices during the lean season have had a negligible effect on prices. The effect of price stabilization on producers and consumers economic welfare have been found to be limited, even if aversion to risk on the part of consumers and producers is taken into account. From the point of view of poverty, price stabilization has also a rather negligible effect; the analysis shows that rice price stabilization is not able to reduce neither the number of poor nor their average calorie gap below the poverty level. Only the distribution of poverty is affected, eliminating the extreme deviations below the poverty level. However, the implementation of efficient price stabilization is quite complex and its cost may well outweigh the quite limited benefits. Finally, even though the contribution of policy to the decline in price variability has been important, counting about 40 percent of the total reduction, the remaining 60 percent has been the result of various other factors, such as the technological change leading to a more balanced intra-year rice crop production and development of efficient markets, in which the useful function of storage to moderate price fluctuations has played an important part.

The prospects of continuous growth in rice yields have been examined within the context of a simulation model where demand parameters for both rural and urban population and different income

groups have been used. Coupled with available estimates of supply response parameters, the prospects of rice surplus appear moderate. On average, only 157 thousand metric tons of rice surplus would result if current prices were to prevail. If prices are let to adjust, only negligible price decline would result. That is also the case in the more favorable scenario of high growth of rice yields. Domestic demand will be capable of absorbing the increased rice surplus without an appreciable decline in price. The analysis of the proposal of supporting rice prices through procurement of domestic production has led to the conclusion that even massive increases of domestic procurement would result in very small price increases, while, at the same time, causing serious capacity and budgetary problems to the government.

The prospects for exporting rice are more interesting. Even though international markets of rice are very thin, the major exporters have been able to improve their share of world exports. In the most recent period, Bangladesh has shown a dynamism in rice production even superior to the first five exporters. The analysis of various comparable varieties of rice produced domestically and internationally has led to the conclusion that high quality of Bangladeshi rice have a comparative advantage. The implication for food security have been examined in the case of swap arrangements whereby rice of high quality rice are traded in exchange of wheat in international markets. It was found that export of moderate quantities of high quality rice has positive effect on aggregate foodgrain consumption, without compromising the food security of the poor.

CHAPTER 2: INTRODUCTION

MOTIVATION

Growth of rice production in Bangladesh has been sustained throughout the two decades since the independence of the country in 1971. The introduction of modern technology has increased yields and changed cropping patterns thanks to the adoption of modern yielding varieties. The country has been able even to accelerate yield growth during the 1980's, notwithstanding two of the worst floods of the century. Productivity growth, as measured by improvements in aggregate yields, has been very high in the most recent years, even in comparison to the five main rice exporters, namely Thailand, USA, Pakistan, Vietnam, and Myanmar. The economy seems to be moving toward rice self-sufficiency; a remarkable accomplishment for a country characterized by chronic food deficit. At the same time, the recent move in many developing countries toward a heavier reliance on the market, and a progressive removal of regulatory measures that directly and indirectly control the operations of the food markets, has also had an influence in Bangladesh. A series of reforms in the foodgrain sector has removed numerous controls and increased the reliance on the private markets. In some cases both an attempt to liberalization, and to privatization has been carried out. Elimination of food subsidies, withdrawal of restrictions to both domestic and international foodgrain trade, liberalization of imports and distribution of fertilizers and irrigation equipment are some of the major accomplishments. This process has not been accompanied by the negative aspects that have characterized some other liberalization experiences. Food prices have been relatively stable and poverty has shown a declining trend.

Notwithstanding these remarkable successes, large segments of the population are still food insecure and the extent of extreme poverty is very considerable. People have gained from productivity growth. However, the gains are still limited, given the extremely low initial conditions of the country, with its vast poverty, low material resource base, and high density of population.

The movement toward rice self-sufficiency coupled with a rapid process of liberalization opens many questions regarding the role of markets and public sector in the foodgrain system. There is a

concern that price instability will result because of structural deficiencies that impede the effective functioning of the market. Even gains in productivity growth are an occasion for concern, when they are seen as the cause of lower rice prices that may hurt producers.

Within this new environment, it is not clear how still relevant are some of the objectives of food policy as laid out in the past, namely price stabilization and price support to producers. New functions, such as those related to the promotion of exports and a facilitating role in the marketing of foodgrain, are becoming object of considerable interest.

OBJECTIVES AND MAIN ISSUES

The main objective of this report is to investigate the changing role of government intervention in the foodgrain markets when the country is moving towards rice self-sufficiency. To this purpose, the study will try to understand the performance of markets and public sector within the context of a growing rice production.

The relation between foodgrain markets and government has been evolving over time, developing from a very heavy control of the sector to a progressive liberalization of many functions. The relation has been influenced by the evolution of the Public Foodgrain System. Since its inception in 1943, the Public Foodgrain System (PFS) in Bangladesh has evolved into a complex set of policies. Initially, the system was essentially subsidizing food distribution to urban consumers under the rationing system; during periods of natural calamities and severe crop failures, relief distribution to rural people was also undertaken (see Hossain 1989). In the period after independence it has expanded to include several activities ranging from public distribution to price stabilization, from domestic procurement to commercial foodgrain imports, from distribution of modern agricultural inputs to agricultural research and extension. Each of these activities has various goals, often overlapping. For example, domestic procurement has the objective of supporting prices, replenishing public storage facilities, and stabilizing prices.

Four specific issues will be examined in the following chapters.

First, the study will address the issue of how effective private markets are in transmitting information over time and over space. Too often, liberalization or intervention policies have been

advocated without knowing the extent and the effectiveness of the market system. In this study the market is considered as a process whereby goods are exchanged and information is disseminated. This process whereby the information conveyed by price signals is transmitted allows agents in the economy to take decisions largely without the need of a centralized mechanism. It is often claimed that markets in many developing countries are not well functioning. Market failures may result as a consequence of the presence of externalities, public goods, imperfect information, non-competitive structure, and incomplete markets, such as those for insurance and futures. In these cases, public intervention may be beneficial to the welfare of the population. As an example, public foodgrain distribution system may be advocated as the result of the incapability of the market to provide for a safety net for poor consumers. Moreover, markets have been often cousidered responsible for aggravating the instability arising from crop failures. There is some evidence (see Ravallion 1987) that markets during the Great Famine of 1974 have not worked efficiently. The arbitrage function of markets over time and space was characterized by destabilizing speculation and failure of market integration. An effective public intervention has to take into account to what an extent markets are capable to process and transmit information without creating instability in the system.

Second, the issue of price stabilization will be analyzed, in order to understand its relevance to the overall goals of food policy. Price stabilization has been considered in the past as one of the main objectives of government intervention in foodgrain sector. The desirability of this goal was based on the perceived positive welfare effect on both producers and consumers. In the past, price stabilization objectives have been implemented in various activities including domestic procurement, imports, and release of foodgrains in the market through either open market sales or ration shops. The management of public stocks was the chosen mode of affecting the availability of foodgrains in the market and to influence prices. However, it is not clear how beneficial these activities have been to its intended beneficiaries, namely poor consumers, and farmers.

Third, the study will examine the prospects of declining rice prices and the concern that the elimination of price support policies such as procurement will put a further pressure down on prices. The prospects of declining rice prices have to be evaluated within the context of both demand and supply movements. The case for the long term decline may have been exaggerated, due to a failure to take into

account both supply and demand factors. Moreover, the effectiveness of domestic procurement as a way of supporting rice prices deserves further consideration. Its past success in supporting prices has been questioned. The function of domestic procurement is sometimes regarded as mainly one of replenishing public storage facilities in order to carry out the distribution policy of the government. The recent elimination of rural rationing, followed by the elimination of other channels of ration distribution, has already started to put pressure on the accumulation of public stocks. Unless countervailing measures are taken, the pressure on storage capacity and fiscal cost can become too high, if domestic procurement or imports are not reduced at the same rate as the public distribution. The enormous amounts of domestic procurement of rice in 1989/90 and 1990/91 are good examples of the high cost involved. This has put procurement activities under a severe scrutiny leading to proposals for both a massive restructuring of their operations and a drastic reduction of their level.

The final issue is to examine the prospects for rice exports. If the likely situation at the end of the decade is one of moderate rice surplus coupled with wheat deficit, some attention should be given to the possibility of trade of foodgrains. Total foodgrain consumption may be increased by swaps of rice for wheat in the international markets. The recent opening of trade of foodgrains to the private sector is a positive movement towards the goal of making international markets accessible to the private sector. That may contribute to improve the food security of the population. The important aspect in this context is the one related to the quality of rice that will have a comparative advantage in international markets. Given the paucity of information available on prices of different rice qualities this question deserves careful consideration.

The Conceptual Framework

In order to address these research issues on market performance, price stabilization, and prospects for price and exports, it is important to understand the links between private markets and the Public Foodgrain System (PFS). These links are illustrated in figure 1. Policies affecting the foodgrain system have to take into account the interplay among three main systems, namely the domestic marketing system, the public foodgrain system, and the rest of the world. The marketing system has the main role of transferring grain from producers to consumers through transport, storage, and processing activities. When

foodgrain trade is allowed, the marketing system will also transfer or receive grains from the rest of the world. The rest of the world acts upon the domestic foodgrain sector mainly through international trade and food aid. The public stocks are augmented by domestic procurement, food aid, and commercial imports, whereas they are decreased by open market sales, transfers, subsidies, and exports. These stock operations are supposed to meet several of goals of food policy, namely food security, price stabilization, price support for producers, and poverty alleviation, whereas the goal of food self sufficiency and productivity growth are the main objective of input policy and research and extension policy. However, each policy has multiple links and objectives. Domestic procurement, for example, serves the objectives of price support to producers, but can also be used to stabilize prices. Price support to producers and price stabilization may also serve the purpose of increasing productivity. Productivity growth, in turn, will contribute to the food security of the country and of the poor. Finally, the overall performance of the foodgrain sector is affected not only by the direct links between the PFS and the private sector. It clearly depends both on the macroeconomic environment (exchange rate policy, credit policy, monetary and fiscal policy), and on the development of adequate infrastructure.

Chapters Outline

Chapter 3 gives the context of foodgrain production and Public Foodgrain policy in Bangladesh. It reviews production trends of major foodgrain crops and the salient features of foodgrain policy. Chapter 4 examines the efficiency of rice markets over time and their integration over space. It introduces a model of storage and tests the hypothesis of destabilizing speculation and informational efficiency; then, it extends the analysis of markets from a time to a space dimension, by studying how the information conveyed by price signals is transmitted from one market to another in a specified geographical area. Chapter 5 analyzes the effects of price stabilization on welfare and poverty on various groups. Chapter 6 relates projection of the foodgrain situation to the relevance of the concern that the elimination of rice price support may result in a heavy fall of prices. Moreover, it examines the prospects for foodgrain trade. Chapter 7 gives the conclusions and policy implications.

CHAPTER 3: THE CONTEXT OF PRODUCTION AND POLICY

INTRODUCTION

Two main features of the foodgrain sectors in Bangladesh have emerged in the past two decades. First, a sustained growth of rice production has moved the country toward declining food gaps. Second, policy has removed several constraints to the operations of private markets and reduced the presence of government intervention in the sector.

The purpose of this chapter is to provide a basis to understand the operating environment of the foodgrain sector, by documenting the characteristics of this experience of production growth and policy liberalization. After presenting some basic features of foodgrain production in Bangladesh, the chapter will focus upon production and price trends. Then, it will give a descriptive analysis of the main components of foodgrain price and public distribution policy.

FOODGRAIN PRODUCTION

Despite the rapid decline of the share of agriculture in total GDP in the Bangladesh economy, from 60 percent in the early 1970's to 40 percent in the late 1980's, the country is still heavily dependent on agriculture for its growth. About 60 percent of the labor force was engaged in activities directly related to agriculture in 1985/86 according to the 1985/86 Labor Force Survey. However, in comparison with other low income Asian countries Bangladesh has one of the lowest records in terms of agricultural growth rate. According to the World Development Report (WDR 1992), during the period 1980-90 Bangladesh agriculture grew at 2.6 percent, versus a growth of 3.1 percent in India, 6.1 percent in China, and 4.3 percent in Pakistan. Because of the large share of agriculture in GDP, that also implies a low growth of GDP. In the period following the constitution of Bangladesh as an independent country in 1971, total growth rate of agricultural GDP has been 2.76 percent, slightly higher than the growth rate of population of 2.16 percent during the same period. Within agriculture, the crop sector has still the main share, providing about three fourths of the sectoral GDP.

Main Foodgrain Crops and Prices

Cereals provide over 75 percent of crop production, contributing about 25 percent of total GDP (see BBS 1991). Rice and wheat are the two main foodgrains in Bangladesh. Whereas wheat is harvested during only one season, between March and April, rice is produced and harvested during most of the year. Within a year three main crops are grown. They are called Aman, which is harvested from November to January, Boro, harvested from April to June, and Aus, harvested from July to September. Aman is the major crop. In the last few years, though, Boro has been increasing very rapidly from a 21 percent share of total foodgrain production in 1973 to an estimated 35 percent share in 1989, largely due to the diffusion of high yielding varieties (HYV) and the extension of irrigation facilities. Aus and Aman shares have declined commensurately. Therefore, rice production is now more evenly distributed during the year, causing arrivals in the market to occur more smoothly.

This change in production is reflected in a change of price seasonality, characterized by two main peaks within the year, one before the Aman harvest, and the other before the Boro harvest (see figures 2 and 3). Harvest prices of both rice and wheat, deflated by the index of wholesale prices, have declined slightly during the past two decades, at a rate of 1.5 percent (see table 1). The decline has occurred mostly during the Eighties, and has been associated with higher growth of rice yields during this latter decade. The relative price of wheat and rice has not exhibited any definite trend.

Growth and Stability of Main Crops

Over the period 1972/73 to 1989/90 total rice production grew at an exponential rate of 2.54 percent, without marked difference in the growth rate of the two decade of the 1970's and 1980's. Most of the growth of rice production in the 80's was due to the growth of Boro production, which is mostly an HYV crop (see table 2 and figures 3-5). In the case of Aus a substitution of acreage towards Boro explains the declining growth of this crop. Wheat has witnessed a remarkable growth over the two decades of the 70's and 80's; during the 80's production growth has slowed down, suggesting the existence of constraints to further improvement in the expansion of this crop (see Mahmud, Rahman, Zohir 1993). By taking the deviations of production figures from trend, it is possible to study the variability of production. This analysis shows that production in the 80's has been more stable than in the 70's. This is the case, even

though the 80's have witnessed two of the worst floods of the century. One of the reasons for this added stability of yearly production is the negative correlation between Aman and Boro production, indicating some tendency to intra-year compensation (see table 3). A bad crop has a tendency to be followed by a good crop within the same year. The failure to take this negative correlation into consideration has been responsible in the past for an exaggerated assessment of food imports requirement (see Hossain 1990). Moreover, this also partly explains why time series estimations of supply response based on yearly production yield very low price elasticities, often not significantly different from zero (see Mahmud, Rahman, Zohir 1993). Seasonal crops may be much more price responsive implying substitution among rice crops, and canceling out the effect at the aggregate level.

Yields and Modern Inputs

Yield growth has been the main source of growth of production; growth of acreage has only contributed about 15 percent of total production growth. Rice yield growth has accelerated from a level of 2.16 percent in the Seventies to 2.7 percent in the Eighties (see table 4), as a result of the introduction of high yielding varieties in Aman production and the increasing share of the Boro crop in total production.

The increase in yield has been the result of the adoption of modern technology, which came as a package of modern inputs including irrigation, fertilizers, and improved seeds. The provision of transportation infrastructure and electricity facilitated the process of development (see Ahmed and Hossain 1991). HYV acreage, namely that part of total acreage devoted to high yielding varieties, has been growing from 11 percent of total area in 1972/73 to 41 percent in 1989/90. While most of Boro and wheat are of HYV type, there is still a broad scope for expansion of high yielding varieties for Aus and Aman (see Table 5).

Irrigated area in Bangladesh has been growing at 4.4 percent over the period 1972/73 to 1989/90 (see table 4). The share of irrigated rice area has increased from 11 percent in 1972/73 to 23 percent in 1989/90. The biggest share of irrigated land is devoted to foodgrains production and is around 90 percent of total irrigated area. There has been a bias toward foodgrains against other crops, the share of irrigated land of which has declined from 13 percent in 1972/73 to 8 percent in 1987/88. Within foodgrains, Boro

has attracted most of the irrigated land, even though the growth of irrigated land devoted to Aman and Aus has been higher.

Irrigation policy has been characterized by a reduction of subsidies and removal of impediments to trade and distribution of irrigation equipment (see Chowdhury and Shahabuddin 1992). The liberalization of import of irrigation equipment in 1988 has resulted in a wider spectrum of minor irrigation equipment available to farmers. Despite the removal of heavier subsidies on similar, "approved" equipment, farmers have been able to expand irrigated areas at a faster rate, because of the enhanced possibility of choosing the adequate equipment (see Gisselquist 1992).

Fertilizer use has been increasing quite rapidly, at an exponential growth rate of 10.8 percent, from an initial level of about 250 thousand metric tons in 1972/73 to about 2 million tons in 1990/91. Since the early 1980's, Bangladesh has reduced fertilizer subsidies considerably, and has promoted the development of private wholesale trade, which was previously heavily controlled by the Bangladesh Agricultural Development Corporation (BADC) (see Chowdhury and Shahabuddin 1992, and Hossain and Dhaly 1991). With the Import Policy Order 1991-93, dated July 1992, private imports of fertilizers have been allowed. This process of liberalization has been accompanied by a slight decrease of the growth of fertilizer use in the 1980's, even though the growth has continued to be at a considerably high level of 9.3 percent.

POPULATION AND FOOD GAPS

The 1991 Census population figure of 109.8 million shows a marked decline of growth during the 1980's. The inter-census growth rate declined from 2.32 in the 1970's to 2.03 in the 1980's. During the 1980's the Planning Commission and the World Bank were using a higher rate. The Bangladesh Bureau of Statistics (BBS) in 1986 adopted higher growth rate that was identical to that of the Planning Commission. On the other hand, the Demographic Survey and the Vital Registration System (VRS) carried out by the BBS since 1980 showed a changed demographic pattern with a crude birth rate of 34 per thousand during the 1980's and a crude death rate of 11.7 percent, giving a natural growth rate of 2.23

percent for the 1980's. Lacking further evidence on this issue, the inter-census growth rate has been used in this study.

From the Census population for 1974 and 1991 it follows that rice production has grown at a rate slightly above the population during this period (2.54 versus 2.16). Foodgrain production has performed a little better, but it has slowed down in the Eighties, because of lower growth of wheat production; rice growth has been stable in both decades. In order to define food gaps, it is necessary to make some assumptions about food requirements. Given a standard of 2200 calories per person per day, a contribution of foodgrain to total calories equal to 75 percent, and a relative share of total foodgrain calorie equal to 88 percent for rice and 12 percent for wheat (as in the Household Expenditure Survey of 1988/89), the daily rice requirements are 419 grams (assuming calorie conversion coefficient of 346 calorie per gram) and the daily wheat requirements are 57 grams (assuming a calorie conversion coefficient of 330 calories per gram). The foodgrain gaps can then be defined as the differences between requirements and availability. Availability is simply measured by total production net of 10 percent for wastage, feed, and seed. The foodgrain gap has declined from a level of about 40 kg in the first part of the Seventies to about 20 kg in the latter part of the Eighties (see figure 5). Figure 6 shows that the gap between rice requirement and rice availability is closing over time, being at about 6 kg per person per year in 1991/92, suggesting that the country is moving toward rice self-sufficiency. Wheat gap, after a downward movement in early eighties, seems to have reached a plateau with a level of about 13 kg per person per year in 1991/92 (see figure 7).

THE EXTENT OF PUBLIC INTERVENTION IN THE FOODGRAIN SYSTEM.

The foodgrain sector in Bangladesh is characterized by the active presence of the government sector, which is involved in various operations related to public distribution, open market sales, procurement of domestic production, and imports. The complex set of these activities is often referred to as stock policy, because of the central role of public foodgrain stocks. Stock policy in Bangladesh has been variously related to both the level and the variability of prices. Its priorities have changed over time. Whereas in the Seventies the concern for price stabilization and food security of the country as a whole were the major concerns, in the Eighties the emphasis shifted gradually towards the alleviation of rural poverty, and price support to producers in view of the declining trend in farmer' prices. Stock policy can be broadly classified into two main dimensions. The first dimension is public distribution and involves various types of subsidies and transfers to selected groups of the population; the second dimension is price stabilization and includes open market sales, imports, and domestic procurement.

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

$$\text{stock} = \delta \cdot \text{stock}(-1) + \text{imports} + \text{procurement} - \text{offtake} \qquad [1]$$

where stock denotes public stock of grain, offtake is public distribution of grain, and δ accounts for losses of grain in public godowns. stock(-1) refers to stock during the previous period.

One way to gauge the extent of government operations in the foodgrain sector is to consider the ratio of total offtake to total availability, the latter being defined as net domestic production (gross production less 10 percent for wastage and feed) plus imports plus opening stocks, for any particular year. The dimension of government intervention in foodgrain distribution has been substantial, ranging from 8 percent to 21 percent, with an average value of 13 percent for the ratio of total offtake to total availability during the period 1972/73 to 1990/91 (see table 6). In this respect the total involvement of the government did not change too much over the past two decades.

Another way to look at the extent of public distribution in the foodgrain market, is to consider the ratio of offtake to marketed surplus. Assuming that marketed surplus grew from 16 percent to 50 of total production (see Chowdhury 1992), then public distribution decreased very considerably from 78 to 36 percent of total marketed production of foodgrains.

COMPONENTS OF THE PUBLIC INTERVENTION IN THE FOODGRAIN SYSTEM

Government intervention in foodgrain markets has tried to affect both the level and the variability of prices through three main components that affect the stock balance equation, namely domestic procurement, public distribution, and imports. The following subsections will describe salient features of these components

Procurement

The two main objectives of domestic procurement have been to replenish public foodgrain storage facilities in order to carry out public distribution and to support domestic prices. The success of the government at achieving either of these two objectives has been quite limited.

First, procurement has represented a small percentage of total foodgrain production, averaging 2.6 percent (see table 6). Moreover, domestic procurement has been unable to supply the public distribution of foodgrains, contributing on average about 20 percent, whereas imports have always been crucial, contributing around 90 percent of total distribution over the period from 1972/73 to 1990/91. The changes between the 70's and the 80's are not very appreciable.

The objective of replenishing public stock has often overlapped with the objective of price support. The result has been a lack of focus and a very limited impact on prices. This is not very surprising given the modest amount of procurement mentioned above. The way the government has implemented procurement activities in the past has been to buy a certain quantity at a preannounced price, called procurement price. Since procurement depends on the capacity and willingness of the farmers and traders to sell (Gulati and Sharma 1990), unless some forced arrangement is put into effect, procurement is constrained by the supply decisions of traders and farmers. That implies that procurement prices should be remunerative with respect to market prices. In fact, for most of the past two decades procurement

prices have been higher than harvest' prices (see World Bank 1990). However, the impact on prices has been quite negligible (see table 7). A simple model of supply and demand balance in the rice sector (see Appendix 1) shows that the elasticity of rice prices with respect to procurement has been just 0.05.

Public Distribution

Public distribution is carried out through releases of foodgrains from public storage facilities. In Bangladesh, these releases are referred to as offtake. Their objective is to make foodgrains available to those sections of the population that are most sensitive to food prices and who, even in normal circumstances, experience malnutrition and hunger. While in the Seventies most of the public supply in Bangladesh has been geared to the needs of the urban population and government employees, in the Eighties this bias against rural areas, where the food problems are often more severe was partly corrected through changes in the rationing system, especially the introduction of rural rationing (see Chowdhury 1988 and World Bank 1990). At the end of the Eighties, however, the rural rationing was eliminated because many doubts were raised about its performance (see Ahmed 1992).

The Public Foodgrain Distribution System in Bangladesh has evolved into a complex set of programs, that fall into one of two broad categories, named monetary distribution and non-monetary distribution. Monetary distribution includes all channels of subsidized distribution, and open market sales. Subsidized distribution is implemented through the ration system, in which ration card holders have the option of drawing their food rations at licensed shops at fixed prices, called ration prices. Non-monetary distribution consists mainly in direct food transfers to the population, through either Vulnerable Group Feeding programs geared to destitute women, or Food for Work and Rural Maintenance programs which have the objective of sustaining employment engaging the poor in the building of rural infrastructure in exchange of food.

The performance of some channels of monetary distribution has been quite dismal, in reaching the intended beneficiaries. Leakages of the order of 70 percent of total distribution have been computed for rural rationing (see Ahmed 1992), and 90 percent for Statutory Rationing (see Haggblade and Rahman 1992). On the other hand, the non-monetary distribution has generally been regarded as effective in

reaching the poor, even though there is still ample scope to reduce the cost and the leakages of the programs (see Chowdhury and Shahabuddin 1992, Hossain and Ashakh 1993).

Open market sales were started in 1979, as a price stabilization mechanism, to be conducted mainly during the lean season, at a trigger price above the procurement price (see Chowdhury 1989). Their role in stabilizing prices has been quite limited, with mixed evidence suggesting that they had moderated price increases. Even though their level has increased during the 1980's, their magnitude is still negligible with respect to other channels of public distribution.

The decline in monetary distribution during the Eighties has been accompanied also by declining subsidies. Ration prices as percentage of market prices have progressively increased. This has been partly responsible for the limited resistance found in the population when rural rationing was eliminated. In the late 1980's ration prices were basically at the same level as market prices.

Imports

Traditionally, imports of foodgrains in Bangladesh have been the domain of public monopoly. Only recently some private imports have been allowed, but their importance is still negligible. The most powerful factor affecting imports has been food aid, which in turn has been responsive to both public stocks and expected production shortfalls. In particular, the ability of Bangladesh to pay for her imports of foodgrains has been growing over the last decade. This is highlighted by the declining value of the food dependency ratio, measured by the ratio of the value of foodgrains imports and the total receipts of the country (see table 6). As the economy has grown, the share of total food imports necessary to guaranteed food security in the total imports has been declining.

Even though trade in foodgrains was heavily controlled by the government during the past two decades, this has not resulted in a complete isolation of domestic price from international prices. The 9-trend of border prices of rice and wheat has been closely followed by domestic prices. A formal test of cointegration between these series points to the existence of a long run relation (see table 8). This suggests that the deviations between domestic and border prices have not driven far apart from a common linear relation.

CONCLUSIONS

Foodgrain gaps between availability and requirement have been declining over time in Bangladesh. This seems to be the result of growth of production coupled with declining growth of population. Growth of rice production, the major food staple of the population, has been sustained and increasingly stable during the past two decades. The main reason is that cropping intensity has increased, as a result of the spectacular growth of Boro production, the dry season rice crop, mostly irrigated and high yielding variety. Fluctuations in yearly production have been smoothened by the increasing share of this crop in yearly production. The process of growth has been associated to the adoption of modern technology involving the combination of new high yielding varieties, irrigation, and fertilizers.

The government has been a critical actor in facilitating the process of diffusion of modern technology. By its involvement in the distribution of modern inputs, irrigation investment, and agricultural research and extension, the government has contributed to long term growth of the foodgrain sector. At the same time, its price policy has tried to affect the level and distribution of prices in such a way to maintain incentives to producers and protect consumers from undesired price fluctuations providing a safety net for the poor groups. Its preferred mode of operations has been to use stock of foodgrains in order to affect total availability.

Its performance with respect to some objectives of food policy, such as food security, price support to producers, and poverty alleviation has been mixed. Most of the public distribution of foodgrain has been originated by imports, of which food aid has been the major component. However, the capacity of the country to pay for its import has grown over time. Food security of the population, especially of the poor ones is still a major concern of the government, but it is more manageable than in the past, given the gain in production.

The performance with respect to price support has been quite mediocre, mostly due to the limited effort done. Domestic procurement has been mainly a way to replenish public storage facilities, with a negligible impact on prices. Public distribution in the form of targeted in kind distribution to the poor has had a moderate success, but food subsidies have largely failed in their purpose of reaching the intended beneficiaries.

Domestic prices of rice and wheat have been partly sheltered by fluctuations from the vagaries of international markets, restricting the access to international trade. However, this has not isolated the trend of these prices from the trend of international prices. The degree of cointegration between domestic and border prices has been very high. In the future, this is likely to further increase given the recent lifting of trade restrictions.

In the past decade, the extent of commercialization of the foodgrain sector has increased considerably. While marketed supply of rice has increased from 15 percent in 1972 to about 50 percent in 1990/91, public distribution has declined from an average of 78 percent of marketed surplus in the Seventies to 38 percent in the Eighties. Moreover, numerous policy changes have created an environment more favorable to the development of markets. Various restrictions to domestic and international trade in foodgrains, irrigation equipment, and fertilizers have been lifted. However, this has created a concern that price instability may result, because of market inefficiency and limited integration of markets. The next chapter will explore these issues in the context of rice markets in Bangladesh.

CHAPTER 4: INFORMATIONAL EFFICIENCY AND INTEGRATION OF RICE MARKETS.

INTRODUCTION.

The success of market reform depends to large an extent on the level of development of existing markets. Structural deficiencies that impede the efficient working of the marketing system endanger the success of liberalization policies. This chapter examines the performance of rice markets focusing upon some issues related to the efficiency of the process of price transmission both over time and over space.

One of the main motivations for government intervention in the rice markets of Bangladesh in the past was the alleged inefficiency of these markets. Specifically, there was a concern that the speculative behavior of rice traders could generate excessive price volatility detrimental to consumers and farmers. In extreme cases such behavior was even identified as one of aggravating causes of famine. There is some evidence that the "Great Famine" of 1974 was to some an extent associated to hoarding behavior on the part of traders (see Alamgir 1980). The diffidence towards grain merchants has been well entrenched both in the general population and in the public administration. It has been at the basis of a series of measures, such as the anti-hoarding laws, that have persisted until recently even though their efficacy has not been subjected to examination.

Similarly, the presence of locations that are not well connected with the rest of the country because of poor infrastructure causes concern that, during period of scarcity, the market process could not smooth price movements. According to this argument, the government should take upon itself the burden of delivering foodgrain to those locations.

This chapter is organized into two parts. The first part examines the issue of informational efficiency within the context of storage behavior on the part of traders. The second part analyzes market integration and relates it to its structural determinants.

THE ANALYSIS OF DESTABILIZING SPECULATION AND INFORMATIONAL EFFICIENCY

The trading sector of foodgrains in Bangladesh is characterized by a variety of agents that are intermediaries between production and consumption (see Chowdhury 1992). Their number has increased considerably in the past twenty years, by a factor estimated between twelve and fifteen since 1973 (see Chowdhury 1992). The marketed supply has also increased tremendously, from fifteen percent of total production twenty years ago to about fifty percent in 1990/91 (see Chowdhury 1992). The process of commercialization was accompanied by an increasing competitiveness of the market, reflected by the exponential increase in the number of marketing agents and the declining marketing costs associated to paddy collection and processing (see Chowdhury 1993).

Price speculation is the behavior of profit maximizing traders who store rice to gain out of price fluctuations. Normal price fluctuations due to seasonality are not the main concern of policy. Seasonal storage performs the useful function of transferring goods from periods of relative abundance, such as after harvest, to periods of relative scarcity, such as during the lean season. Abnormal price fluctuations are those in excess of trend and normal seasonal movements. These excessive price fluctuations create the opportunity for what is perceived as excessive profits on the part of traders. Since speculation is linked to storage activities of traders, the analysis of speculation has to take into account the mechanism of forming expectations, on the basis of which storage decisions are made.

Three major issues are examined in this section. The first issue is to know whether or not speculation is destabilizing. The second issue is to explore if traders use all the available information efficiently. The third issue is to evaluate the concern that excessive price instability may result from the reduction of government intervention in rice markets.

These issues are examined within a context of a model of the rice economy of Bangladesh that incorporates the storage decisions of the trading sector (see Appendix 2).

The model assumes that merchants behave competitively and take decisions based on information arising from both the inherent seasonality of production and the behavior of the public sector which intervenes through procurement of rice, public distribution, imports and buffer stocks operations. Since rice is a storable commodity, the basic decision of a merchant is whether to sell immediately or to store

the commodity in order to sell it later at a higher price. The behavior of risk neutral merchants consists in storing rice until the expected profit equals the cost of holding stock. Since time series data on private stocks are not available, it is necessary to express the unknown private storage quantities in terms of prices and other observable variables. As shown in Appendix 2, this leads to the following equation:

$$p_t = \beta_0 + \beta_1 p_{t+1} + \beta_2 p_{t-1} + \beta_3 x_t + \beta_4 \Delta\Omega_t + \beta_5 \Delta G_{t+1} + \mu_t \qquad [2]$$

where p_t is the price of rice at time t; x_t includes total availability of rice, sp_t, price of wheat, p^w_t, the main grain substitute, and income, Y_t; Ω_t is the information available at time t to traders, different from current prices, and G_t denotes the public stocks at the beginning of period t. The operator Δ refers to the difference operator, so that $\Delta G_{t+1} = G_{t+1} - G_t$; the β_i's are coefficients to be estimated and μ_t is an error term.

The previous equation expresses rice prices as a function of their own past and future, the total availability of rice, wheat price, income, the change in the available information and the change in government stock.

The hypothesis of informational efficiency can now be expressed in terms of the coefficients β_i's. The hypothesis that all information different from current prices is used efficiently is formulated as H_1: $\beta_4 = 0$. If the market is informationally efficient, any change in the information occurred in the past should already be reflected in current prices. If this is not the case, that implies that further profits could be made by using this information. Suppose for example that the level of initial period public stocks is part of this information. Current prices p_t should already incorporate the change in public stock ΔG_t between last period and the current period. If public stocks have increased, prices should presumably have declined, because the government is expected to be in a better position of releasing prices in the market. If this did not happen, then traders would tend to sell part of their stocks in order to make profit.

The hypothesis that traders do not overreact to current prices in forming their expectations about the future, which can also be rephrased as the hypothesis of non-destabilizing price speculation is formulated as H_2: $\beta \cdot \beta_2 = \beta_1$, where β is the factor used to discount the future. For most practical

purposes $\beta = 1$. Then, if the hypothesis H_2 is rejected, the case of over-reaction is when β_2 is greater than β_1, and the case of under-reaction is when $\beta_2 < \beta_1$.

When only one of either H_1 or H_2 cannot be rejected, then a weak form of informational efficiency obtains. A strong form of informational efficiency hypothesis occurs when neither hypothesis H_1 nor H_2 can be rejected. In that case, current prices are processing available information without resulting in excessive profits.

Estimation method and data

The estimation of equation [2] presents some difficulties related to the exogeneity of the stochastic regressors on the right hand side.

First, next period price p_{t+1} is correlated with the error term μ_t, since any shock to current prices is also altering the expectations about future prices and, via storage, the rice availability next period. To take care of this problem instrumental variables for p_{t+1} are used.

Second, given the substitutability between rice and wheat, it is not surprising that also p^w_t should be correlated with the error term μ_t. Therefore, equation [2] might be regarded as one equation in a simultaneous system including p_t, p^w_t, and ΔG_{t+1}, as endogenous variables.

Third, end of period government stocks are also decision variables, that depend on the current state of the foodgrain system.

The consequence of this is that in estimating [2] instrumental variables for both p^w_t and ΔG_{t+1} should be used. The estimation procedure is then a 2SLS where in the first stage p_{t+1}, p^w_t and G_{t+1} are regressed over the instruments, and in the second stage the fitted values $\hat{p}_{t+1}$, $\hat{p}^w_t$, and $\Delta\hat{G}_{t+1}$ from the regression computed in the first stage are used as independent variables.

The sample period is July 1973 to June 1990, a total of 204 monthly observations. Rice prices refer to weighted averages of wholesale monthly coarse rice prices as compiled by the Department of Agricultural Marketing. Wheat prices are also wholesale weighted averages. Both rice and wheat prices are reported in Taka/Maund. Prices are deflated by the price index of manufactured goods, with base 1969-70, as compiled by the Bangladesh Bureau of Statistics (BBS). Rice production, losses, and imports are expressed in metric tons and are in per capita terms.

Instrumental Variables and the Information Set Ω_t.

The instrumental variables used as of time t are:

$$IV_t = \{ p_{t-1}, p_{t-2}, p^w_{t-1}, p^w_{t-2}, G_{t-1}, G^w_{t-1}, spp_t, trend, lossr_{t+3} \} \quad [3]$$

The variable reported for production, spp_t, refers to the production in the last three months; the lead in the variable measuring rice losses, $lossr_{t+3}$, is due to the fact that such losses can be assumed to be known by the agents of the economy at least three months before the harvest .

The information set incorporates variables of different types, such as price variables, supply variables, and policy variables. The specification chosen in this analysis is given by:

$$\Omega_t = \{p_{t-1}, G_t, spp_t\} \quad [4]$$

Different specifications of the Information Set and the set of Instrumental Variables, incorporating variables such as offtake, imports, rainfall could be considered. The specification largely depends on the questions asked. Here, the main interest lies in examining if price speculation in rice markets is reacting inefficiently to information arising from the supply side, the market, and the policy environment. The choice of the three variables in Ω_t is intended to provide an answer to these questions.

Results

The model describes the data generating process quite well (see table 9) for the period starting from June 1975, that is for the period after the Great Famine of 1974. The fit of the equation is quite acceptable, the residuals pass the usual test for autocorrelation, normality, autoregressive conditional heteroskedasticity (ARCH), and the White test of heteroskedasticity.

The tests for informational efficiency both in the strong form and in weak form cannot be rejected. Rice markets, for at least the period after the Great Famine seem to be informational efficient. Price speculation is an ongoing activity that accompanies the useful function of storage, consisting in transferring food over time. Contrary to common perception, it is not destabilizing prices.

What can be said about the robustness of this result? In particular, what happens when even the period of the Great Famine of 1974 is included? Ravallion (1987) has shown that markets during this period were informational inefficient.

The model applied to the sample starting from July 1973 shows that the hypothesis of informational efficiency with respect to price information is rejected, whereas the hypothesis of informational efficiency with respect to non price information cannot be rejected. In this case though, the model does not seem to be a good description of the data. Even with an ARCH correction, there is still non normality and autocorrelation of residuals.

In other words, the Great Famine of 1974 (see Alamgir 1980) has been such a great shock for the system that markets have not been able to process information correctly. In particular, markets have over-reacted to current information, putting upward pressure on prices (see Ravallion 1987). This is not surprising, considering a series of internal and external conditions that created exceptional pressure on the system. However, beginning with the period after the Famine of 1974, the foodgrain system seems to have learned the rules of the game. Even if shocks have often been of the same and higher intensity than in 1974, markets and public intervention have reacted in an orderly way.

One possible explanation for the presence of informational efficiency is the reduced role of arbitrage opportunities because of government intervention. This argument can be rephrased as saying that markets have behaved well, mainly because they were not allowed to destabilize prices. The implication of this argument is that the withdrawal of the government stabilizing role would generate excessive instability in the markets. A way to shed some light on this difficult issue is to apply the model to test informational efficiency in two periods, that can be thought as having different degrees of involvement with stock policy. A rough way to measure such involvement is to consider the average foodgrain stock level in per capita terms. The two periods considered in the analysis are July 1975 to June 1982, and July 1982 to June 1990 (see table 10). The first period is showing both a higher level of foodgrain stocks and a higher variability of public stocks, pointing to a greater involvement of stock policy than in the second period. Both periods exhibit a well behaved market behavior, as indicated by the test of informational

efficiency. Therefore, it seems that the concern for destabilizing markets, once the government reduces its presence, are largely exaggerated.

THE CONCEPT AND DETERMINANTS OF MARKET INTEGRATION

Market integration relates to the process of transmission of price signals from one market to another in a specified geographical area. The study of market integration allows to identify groups of integrated markets, so to avoid duplication of interventions. If locations A, B, and C, are well integrated, then the government may think of withdrawing from, or at least reduce, its effort to influence the price process in those locations. A scarcity in A will be quickly transmitted to B, and C, making it redundant to duplicate the same program (for example an open market sale operation, or a procurement activity) in all three locations. Moreover, by giving a more detailed picture of the process of transmission of incentives across the marketing chain, knowledge of market integration is relevant to the success of policies such as market liberalization or price stabilization. Market integration ensures that a regional balance occurs among food deficit, food surplus regions, and regions producing non-food cash crops (see Delgado 1986). If price transmission does not occur, the localized scarcities and abundances may result in excessive strain for the population (see Ravallion 1986). Finally, by identifying the structural factors responsible for the integration of markets, investment policy that is directed to the development of markets could be improved.

The main issues and methodology

Most of past studies have identified market integration with one specific measure, be it correlation coefficients (see Farruk 1970, Lele 1972, Jones 1972, Blyn 1973), cointegration coefficients (see Ardeni 1989, Goodwin and Schroeder 1991, Wyeth 1992, Palaskas and Harris 1991, Goletti 1993), or any other measure derived from time series analysis. However, a comparison of various measures as well as an analysis of the structural factors affecting these measures of market integration is necessary in order to address two sets of issues.

The first set of issues is about the concept and measurement of market integration. What does it mean that markets are integrated? How is market integration measured and translated into an

operational concept? How do different measures of market integration relate to each other and what different insights do they give?

The second set of issues is about the relation between market integration and structural factors. What are the main determinants of market integration? To what an extent marketing infrastructure, policy, and production characteristics affect market integration?

These issues are addressed within a two-stage approach. In the first stage, time series analysis of price data is conducted in order to arrive at a reasonable set of measures of market integration. In the second stage, the measures of integration computed in the first stage are related to structural factors. The structural factors considered here are those related to marketing infrastructure, policy, and production.

The analysis uses weekly prices of coarse rice over a period of 3 years, from 1989/90 to 1991/92, and structural variables for 64 districts (zilas). A description of the main structural variables in given in table 11, which shows the marginal self-sufficiency in rice production, the high density of population, and the low level of marketing infrastructure.

MEASURES OF INTEGRATION

The intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets. In the extreme case of two markets A and B completely isolated from each other, the prices of the same commodity should not be related. If the area where market A is located experiences a bad harvest, prices will suddenly increase. In market B, there is no reason to assume that a bad harvest has also occurred. In the absence of trade flows between the two markets, prices in B would not show any movement. On the other hand, if A and B were integrated, the price in B would also increase. This is because some food would flow from B to A decreasing the available supply in B. At the same time the price in A would be lower than in the absence of market integration.

Therefore, the comovement of prices gives an indication of the degree of market integration. However, it is conceivable that two pairs of markets (A,B) and (A',B') exhibit the same degree of price comovement and yet show a different process of price adjustment. That suggests that the dynamics of price adjustment may also give important information about the integration of the two markets. If, for example,

price shocks from A to B take longer to be transmitted than from A' to B', even though the index of price comovement between A and B is the same as between A' and B', then one may think of the second pair as more integrated than the first one.

The next sections consider various measures of integration, all derived from transformation of time series of prices. The first two measures, namely correlation and cointegration coefficients are explicitly trying to capture the comovement aspect of price integration. The last two measures, namely long term multipliers and composite measures, try to capture the dynamic aspect of price integration.

Correlation Coefficients

One simple way to study market integration is to consider correlation of price series at different markets. This is intuitively related to the idea that integrated markets exhibit prices that move together. Price correlations are the easiest way to measure these comovements. However, the traditional tests of market integration focused on correlation coefficients of spatial prices (see Lele 1972 for India, Farruk 1970 for Bangladesh, Jones 1972 for Nigeria) mask the presence of other synchronous factors, such as general price inflation, seasonality, population growth, procurement policy, etc. Early criticism of this approach has been advanced by Blyn 1973, Harriss 1979, and Timmer 1974.

One way to take care of some of this criticism is to consider correlation of price differences, which has the attractive property of interpreting market integration as interdependence of price changes in different markets. Moreover, price changes would largely eliminate common trends that introduce spurious correlation. Besides the problem of spurious correlation, there are other serious problems related to the often non stationary nature of the price series involved. These problems are taken up by the cointegration analysis undertaken in the following subsections.

Cointegration coefficients and market segmentation

Cointegration analysis is concerned with the existence of a stable relation among prices in different localities. Prices move from time to time, and their margins are subject to various shocks. When a long run linear relation exists among different series, these series are said to be cointegrated (see Engle and Granger 1987).

The presence of cointegration between two series is indicative of interdependence; its absence indicates market segmentation. In the data set used in this analysis 216 out of 2016 links are segmented. However, in order to have practical relevance, the definition of market segmentation should be restricted even further.

Only those pairs of markets that are not "close" should be considered. If market A and B are very far away from each other, the lack of cointegration may be due to transportation costs. It is more interesting to focus on those markets that, in spite of being "close enough", do not exhibit cointegration. The problem is to define what constitutes a "close enough" distance. One reasonable way to solve this problem in the case of rice markets in Bangladesh, is to consider only those markets such that a truck could do a delivery within one day. A crude approximation is to consider markets separated by a distance of less than 250 km, assuming that this is the maximum distance that could be covered by one day trip of a truck loaded with rice bags.

Under these assumptions, segmented markets are those markets that are not cointegrated with each other and that are separated by a distance of less than 250 km. The interesting result is that, out of 2016 links, only about 44 are segmented in the sense specified above (see table 12).

Dynamic Adjustments

Often, it is not enough to say that markets are integrated. One would like to know the extent of integration. Segmentation occurs when there is no cointegration. Perfect integration would occur if the price in one market is just a translation of the price in the other market, implying that price changes are the same. The translation factor can be interpreted as a transfer cost between the two markets. However, it is only in extreme cases that perfect integration or segmentation occurs. The main effort is then to measure these different degrees of integration. To this purpose, the immediate impact of price shocks should be distinguished from the impact that is building over time, due to a process of price transmission. A short run and a long run can then be distinguished, and dynamic multipliers computed from estimation of equations such as

where $p_{i,t}$ is the price of rice in market i at time t, $p_{j,t}$ is the price of rice in market j at time t; X_{it} are exogenous variables such as seasonal dummies and time trend, and $\epsilon_{i,t}$ is an error term. $\alpha_{i,k}$, $\beta_{i,h}$, and γ_i

$$p_{i,t} = \sum_{k=1}^{k=m_i} \alpha_{i,k}\ p_{i,t-k} + \sum_{h=0}^{h=n_j} \beta_{i,h}\ p_{j,t-h} + X_{i,t}\ \gamma_i + \epsilon_{i,t} \qquad [5]$$

are coefficients to be estimated, and m_i, and n_j are the number of lags of prices in market i and j, respectively.

In the estimation, problems of simultaneity may be encountered, related to the contemporaneous use of price in market i and in market j. Since both prices may respond to the same type of shocks, it is expected the error term $\epsilon_{i,t}$ to be correlated with the price $p_{j,t}$. To overcome this problem, an instrumental variable estimation of $p_{j,t}$ has been used, taking lagged values of the prices of all markets included in the study. The three lags, one for prices in market i, one for prices in market j, and one for the instrumental variables, are determined simultaneously by application of the Akaike information criterion (see Akaike 1969).

The magnitude of price adjustment is estimated with dynamic multipliers. Dynamic multipliers are interpreted as the effect of a price change due to a random shock or a shift in an exogenous variable. In the context of the model introduced above, the cumulative effect of a shock to price in market j on the price in market i, after k periods is

$$\lambda_k^{ij} = \sum_{h=0}^{k} \frac{\partial E[p_i(t+h)]}{\partial p_j(t)} \qquad [6]$$

The full adjustment of the dynamic process described by the model is given by the long run dynamic multiplier, which corresponds to

$$\lambda^{ij}_{\infty} = \lim_{k\to\infty} \mu^{ij}_k \qquad [7]$$

Composite measures involving both magnitude and speed of adjustment

The analysis of dynamic adjustments allows to study the *speed* of price transmission. That is, how many days, weeks, or months are needed for prices to be transmitted from one location to another? This is an issue of concern to policy makers for reasons related to planning of food distribution and price

stabilization. Sometimes, the speed of the response of prices is associated with the efficiency of the market system. However, this statement has to be qualified. Rapid adjustments are just an indication of flexibility of the mechanism. They do not necessarily imply well functioning systems. Within the context of this discussion, it is important to consider the speed of adjustment as just another dimension of integration. Given two markets A and B with the same value of the magnitude of price adjustment with respect to a third market C, then the lower is the time to complete this adjustment, the better integrated the market. In other words, this suggests a new indicator of integration which is a combination of the magnitude and speed of adjustment. A ratio of the two is an example of such an indicator, after normalization between 0 and 1. This ratio is denoted by μ, with $\mu = \lambda/\tau$, where λ is the long term multiplier and τ is the time to adjust to the long term.

Comparison among main indicators of market integration

As shown in table 13, whereas over 50 percent of markets are integrated according to the correlation and cointegration measures, only 35 percent of the market links are integrated according to the dynamic adjustment measures (magnitude, speed, and composite measure). One possible explanation for this lower percentage in the case of measures that explicitly involve dynamics of price transmission is that the requirements for the long term multipliers to be significantly different from zeros are more stringent than the requirement that prices simply move together.

Table 13 also reports the descriptive statistics for these measures of integration, showing that the average correlation coefficient of price changes is 23 percent, the average cointegration coefficient is 0.68, that the long term adjustment is 61 percent of the initial shock and takes an average of 2.6 weeks. Even though the number of segmented markets is negligible, the degree of integration is still moderate. In order to understand how this situation could be improved, the determinants of market integration need to be studied.

Determinants of market integration

All the measures of integration considered so far, have in common the feature of being computed using only price information available in a specified period of time (156 weeks, covering three years). Each market link is summarized by just one number; but markets are complex institutions, and their performance as well as their integration is the result of numerous factors that need to be made explicit.

Among these factors, marketing infrastructure related to transportation and communication is an obvious candidate since it contributes to lower transaction costs. Integration is also affected by policy, particularly by price stabilization, which is expected to improve the degree of comovement of prices in different locations. A third structural factor is the degree of dissimilarity in rice production of various markets. The more dissimilar are the markets, the more incentive they have to trade with each other. A final factor that might explain integration is the presence of monopolistic practices, as suggested by Faminow and Benson 1990. However, recent surveys conducted in rice markets in Bangladesh seem to lend little reliability to collusive or basis point pricing as a good description of the market structure (see Chowdhury 1992).

The first three factors can be succinctly expressed as follows.

$$\text{Market integration} = f(\text{marketing infrastructure, price stabilization, dissimilarity in production}) \qquad [8]$$

For each pair of markets i and j, let M_{ij} denote a measure of market integration. The four measures introduced in the previous sections will be used, namely the correlation of price differences, ρ_{ij}, the cointegration coefficient, b_{ij}, the long term multiplier λ_{ij}, and the composite measure, μ_{ij}, incorporating both long term multiplier and speed of adjustment.

Marketing infrastructure includes transportation, communication, and credit. The choice of the variables used to measure marketing infrastructure is clearly limited by the availability of data at district level.

Transportation infrastructure and costs are captured by the road distance between market i and j, d_{ij}, the road density, $road_{ij}$, measured by the density of paved roads per squared kilometer in the areas

surrounding the two markets i and j, the railways density, $rail_{ij}$, measured by the density of railways per squared kilometers in the areas surrounding the two markets i and j, and the number of strikes, $strike_{ij}$, in the areas surrounding the two markets i and j.

Communication is measured by the density of telephones per capita, $tele_{ij}$, in the areas surrounding markets i and j; credit availability is measured by the density per squared kilometer, $bank_{ij}$, of bank branches in the areas surrounding markets i and j.

Price stabilization policy is supposed to influence market integration in a complex manner. On one hand, by smoothing seasonal and inter-year fluctuations it enhances the comovement of prices across markets. On the other hand, this very stabilizing process may hinder the transmission of price signals across markets, in a way that long term multipliers should be able to capture. In order to test these hypotheses, it is necessary to get an index of the degree of price stabilization policy undertaken by the government in various districts. One simple way to do this is to consider the absolute value of the correlation between prices and end of period public foodgrain stocks, in each district. This variable is denoted by $policy_{ij}$. This correlation is expected to be negative; its absolute value is taken to be indicative of the degree of foodgrain price stabilization policy.

Production affects market integration through the degree of dissimilarity in rice self-sufficiency of various markets. If i is a surplus market and j is a deficit market, then the likelihood that i and j are linked by trade in rice is higher than if both markets were surplus or deficit. The degree of dissimilarity is measured by the absolute value of the percentage difference in production per capita, and is denoted by $prodct_{ij}$.

Moreover, production shocks such as days of flooding, drought, cyclone, salted water, pest attack will affect market integration in a complex manner. These data, denoted by $shock_{ij}$, have been collected from newspapers. Their effect on market integration is not clear a priori. When the production shocks are of a tremendous magnitude, as for example during the flooding of 1987/88 and 1988/89, one would expect that market integration is disrupted. In the case of normal production shocks, they may even positively affect market integration, in so far as they add incentives to trade between affected areas and other areas.

The equations that are estimated are then of the following type:

$$M_{ij} = f(d_{ij}, road_{ij}, rail_{ij}, strike_{ij}, tele_{ij}, bank_{ij}, policy_{ij}, prodct_{ij}, shock_{ij}) \quad [9]$$

Results

The results of the estimation are reported in detailed form in table 14. Table 15 summarizes the results. The positive feature of the model is that the effect of some structural factors appear to be robust across different specification of the measure of market integration. Distance is affecting market integration negatively, as expected; but this effect is significant only for correlation and cointegration coefficients. Road infrastructure has a positive effect on market integration, significantly so for correlation and composite measures of integration. The sign of telephone density is quite puzzling, and contrary to the hypothesis of a positive effect of communication on market integration. The puzzle may be partly explained by the type of data used. What is relevant to trade is not simply the availability of telephones in an area, but the availability of country-wide telephones, as opposed to local phones that work only through an exchange operator in the district headquarter.

Bank branches density does not allow to derive any conclusion. This is probably because this variable is a very bad proxy of credit available to traders. Possibly, the total amount of bank deposits or loans by district could be a better indicator.

Railways density has also a puzzling negative sign, especially for long term multiplier and composite measures of integration. One partial explanation is that rail transportation is undertaken over very long distances, when prompt delivery is not a major consideration, as in the case of deliveries to the government. Moreover, the density of railways is not necessarily related to the location of main trade links. The railway train network was built largely in colonial times for considerations independent of rice trade.

Strikes have a significant negative effect on market integration, since they disrupt normal trade. Dissimilarity in production affects market integration positively. Shocks to production also show a positive effect on market integration. This has probably to do with the period considered in the estimation, namely the three years 1989/90 to 1991/92, characterized by only mild production shocks.

Finally, the degree of price stabilization policy seems to have an asymmetric effect on correlation and cointegration coefficients, on one hand, and on long term multiplier and composite measures, on the other hand. One possible explanation is that price stabilization is strengthening the degree of price comovements as measured by correlation and cointegration coefficients, but is hindering the process of price transmission as measured by long term multiplier and composite measures.

CONCLUSIONS

Two main conclusions emerge from this chapter. First, rice markets in Bangladesh are processing information efficiently, without destabilizing prices. Second, rice markets exhibit a moderate degree of market integration, as a result of road infrastructure development, price stabilization policy, and the degree of dissimilarity in production among various locations.

The concern that increasingly liberalized foodgrain policy may lead to destabilizing private markets and breaking of market integration does not seem fully justified.

Markets seem to have preserved their capacity of processing information efficiently even when the extent of intervention in the foodgrain sector has declined.

Price stabilization policy has contributed to market integration, by improving price comovement among different locations. However, market integration has also been affected negatively by price stabilization from the point of view of a lower magnitude and speed of transmission of price signals in the long run.

As the government continues to reduce its involvement with price policy, its major contribution towards strengthening of market integration will come from investment in road infrastructure, more than from investment in railways and telephone lines. Finally, a negotiating role in solving labor relation conflicts will help to reduce the frequency and the incidence of strikes, contributing to further enhancement of market integration.

CHAPTER 5: POVERTY, ECONOMIC WELFARE, AND PRICE STABILIZATION

INTRODUCTION

Price stabilization of rice has been one of the main objectives of Bangladesh food policy. The country has achieved a considerable reduction in both inter-year and intra-year price variability during the past two decades. One main policy issue it then to evaluate to what extent price stabilization should further be pursued. Given the still massive extent of poverty, it is relevant to address the issue of what is the contribution of price stabilization to reduction of poverty, especially in a period when more targeted interventions are advocated. The effect of price stabilization on poverty should then be assessed vis à vis the effect on economic welfare of both consumers and producers.

In order to study the relation between poverty and price stabilization this study uses the well known Foster, Greer, and Thorbecke 1984 measure, where the poverty line is defined in terms of calorie equivalent of food expenditures. Given the high share of rice in the average Bangladeshi diet and in household expenditure the link between poverty and rice prices is not very surprising. Through its effect on food demand, rice price affects the calorie intake of the population, and therefore poverty.

The organization of the chapter is as follows. The next two sections give a background on price stabilization policy in Bangladesh and report some measures of the incidence of poverty. The remaining sections will be devoted to a comparison between the effects on poverty and economic surplus.

PRICE VARIABILITY AND PRICE STABILIZATION POLICY IN BANGLADESH

Variability of the price of rice, the main food staple of Bangladesh, has declined considerably over the years. Intra-year price variability, measured by the coefficient of variation of monthly prices, has decreased from a level of about 14 percent in the Seventies to about 7 percent in the Eighties (see table 16). Inter-year variability, measured by the coefficient of variations of prices around trend, has declined considerably from 28 to 7.5 in the last two decades. Relative to border prices, there has been a decline in inter-year variability, whereas intra-year variability has not shown any considerable difference.

Even though the government did not follow a clearly stated set of guidelines to implement such a reduction of price variability, its numerous interventions in the foodgrain sector are recognized as having

contributed to price stability (see Shahabuddin 1991, Chowdhury 1987). The government contributes to price stabilization both through domestic procurement and public distribution activities. By procuring foodgrains in the months immediately following harvest, the government tries to support prices; by releasing foodgrains in the lean season through public distribution programs, it puts a downward pressure on prices. As seen in chapter 3, the magnitude of these effects is not major. However, they support the perception of the government as an agent capable of smoothing seasonal fluctuations, and, in the case of severe production shocks, to intervene in order to moderate inter-year price fluctuations. After all, Bangladesh has not experienced any famine of an order even slightly comparable to the one in 1974, notwithstanding that after that year there have been even more severe production shocks.

In order to isolate the contribution of stock policy to price stability from other factors such as seasonality, supply shock, and demand shocks, the first task is to get an appropriate measure of price variability. This is done by taking the variance of price changes conditional on the information available at each time period. Prices change over time because of seasonal movements, trends, and other supply and demand shocks. Similarly, price variability may change over time because of all these factors. The conditional variance could be computed modelling price changes as an ARCH process (see Engle 1982). The conditional variance changes over time, and it can be taken as a measure of variability. The starting point is to estimate the regression:

$$\ln(p_t) - \ln(p_{t-1}) = \alpha + \beta \cdot \text{season} + \gamma \cdot \text{trend} + \epsilon_t \qquad [10]$$

where season is the vector of seasonal dummies, and the error term ϵ_t is modelled as an ARCH process, that is the conditional variance is expressed as linearly dependent on lagged squared residuals.

$$h_t = \text{Var}_t(\epsilon_t) = \alpha_0 + \sum_{i=1}^{p} \alpha_i \epsilon_{t-i}^2 + \eta_t \qquad [11]$$

The next step is to model the conditional variance h_t as an autoregressive process in terms of its own past and in terms of lagged values of public stocks:

$$h_t = \gamma_0 + \sum_{j=1}^{m} \gamma_j h_{t-j} + \sum_{k=1}^{n} \delta_k stock_{t-k} \qquad [12]$$

This specification allows to isolate the effect of stock policy from all other factors that affect variability of prices. These other factors are subsumed in the lagged terms of h_t.

The number of lags is chosen with the Aikake information criterion. The relation between conditional variance of prices and stock is depicted in figures 8 and 9. The tremendous shocks of 1974 are clearly detectable, as well as the progressive decreasing of price variability over time. Nevertheless, periods such as 1977, 1980, 1983 show a considerable degree of price variability.

The identification of the autoregressive process relating price variability and government stocks allows to test the hypothesis of stabilizing stock policy. The long run elasticity of public stock on price variability is equal to -1.14 and statistically significant at 95 percent level. That implies that a 10 percent increase in the level of public stock would reduce the variability of prices by about 11 percent. Since the average level of public stock per capita has increased by 35 percent between the 1970's and the 1980's (see table 16), that suggests that about 40 percent of the decrease in price variability is explained by price stock policy, whereas the remaining 60 percent is attributable to change in production variability and other factors.

POVERTY MEASURES AND INCIDENCE OF POVERTY IN BANGLADESH

In this chapter, poverty is defined in terms of the calorie equivalent of food consumption. A household is poor if its consumption gives rise to a total number of calories per capita less than a prespecified poverty line. In Bangladesh, this definition of poverty makes sense, since low calorie intake is the main manifestation of poverty (see Hossain and Sen 1992).

Among the major expenditure categories, food takes more than 70 percent of total expenditures for the two lowest quartiles of Bangladesh. Among foods, rice provides more than 70 percent of the calorie

intake. Wheat, the other major staple, provides about 10 percent of total calories (see BBS 1991). Therefore, it is not surprising that food price stabilization in Bangladesh has often meant stabilization of rice price.

This paper uses the well known Foster, Greer, and Thorbecke 1984 measure. If z is the poverty level, x_i is the per capita daily caloric intake of household i, n is the size of the population, the total poverty W can be expressed as follows.

$$W = \frac{1}{n} \sum_{x_i < z} \left(\frac{z-x}{z}\right)^{\alpha} \qquad [13]$$

where the parameter α measures the concern for the poorest, and the sum is extended to all those households that are poor. As α becomes larger this measure gives more emphasis to the position of the poorest households (see Foster, Greer, and Thorbecke 1984).

The most common measure of poverty is the headcount ratio, that is the number of people who are below the poverty line. This is obtained when $\alpha = 0$. For $\alpha = 1$, the measure gives the average calorie gap below the poverty line. When $\alpha > 1$ the poverty index satisfies the Transfer Axiom, according to which a transfer of calorie from a poor household to another who is richer must increase the poverty measure. For $\alpha > 2$, the transfer axiom is satisfied even in a stronger form referred to as the Transfer Sensitivity Axiom. The latter states that a transfer of calories from a poor household to one richer not only deteriorates poverty, but also the magnitude of the deterioration declines with the initial level of calorie of the poor household. Therefore, calorie transfers from poor households to richer ones are not compensated; moreover, the transfers make poverty even worse when the initial calorie consumption of the household is very low.

Whatever is the parameter α, the first requirement to measure poverty is to determine an appropriate poverty line. In the case of Bangladesh, the poverty line is based on a biological necessities criterion. This chapter sets the poverty line at 1805 kilo calories per day per person, similar to the definition adopted by the Bangladesh Bureau of Statistics (see BBS 1991). This cut point is computed as 85 percent of the recommended calorie requirements (see BBS 1991).

The number of people with calorie intake less than the poverty level is computed directly with the help of a national household survey. The number and proportion of population below the poverty line are reported in table 17. From this table it appears that the bulk of the poor in Bangladesh is concentrated in rural areas. Moreover, the number is very high, estimated by Bangladesh Bureau of Statistics at about 30 million in 1988/89 out of a population of 105 million. Finally, there is an indication of declining poverty, even though in 1988/89 its value was actually higher than in 1985/86. The behaviour in 1988/89 is probably due to the severe rice production shortfall of that year.

The declining poverty is also associated to the declining rice price variability seen in the previous section. However, poverty decline is associated to many other factors, among which the level and distribution of income and prices are some of the most important ones. The next section will consider one characteristics of the distribution of prices, namely their variability, in order to study its effect on poverty.

PRICE STABILIZATION AND POVERTY

The advantage of using food poverty is that the total calorie intake can be expressed in terms of food consumption. In turn, food consumption is related to prices and income. When rice price changes, the consumption of all food commodities changes as well, due partly to a substitution effect, and partly to an income effect.

Two approaches are proposed here to study the relation between poverty and price stabilization. The first, called the simulation approach, evaluates the effects of price variability on poverty, considering information derived from the consumption pattern of the overall population, such as in a national household expenditure survey. The second approach, called the representative agent approach, studies the conditions under which price stabilization reduces poverty. It takes a short cut by considering a representative agent in each group of the population instead of the overall population.

Simulation Approach

Let q_{ik} denote the consumption of food k by household i as follows:

$$q_{ik} = q_{ik}(p_r, p_{-r}, y_i, d_i) \qquad [14]$$

where p_r is the price of rice, p_{-r} is the vector of prices of foods different from rice, y_i is income, and d_i is the vector of socio-demographic variables associated to household i.

If the total calorie intake of household i, x_i, is given by

$$x_i = \Sigma_k \omega_k q_{ik} \qquad [15]$$

where ω_k is the calorie conversion factor for food k, then total calorie is a function of the same variables as in equation [14], namely

$$x_i = x(p_r, p_{-r}, y_i, d_i) \qquad [16]$$

Putting together equations [13] and [16], the poverty measure W can be expressed as follows.

$$W = \frac{1}{n} \sum_{x_i<z} \left(\frac{z - x_i(p_r, p_{-r}, y_i, d_i)}{z}\right)^{\alpha} \qquad [17]$$

From this equation it follows that the poverty measure W is a function of the poverty level, the parameter α, and the distribution of prices, income, and socio-demographic factors.

Let assume that the distribution of rice prices can be characterized only by the first two moments, that is $p_r \sim (\mu_r, \mu_r \cdot \sigma_r)$, where μ_r is the mean and σ_r is the coefficient of variation of the distribution, respectively. Then, by keeping constant all variables different from rice price and the parameter α, the poverty measure can be expressed as follows

$$W = W(p_r, \alpha, \sigma_r) \qquad [18]$$

By simulation, one can evaluate the expected value of this function and compare it to the value of the poverty measure computed at the mean price.

Complete price stabilization at the mean μ_r will be successful at reducing poverty if

$$W(\mu_r, \alpha, \sigma_r) < E_{p_r} W(p_r, \alpha, \sigma_r) \qquad [19]$$

where E_{pr} $W(p_r,\alpha,\sigma_r)$ is the expected value with respect to the variable p_r.

A case for partial price stabilization is given when the expected poverty associated to a variable price with coefficient of variation σ_{1r} is lower than the expected poverty in presence of higher variability, as measured by a coefficient of variation σ_{2r}, where $\sigma_{1r} < \sigma_{2r}$.

$$E_{p1r}\ W(p_{1r},\alpha,\sigma_{1r}) < E_{p2r}\ W(p_{2r},\alpha,\sigma_{2r}) \qquad [20]$$

The validity of this comparison rests upon the assumption that the two distributions have the same mean. That is $p_{1r} \sim (\mu_r, \sigma_{1r}\cdot\mu_r)$, and $p_{2r} \sim (\mu_r, \sigma_{2r}\cdot\mu_r)$. When the mean changes the comparison becomes blurred by the overlapping of the effects deriving from the changing mean of distribution and the effects deriving from the variability of the distribution.

Representative Agent

The simulation approach requires the availability of household data. It would be desirable sometimes to derive conclusions regarding the effects of price stabilization on poverty, only by using demand parameters available in the literature. Instead of looking at the behavior of each household, representative agents are taken for each income group, and average behavior is considered.

Let $x^G = x(p_r,p_{-r},y^G,d^G)$ denote the average calorie intake of group G, with y^G, and d^G its average income and socio-demographic characteristics, respectively. Then the poverty W^G for group G is simply given by

$$W^G = \left[\frac{z - x(p_r,p_{-r},y^G,d^G)}{z}\right]^\alpha \qquad [21]$$

By focusing now only on prices of rice, keeping constant the other variables, the poverty of group G is a function W^G of rice price that can be expressed as

$$W^G = W^G(p_r) \qquad [22]$$

To study the effect of price stabilization at the mean μ_r of the distribution of rice prices, the expected value of W^G with respect to p_r has to be compared with the value of the same function computed at the price mean μ_r. Price stabilization at the mean price reduces expected poverty if

$$W^G(\mu_r) < E_{pr}\, W^G(p_r) \qquad [23]$$

For $\alpha = 0$, the poverty measure for the representative agent is either one, when the household is poor, or zero. Therefore, if there is a positive probability that the price of rice is low enough so that the calorie consumption of the representative agent is above the poverty level, and if the household consumption at the average price is below the poverty level, then price instability will always be preferred, because the expected value of poverty will be below one. Condition [11] will never be satisfied.

For $\alpha = 1$, from [21], the condition [23] reduces to

$$E_{pr}\, x(p_n p_{-r}, y^G, d^G) < x(\mu_r, p_{-n} y^G, d^G) \qquad [24]$$

This condition will never be satisfied if the calorie consumption x is a convex function of rice price. The intuition is that the representative agent will prefer to benefit from the likelihood of low prices that will more than compensate shortfalls in consumption when prices are high. This is a result similar to that of Waugh 1944 for consumer surplus. The problem with this interpretation is that shortfalls in calorie consumption may not be simply compensated by equal and opposite "bounty" when prices are low. Low calorie consumption may be very bad, because it entails the risk of morbidity, low productivity, and, in extreme cases, mortality. This is one reason to consider values of the parameter α greater than 1.

In general, when α is not equal to zero, the conditions under which [23] holds can be derived analytically, looking at the convexity of the poverty measure. Under convexity, condition * is satisfied. Following Ravallion 1988, the second derivative of W^G can be computed as follows.

$$\frac{\partial^2 W^\alpha}{\partial p_r^2} = \frac{\alpha}{z}\left(1-\frac{x^\alpha}{z}\right)^{\alpha-1}\left[\frac{\alpha-1}{z-x^\alpha}\left(\frac{\partial x^\alpha}{\partial p_r}\right)^2 - \frac{\partial^2 x^\alpha}{\partial p_r^2}\right] \qquad [25]$$

so that the poverty measure W^α is convex with respect to p_r if the term within the brackets of the previous equation is positive. Under the mild condition than calorie consumption is a declining function of rice price (mild because rice is the major food staple), this is equivalent to say:

$$(\alpha-1)\eta^x_{p_i} < \frac{z-x}{x}\rho^x_{p_i} \qquad [26]$$

where η^x_{pi} is the elasticity of x with respect to price p_i, and ρ^x_{pi}, measuring the change of the slope of the calorie consumption curve, is the curvature of x with respect to price p_i, that is:

$$\eta^x_{p_i} = \frac{\partial \log x}{\partial \log p_i} \quad \text{and} \quad \rho^x_{p_i} = \frac{\partial \log \frac{\partial x}{\partial p_i}}{\partial \log p_i} \qquad [27]$$

Note that when $\alpha \leq 1$, rice price stabilization increases expected poverty if the calorie consumption is convex with respect to rice price. The convexity of the calorie consumption function is therefore a critical condition for evaluating price stabilization effect on poverty.

Note also that the higher is α, the more desirable price stabilization will be. That is, the higher is the weight given to the depth of poverty, the more will price stabilization tend to lower expected poverty. The reason is that the higher the weight given to the depth of poverty, the more strongly deviations from the poverty level will be weighed.

Condition [26] can conveniently be expressed in terms of food demand parameters, taking into account that the elasticity and curvature of total calories with respect to prices can be expressed as follows:

$$\eta^x_{p_i} = \sum_k \gamma_k \, \eta_{ki} \qquad [28]$$

and

where γ_k is the calorie share of food k, η_{kr} is the elasticity of food k with respect to rice price, and ρ_{kr} is the curvature of good k with respect to rice price.

$$\rho^{s}_{p_i} = \frac{\sum_k \gamma_k \rho_{ki} \eta_{ki}}{\sum_k \gamma_k \eta_{ki}} \qquad [29]$$

PRICE STABILIZATION AND ECONOMIC SURPLUS

It is useful to compare the analysis of the effects of price stabilization on poverty with selected issue of the rich literature on the effects of price stabilization on economic surplus.

From the point of view of the consumer, price stabilization improves welfare if the expected utility derived from consumption of all goods is lower than the utility computed at the stabilized price. It could be shown (see Turnovsky, Shalit, and Schmitz 1980) that price stabilization improves expected utility if the following condition is satisfied:

$$[s_r \cdot (\eta_{ry} + R^C) - \eta_{rr}] < 0 \qquad [30]$$

where s_r is the budget share of rice consumption, η_{ry} is its income elasticity of demand, η_{rr} is the own price demand elasticity, and R^C is the coefficient of relative risk aversion for consumers. This result suggests that the desirability of price stabilization increases with the coefficient of relative risk aversion and decreases with the magnitude of the income and price elasticities. Poor households with high budget share of food, and high risk aversion are the ones who most likely are going to benefit from price stabilization.

Newbery and Stiglitz 1981 showed that the benefits B of price stabilization to producers, as a proportion of the income y_0 before price stabilization, can be approximated by:

$$\frac{B}{\bar{y}_0} = \frac{\Delta\bar{y}}{\bar{y}_0} - \frac{1}{2}R(\bar{y}_0)\,\{\sigma^2_{y_1}\,(\frac{\bar{y}_1}{\bar{y}_0})^2 - \sigma^2_{y_0}\} \qquad [31]$$

where $\bar{y}_1$ is the mean is the mean of y_i, σ^2_{yi} is the squared coefficient of variation of y_i, and

$\Delta y = \bar{y}_1 - \bar{y}_0$, and $R(\bar{y}_0)$ is the producer coefficient of relative risk aversion, computed at the mean of the income before price stabilization.

The total benefit of price stabilization arises because of transfers from gainers, who typically are producers, to losers, who usually are consumers. When risk is incorporated into the analysis, the benefits from price stabilization are bigger. However, even when price stabilization has positive effects on economic surplus, these benefits are usually very limited in the case of food prices (see Newbery and Stiglitz 1981).

DATA AND RESULTS

The data and parameters used for the simulation of the effect of price stabilization on poverty come from an analysis of food consumption (see Appendix 3) based on the Household Expenditure Survey conducted by the Bangladesh Bureau of Statistics in 1988/89. The consumption functions in [14] were specified as semilogarithmic function of prices of nine food categories, and the analysis was done for four income quartiles both in rural and urban areas.

The semilogarithmic specification of consumption function entails a value of the curvature parameter in [28] equal to -1; for double logarithmic specification, the curvature is directly proportional to the price elasticity, whereas it is zero for linear specification.

The risk parameters in the economic surplus calculation of benefits have been incorporated on the basis of a sensitivity analysis considering a range of values from -1 to -3. The estimation of producer's benefit in equation [31] has followed the method of Braverman et al. 1990 involving a linear specification of demand and supply.

Results on Poverty.

The conditions under which price stabilization improves poverty of the two lowest quartiles are always satisfied when $\alpha \geq 2$ (see table 18). For higher income quartiles the representative agent will give the unambiguous answer that price stability is always good, in so far as poverty is concerned. This is because at the mean of the price distribution the poverty measure for a representative agent in these higher quartiles has a calorie consumption above the poverty level. Therefore, any degree of price instability will

involve a positive probability of falling below poverty, increasing the expected value of poverty above the value zero obtained at the mean of the price distribution. This feature of the representative agent approach does not allow to take into account that even at the mean price, within a higher income quartile there are households with a calorie consumption that would qualify them as poor.

The simulation approach requires more extensive data than the representative agent approach, but it gives this additional kind of information related to the numerous crossings of the poverty line.

The result of the simulation of the poverty measure defined in equation [18] is depicted in figures 10 to 13. The figures suggest that for $\alpha \geq 2$ poverty is a convex function of prices, implying that price stabilization will reduce poverty (see Newbery and Stiglitz 1981). This intuition is confirmed by figure 14 showing that the expected poverty is an increasing function of the coefficient of variation σ_r of prices, whereas for $\alpha \leq 1$ is basically stationary.

For moderate price variability, say when the coefficient of variation of price is less than 8 percent, none of the measures of poverty changes significantly. Only when price variability is very high, say when coefficient of variation is above 8 percent, the behavior of expected poverty differs depending on the emphasis on the poorest, as summarized by the value of the parameter α.

When $\alpha = 0$, the poverty measure is interpreted as the number of people below the poverty level. In this case poverty does not change to any appreciable degree when variability of prices increase. This is an interesting result since it sheds some doubts on the validity of using price stabilization to reduce poverty. The same result applies when $\alpha = 1$, and the poverty measure is interpreted as the average gap of calorie consumption below the poverty line. When price fluctuate, households cross the poverty line in both directions. On average, simulation shows that the number of crossings above and below the poverty line compensate each other. Only when $\alpha \geq 2$, implying that deviations below the poverty line are weighed very heavily, the expected poverty is increasing to an appreciable degree when prices become more variable. In this case price stabilization reduces poverty. However, even in this case, the contribution is very low.

Results on Economic surplus

The Turnovsky, Shalit and Schmitz 1981 condition [30] for price stabilization to improve the consumer's surplus is not satisfied in most of the cases considered, where the range of the coefficient of risk aversion for consumers varies between -1 and -3 (see table 19). Only when the coefficient of relative risk aversion in very high in magnitude, the consumer's surplus of most of the population is increased by stabilization. The parameter should have a value around -3, a value that is high relative to other available studies (see De Janvry, Bieri, and Nunez 1972, and Pinstrup-Andersen, de Londono, and Hoover 1976).

The Newbury and Stiglitz 1981 approximation [31] to compute producer surplus also shows that, unless risk aversion is very high, the benefit to producers are rather small (see table 20). On average, these benefits are about 0.9 percent when the coefficient of relative risk aversion is -1 and rise to 1.4 percent when the coefficient of relative risk aversion is -3.

The main conclusion is that only when risk aversion is very high, price stabilization benefit producers and consumers to any appreciable extent. For values of risk parameters not greater than two, the effects are rather small, less than two percent of total income for producers and negative for most of the consumers.

CONCLUSIONS

Extreme poverty in Bangladesh, measured by the number of people with calorie intake less than 1803 kilo calorie per day, is still pervasive, affecting around 27 percent of the population. Numerous approaches have been attempted in the past to attack poverty. Direct approaches such as subsidies, employment programs, and credit for the poor have shown various effectiveness (see N. Islam 1992). The evaluation of various approaches is complicated by the difficulty of identifying the poor and of understanding the behavioral parameters underlying any adjustment to the economic environment. In the case of Bangladesh, one of the main symptoms of poverty is low calorie intake, which is directly related to low food consumption. Given the extremely high share of rice in the Bangladeshi diet, rice prices play a very important role in the determination of poverty.

The main conclusion of the chapter is that price stabilization is largely irrelevant to reduce poverty. When the concern for the depth of poverty is very high reduction of price variability will be accompanied by a reduction of poverty. However, even in this case the reduction in poverty is rather small.

This conclusion is paralleled by the analysis of the microeconomic effects of price stabilization on economic surplus. The benefits in this case are also small, even when risk aversion on the part of consumers and producers is taken into account.

The analysis of the effects of price stabilization on economic surplus and poverty point to a similar conclusion. Unless the risk parameters, the variability parameters, and the poverty concern parameters are extremely high, price stabilization is not very relevant to improve the general situation.

Given that the programs to stabilize food prices are usually quite expensive in fiscal terms, the whole idea of using price stabilization for improving the poverty situation is rather weak. It is probably more cost effective to design targeted programs that directly address the main problem of poverty reduction rather than using broad policies with negligible benefit.

CHAPTER 6: FOODGRAIN PROJECTIONS, PRICE SUPPORT POLICY, AND PROSPECT FOR RICE EXPORT.

INTRODUCTION

In light of the recent growth of rice production in Bangladesh, it is conceivable to envisage a situation of sustained rice self sufficiency. Moreover, the process of structural change in Bangladesh, as in many other developing countries, is accompanied by increasing urbanization. These tendencies will affect the demand and supply of foodgrains, generating new pressures on the Public Foodgrain System. Sustained growth in rice production, together with accelerated process of urbanization may induce an excess supply of rice, that could result either in a fall of domestic prices, or in an opening to international markets by way of exports. The past mode of operation of the Public Foodgrain System is often questioned, as the effort to stabilize prices is increasingly interpreted to consist in supporting prices through domestic procurement. Mounting public stocks may become a real possibility that raises the problem of how to dispose of them. Since the foodgrain need of the population may become less urgent, then the opportunity of exporting part of the public stocks should be evaluated. Rice is the preferred staple food for the majority of the world's population concentrated mostly in the developing countries. However, the proportion of rice production that is traded internationally is small and has virtually remained unchanged since the mid-70's. The strategy of exporting rice should be weighed carefully in light of the thinness of the international market, and the domestic effects on production, consumption, and prices.

Urbanization and export orientation will pose numerous problems in terms of marketing infrastructure and services. The Public Foodgrain System will have to adapt to this new environment, showing flexibility and capacity in monitoring the changes under way. The gathering and evaluation of domestic and international market information, the analysis of demographic factors affecting domestic food demand, and an understanding of the constraints to future production growth are central elements in any effective policy strategy.

This chapter has two main objectives. First, it explores the likely foodgrain situation of Bangladesh during the 1990's and derives implications for price support policy. Second, it examines the prospects of rice exports, focusing on the role of the government in assisting a trade oriented policy.

DEMAND AND SUPPLY PROJECTIONS

The foodgrain projections presented in this chapter are based on a simple model that captures various dimensions of the foodgrain system. First, foodgrains are disaggregated into rice and wheat. Second, rural and urban disaggregations are brought into the picture, using the demand parameters estimated in Appendix 3. Third, demand is disaggregated by income groups. Finally, the model incorporates the role of distribution of growth which characterizes the process of urbanization. Demand

The projections reported below disaggregate foodgrain demand with respect to rural and urban areas, with respect to rice and wheat, and with respect to income groups.

Let D^{tk}_{ij} denote the demand for commodity k (rice or wheat) by income quartile i in area j (urban or rural) at time t. The total demand for commodity k at time t is given by D^{tk} where

$$D^{tk} = \sum_i \sum_j D^{tk}_{ij} = \sum_i \sum_j q^{tk}_{ij} \pi^t_{ij} \qquad [32]$$

where q^{tk}_{ij} is per capita demand, and π^t_{ij} is the population at time t of quartile i in location j.

The disaggregation of foodgrain demand is done with respect to the commodity (rice and wheat), the income quartile, and the location (urban and rural).

Let specify q^{tk}_{ij} as follows:

$$q^{tk}_{ij} = \alpha_0 + \alpha_1 \cdot p_{tr} + \alpha_2 \cdot p_{tw} + \alpha_3 \cdot y^t_{ij} \qquad [33]$$

where p_{tr} and p_{tw} are rice and wheat price, respectively, at time t, and y^t_{ij} is the income per capita at time t of group i in location j. The parameters α_1, α_2, and α_3 vary with the triplet (i,j,k) and are obtained from elasticity figures estimated in Appendix 3, computed at the mean. The effect of other prices and factors is subsumed in the constant term.

Supply

Supply of commodity k at time t is given by S^{tk} where

$$S^{tk} = (1-\delta)\cdot Q^{tk} + Offt^{tk} - Procu^{tk} \qquad [34]$$

Q^{tk} is the production of commodity k at time t, $Offt^{tk}$ is public distribution of commodity k at time t (called offtake from public stocks), and $Procu^{tk}$ is the domestic procurement of commodity k at time t. The parameter δ accounts for feed, wastage, and seed.

To model the response of supply to prices, and technological factors, a simple model derived by Mahmud, Rahman, and Zohir 1993 has been used. First, production is decomposed into yield and acreage as follows

$$Q^{tk} = A^{tk}\cdot Y^{tk} \qquad [35]$$

where A^{tk} is acreage devoted to commodity k at time t, and Y^{tk} is yield of commodity k at time t. Second, acreage response to prices and other factors is modelled as follows. For rice, the best specification was found were aggregate rice acreage is a function of rice price and rice yield, that is

$$A^{tr} = A_1 + A_2\cdot p_{tr} + A_3\cdot Y_{tr} \qquad [36]$$

where A_1, A_2, and A_3 are coefficients estimated on the basis of elasticities computed at the mean. For wheat, the best specification, involved both rice and wheat price, and lagged acreage, as follows:

$$A^{tw} = A_{1w} + A_{2w}\cdot p_{tw} + A_{3w}\cdot p_{tr} + A_{4w}\cdot A^{t-1\,w} \qquad [37]$$

where A_{1w}, A_{2w}, A_{3w}, and A_{4w} are coefficients estimated using the elasticities from Mahmud, Rahman, and Zohir 1993.

The previous formulation leaves the growth of yield exogenously determined. The assumptions regarding yield growth are stated in a later section.

The behavior of public distribution and of procurement is also assumed to be exogenously determined. In the case of rice, offtake and procurement in the base year are taken to be equal. The

initial value of procurement is equal to 4.2 percent of total production. In a later section, different behavior of the government concerning domestic procurement of rice is formulated. Moreover, in this model the economy is assumed closed, with no trade in foodgrains allowed. This assumption is going to be removed in a later section. Finally, note that in the specification of supply, initial private stocks are not included.

EQUILIBRIUM AND GROWTH ASSUMPTIONS

Equilibrium

In equilibrium, prices adjust to equalize supply and demand. For each commodity and for each time period, the following equation holds:

$$D^{tk} = S^{tk} \qquad [38]$$

By expressing demand and supply in terms of prices, one obtains the following equation for each commodity k:

$$\Sigma_i \Sigma_j q^{tk}_{ij}(p_{tr}, p_{tw}) \cdot \pi^t_{ij} = S^{tk}(p_{tr}, p_{tw}) \qquad [39]$$

Assumptions about Growth of Population, Income, and Yield

In this model population growth, income growth, and yield growth are exogenously determined. Moreover, explicit assumptions on the behavior of the public distribution net of domestic procurement have to be done.

For the country as a whole, *population* at time t is given by:

$$\pi^t = \Sigma_i \Sigma_j \pi^t_{ij} \qquad [40]$$

The overall population growth rate is denoted by ν so that

$$\pi^t = \pi^{t-1} \cdot (1+\nu) \qquad [41]$$

The distribution between rural and urban areas is given by

$$\pi^t = \pi^t_r + \pi^t_u \qquad [42]$$

where π^t_r and π^t_u are rural and urban population at time t, respectively. Given an outmigration rate ρ from rural areas to urban areas, the urban population at time t is evolving as follows:

$$\pi^t_u = \pi^{t-1}_u (1+\nu+\rho\frac{1-u_{t-1}}{u_{t-1}}) \qquad [43]$$

where u_{t-1} is the urban population rate at time t-1, that is $u_{t-1} = \pi^{t-1}_u/\pi^t$. The rural population is the residual $\pi^t_r = \pi^t - \pi^t_u$. The population of each quartile i in any location j grows at the same rate, and is given by:

$$\pi^t_{ij} = 0.25 \cdot \pi^t_j \qquad [44]$$

Three cases are considered in the simulation exercises. The high growth case corresponds to a yearly population growth of 2 percent, the medium growth is 1.86 percent, and the low growth rate is 1.5 percent. The high growth is consistent with the growth rate for the 1980's as derived by the 1991 Census (see BBS 1992). This high growth is expected to decline further as a result of structural changes such as urbanization, education and income growth, and increasing participation of women in the labor force. The outmigration rate from rural to urban areas is assumed to be equal to 1 percent (see also Chowdhury and Shahabuddin 1992).

For income growth, the assumption is that each quartile grows at the same rate within the same location. The distribution between urban and rural areas may be different. Because of the process of urbanization, the distribution of growth is affecting the demand for food very critically. In correspondence to the same aggregate income growth there are infinite paths of demand growth, each associated to a

different growth of income in rural and urban areas. To illustrate the consequences of the distribution of growth between urban and rural areas a matrix is constructed, whereby in one case growth is distributed equally and in the other case urban areas growth is faster than in rural areas. The second hypothesis is the most likely one since it is related to the process of urbanization, originated by migration from rural areas (see Todaro 1976).

Therefore, income growth is affected both by the level of growth and the distribution of growth across rural and urban areas. In the simulations, three levels of aggregate income per capita growth are considered, corresponding to 1, 2, and 3 percent, respectively. For each level, two distributional assumptions are considered. In the first assumption, growth takes place equally in rural and urban areas. In the second assumption, urban growth of income per capita is 30 percent higher than in rural areas. The second assumption is consistent with the actual growth of the urban-rural income differential as indicated by the Household Expenditure Surveys in 1983/84, 1985/86, and 1988/89 by Bangladesh Bureau of Statistics (see BBS 1991).

For rice yield, the assumptions are of high growth, equal to 2.5 percent, medium growth, equal to 2.3 percent, and low growth, equal to 2.1 percent. Note that these assumptions are cautious with respect to the yield growth of 2.7 percent in the 1980's and with respect to other studies such as Islam 1989, Goletti and Ahmed 1991, Shahabuddin and Chowdhury 1992. These growth assumptions are consistent with the large scope in yield improvement in the Aman crop, and continuation of expansion of Boro acreage, since only 40 percent of cropped area is currently devoted to high yielding varieties. Wheat yield growth is assumed constant and low. It is set equal to 1 percent, in agreement with the limited scope for further expansion of wheat production (see Mahmud, Rahman, and Zohir 1993).

The parameters and assumptions used in the simulation are reported in Appendix 4.

RESULTS OF PROJECTION ANALYSIS

Informed opinion may differ as to the realism of each of the assumptions on which the projected growth rates are based. However, a comparison of different scenarios may still be useful. To guide this comparison, and to state the perception about the likelihood of different scenarios, each assumption has

been assigned a given probability (see Appendix 4). Based on these priors, expected values of demand were determined both for rice and wheat.

The results are reported in table 21 showing a situation characterized by a rice surplus of 157 thousand metric tons and a wheat deficit of 1535 thousand metric tons when prices are kept at the initial level. When prices are allowed to respond, the excess demand is zero, and prices of rice and wheat ares going to decrease by 2 and 12 percent, respectively, over the decade. The reason for the bigger decrease in the case of wheat is the negative income elasticities of demand for this commodity. Total foodgrain consumption is increasing for all income groups except for urban rich. However, as a consequence of the mostly urban biased growth, urban poor are benefitting from growth more than rural poor.

In order to gain better understanding of the model, it is useful to consider also a high growth scenario, where rice yields are growing at 2.5 percent over the decade, and a low growth scenario, where rice yields are growing at 2.1 percent. The results in table 21 show that rice prices may vary between 4 percent below and 2 percent above the initial level of 388 Taka per Maund. Wheat prices always decline, between 12 percent and 8 percent below the initial level of 299 Taka per Maund.

In conclusion, price changes are going to be quite modest in the case of rice, whereas they will be slightly more appreciable in the case of wheat. In any scenario, most groups are going to gain out of growth of production, and particularly so the lower urban quartiles.

Implications for Price Support Policy

In the analysis of the previous scenarios, the behavior of the government was kept constant at the initial levels in the simulation period. The main conclusion of the analysis, namely that rice prices are not going to change significantly during the decade of the 1990's has some important implication for price support policy. The recent fall in rice prices after the Boro harvest of 1992 has risen the concern that growth of production will result in a precipitous fall of rice prices that would hurt farmers. As a countervailing policy measure, procurement of rice has been proposed. It is useful to see what different assumptions about procurement policy will entail for prices and public stocks. Since only rice procurement is relevant in the foodgrain system of Bangladesh, given that over 95 percent of foodgrain production is

given by rice, two different assumptions about the growth of rice procurement are made. In the first case, procurement is assumed to grow at 2.5 percent, and in the second case at 5 percent per year. As table 22 shows, the effect on rice prices in both cases are quite marginal. However, the increase of public stocks is quite remarkable. In the case of moderate growth of procurement, the increase in stock will be almost 900 thousand metric tons, representing an increase of 157 percent with respect to its initial average level of 570 thousand metric tons; for accelerated procurement growth, resulting in an increase of just a 2.3 percent of rice price, the increase of public stock would be of 1.9 million metric tons, which would pose capacity problems given the current space availability constraints of public storage facilities.

The main conclusion seems to be that even massive increase in procurement would result only in modest price changes. However, this massive increase in procurement will pose formidable problems in terms of both storage capacity and accompanying mounting fiscal cost.

RICE PRODUCTION AND EXPORT MARKET

Over the period 1975-90 world rice exports averaged only 4.1 percent of total production, making the international market for rice very thin (Table 23). During the same period world production grew at a rate of 2.67 percent compared to a 2.57 percent growth achieved in export. Table 24 shows that the five major exporting countries together achieved an annual export growth of 4.75 percent during 1975-90. There is, however, a wide variation among the growths of the concerned countries, with the one extreme of -7.08 percent for Myanmar, and another extreme of 39.46 percent for Vietnam. Thailand is the other country whose export growth of 8.6 percent exceeded the average growth attained during the period. Besides Myanmar, the growth rate of U.S.A. and Pakistan were below average, at 0.61 percent and 2.54 percent, respectively. Comparison with the world scenario shows that the export growth of 4.75 percent for major exporting countries by far exceeds the overall growth of 2.57 percent achieved in world export over the corresponding period. The growth of market share of the first five exporters has been steady from 57.3 percent during 1975-79 to 71.1 percent in 1985-90. Moreover, the proportion of export to milled production for the major exporting countries grew at the rate of 2.12 percent over the 1975-90 period compared to a negative growth of 0.1 percent for the world as a whole. This demonstrates that the major exporters are

generally well equipped to tackle a sluggish world market. Also, they do better compared to other competitors when the world market experiences a boom.

It is interesting to note that the rate of growth of rice production of Bangladesh relative to the major five exporters during 1975-90 is surpassed only by Vietnam and Myanmar; the same holds true for yield growth (see table 25). However, in the five years period 1985-90, Bangladesh growth of both rice production and yield has been higher than for the first five exporters, including Vietnam.

WORLD VIS A VIS DOMESTIC RICE PRICES

Rice Varieties

Key to export are the rice prices of different varieties traded in the domestic markets. The analysis of prices of these varieties and of comparable international grades will help determine their competitiveness in the international market. Thai prices for the regular rice have been chosen for comparison with the similar varieties of Bangladeshi rice as Thailand is the single largest exporter of such rice and for its proximity of geographical location. Similarly, prices of Pakistani Basmati rice have been used for comparison with that of Bangladeshi aromatic varieties.

Thai export standards classify rice into different grades based largely on such physical properties as length of grain, degree of milling, percentage of broken and damaged grain, colored grain, moisture level, and impurities. Such standards or any other specifications for grading rice are practically non-existent in Bangladesh. Rice in Bangladesh is classified into three broad categories based on the growing seasons for the crop, namely, Aus, Aman and Boro. All species of aus and boro rice, except the species called Pajam, are generally regarded as coarse chiefly due to the short and bulky shape of the grains. Pajam is regarded as a medium variety rice. It is the Aman season when more diverse qualities of rice are produced. Aman rice can be classified into four categories - special aromatic, fine, medium and coarse (see figure 15).

Two sets of prices, export parity and import parity, for Thai rice have been used for comparison with the wholesale rice prices in Bangladesh. Thai Free on Board (FOB) prices for the grades involved have been multiplied by a factor of 0.85 to arrive at the export parity prices, which basically are estimates

of wholesale prices for those Thai grades plus any export levy charged by the Thai government. An assumed zero export levy for Bangladesh posits the prices on a par with each other. For the aromatic varieties, only export parity prices for Pakistani Basmati rice have been used for the comparison since Bangladesh is unlikely to import such high valued rice in the near future.

For computing import parity prices, first a shipping cost of $20 per metric ton has been added across the board to obtain estimates of Cost and Freight (C&F) prices for the same Thai varieties. Then the C&F prices have been multiplied by a factor of 1.15 to determine their import parity prices, which are again literally estimates of wholesale prices for those grades in Bangladesh markets when imported. The purpose is to bring the Thai FOB prices on an equal term with that of Bangladesh prices for the selected grades.

Export Parity and Import Parity vis à vis Domestic Wholesale Prices

From the comparison of prices of fine Aman variety with Thai 5 percent broken rice (see table 26) it emerges that over the seventeen years between 1975 and 1991 the domestic prices have exceeded export prices by 27 percent. A similar behavior holds for prices of high yielding variety (HYV) rice, generally considered as coarse rice, which has been compared with the Thai 25 percent super.

The prices of Kalizira and Kataribhog, two of the best aromatic rice varieties, have been compared with that of export parity prices for Pakistani Basmati rice. Shapewise both are slender but Kalizira is short whereas Kataribhog is long. The ratios for this special variety aromatic rice appears to be a lot more encouraging than the ratios for any of the regular varieties. For most of the years the prices were below the export parity prices for Basmati rice. Kataribhog rice presents the most promising picture. Better ratios for this variety are explained by the relatively low price it commands in the domestic market. Although Kataribhog is a long variety, price is lower as it contains less aroma than Kalizira.

It is apparent from the above analysis that only the two aromatic varieties have an immediate prospect in the international market. Prices of the regular varieties are not presently competitive to international market prices for the comparable varieties.

The comparison between the fine Aman rice domestic prices and the Thai 5 percent broken import parity price shows that over most of the period 1975-90 the ratio of domestic wholesale to import parity

prices were below 100 percent, implying that imports were not commercially feasible during most of those years. Prices for HYV, which is generally regarded as coarse rice in Bangladesh, have been compared with the Thai 25 percent super rice. The results of the analysis is similar to the case of Aman rice, pointing out that during this period commercial imports of rice were not viable (see table 27).

Price Fluctuations in Domestic vis à vis International Markets

Variability of domestic prices has declined substantially in the past two decades. Both measures of inter-year variations and intra-year variation shows this decline. The decline has also characterized international and border prices during this period (see table 28). However, inter-year variability of domestic prices has declined more than for international and border prices, whereas intra-year variability has been at approximately the same level. In the 1980's, domestic prices have been more stable than either international or border prices. As it was seen in the previous subsections, domestic prices of coarse rice, the most common variety of rice in Bangladesh, were among import and parity prices, suggesting that there were not major incentives to trade rice. The existence of a large band for import and export parity prices did not prevent domestic prices to maintain a long term relation with border prices, as the analysis of cointegration in chapter 3 has shown.

Looking at the seasonal pattern of domestic versus international rice prices, table 29 shows that price differences are the lowest in December for both the fine and medium varieties. Understandably so as December happens to be the peak month for Aman harvest, which contributes most to the aggregate production of fine and medium rice. The highest level of differences are observed in October and September for the fine and medium rice, respectively. These two months precede the Aman harvest and are regarded as lean months in terms of rice supply in the domestic markets. Overall, the differences are relatively lower between December and March for either being the period of Aman harvest or for being closer to it. This suggests that the period between December and March will be the most favorable for Bangladesh to export fine and medium variety rice. One can draw similar conclusion with respect to aromatic rice as most of the domestic aromatic rice is also produced during the Aman season. Price differences for coarse rice are likely to behave differently from those of fine and medium varieties as a large portion of coarse rice is produced during the two other rice growing seasons -Boro and Aus.

SWAP OF RICE FOR WHEAT

The likely situation for foodgrains in the 1990's is one whereby rice excess supply may persist together with wheat excess demand. With a view to attaining food self sufficiency, it is then interesting to ask the following question, initially posited by Chowdhury and Aziz(1983):

How would the foodgrain sector be affected if the surplus of rice is swapped for wheat in the world market?

Of particular interest is the determination of the effects of rice exports on production, consumption, and prices. To address this question a simple trade model is proposed. The model builds upon Bernard (1989), but it incorporates different rice qualities, and cross price elasticities both for demand and supply. The basic structure of the model follows.

There are three goods: two qualities of rice, "high" and "low", and wheat. The superscripts h, l, w, denote high, low, wheat, respectively. Demand and supply of the three foodgrains depend on the prices of the three goods. Income effects are assumed within the functional forms, and therefore are not mentioned explicitly. The government exports rice of good quality, and the exported quantity of rice is denoted by X. It swaps X for a quantity M of wheat in the international markets, using world prices of rice and wheat, denoted by wo^{r}, and wo^{w}, respectively. Let the letter D denote demand, S supply, and p domestic price.

Demand

$$D^h = D^h(p^h,p^l,p^w) \quad [45]$$

$$D^l = D^l(p^h,p^l,p^w) \quad [46]$$

$$D^w = D^w(p^h,p^l,p^w) \quad [47]$$

Supply

$$Q^h = Q^h(p^h,p^l,p^w) \quad [48]$$

$$Q^l = Q^l(p^h,p^l,p^w) \quad [49]$$

$$Q^w = Q^w(p^h,p^l,p^w) \quad [50]$$

Equilibrium

$$Q^h(p^h,p^l,p^w) = D^h(p^h,p^l,p^w) + X \quad [51]$$

$$Q^l(p^h,p^l,p^w) = D^l(p^h,p^l,p^w) \quad [52]$$

$$Q^w(p^h,p^l,p^w) + M + FA = D^h(p^h,p^l,p^w) \quad [53]$$

where FA is foreign aid assumed to be received all in wheat.

Swap Condition

$$wo^{l} \cdot X = wo^{w} \cdot M \qquad [54]$$

The endogenous variables of the system given by equations [45] to [54] are domestic prices p^{h}, p^{l}, p^{w}, and imports of wheat M. The exogenous variables are world prices wo^{l}, wo^{w}, and rice exports X.

The model is used to study the effect of exporting an amount X on prices, quantities consumed and produced, and total foodgrain consumption.

The comparative statics of the model does not allow to derive clear cut conclusions. Only for the case of zero cross effect the results are unambiguous . In this case the price of high quality rice increases and the price of wheat decreases when exports increase, leaving the price of low quality unaltered. This is basically the same result that one obtains when only one quality of rice is considered, as in the Bernard (1989) model.

To study the effects of exporting different qualities of rice the model [45] to [53] is solved numerically by specifying the demand and supply functions as linear logarithmic, with the coefficients of the linear terms interpreted as cross price elasticities.

Results of Simulations

Some of the parameters needed to implement the model empirically are not readily available; hence an informed guess is required. The assumptions relative to these parameters must be clearly stated. Sensitivity analysis with respect to these parameters helps to understand the robustness of the results. In the case of demand elasticities, for high quality rice, educated guesses have taken into account the parameters of the higher urban income groups. Similarly, for low rice quality, the parameters of the lower rural income groups have been taken into account. For supply elasticities, the major effects are assumed to go from rice price to wheat production and not vice-versa, at least when aggregate rice is considered.

The baseline of the exercises uses the 1989/90 level of production, availability, and prices. All foreign exchange earned from the export of rice is assumed to be spent to import wheat. All the baseline figures are given in Appendix 4.

Table 30 reports the results. The main conclusion is that once cross price elasticities for wheat and rice are taken into account, there is a tendency for the aggregate foodgrains price to go up, and this is most evident for wheat and the high quality rice. The reason is that the demand for wheat increases as a result of higher prices of rice and very high cross price elasticities with respect to rice price. Therefore, domestic aggregate price of foodgrains may go up, even though total foodgrain consumption increases as a result of rice for wheat swaps in the international market. By exporting 200,000 metric tons, total foodgrain consumption goes up by approximately 0.8 percent, that is by 147,000 metric tons with respect to the baseline case of no exports.

Higher foodgrain prices affect the distribution of food consumption of different income groups. High income groups are most likely to consume high quality rice, and therefore they will be mostly penalized. Low income consumers will not be affected negatively by higher prices of foodgrains, as long as they consume mostly lower rice quality. The reason is that consumption of wheat will more than compensate for any loss in rice consumption.

Note also that foodgrain consumption increases with the magnitude of supply and demand elasticities. As the commercialization of rice production increases, supply elasticities are also expected to go up, implying that bigger gains in total foodgrain consumption are expected from similar swap arrangements.

In summary, the export of moderate quantities of high quality rice has positive effect on aggregate foodgrain consumption, without compromising the food security of the poor.

PRECONDITIONS OF RICE EXPORTS

Besides competitiveness of prices, there are a few other important elements which should be appraised before undertaking export of rice. The focus of this section is on marketing infrastructure, and quality and grading.

Marketing Infrastructure (storage, milling, and transportation)

The storage facilities presently available in the private sector are unsuitable for long term storage of foodgrains, and can at best be used for storing rice for short periods following its procurement at different points of the surplus producing areas (see Jahangir and Goletti 1991). Renting a part of government-owned warehouse facilities may help mitigate the immediate space and quality problems with regard to storage. In the long run, however, construction of more warehouses of standard specifications will be necessary to ensure delivery of good quality rice in the world market. The government may encourage the process by amending and simplifying banking regulations on credit facilities to the private sector entrepreneurs for construction of warehouses.

A vast majority of the existing milling facilities are incapable of producing internationally acceptable rice quality. The rice mills in Bangladesh are generally classified into three categories - husking, major, and automatic.

Husking mills, mostly found in rural areas, are only capable of separating the husk from the paddy. Bran is separated manually to obtain the final product. The rice so obtained still holds parts of brans due to lack of polishing under the process. Thus, the translucency in the rice, considered to be an important criterion for determining quality of rice in the world market, suffers. Percentage of broken grains, another important quality criterion, also turns out to be higher as such rice mills use stone hullers.

The major rice mills use a two stage process for milling rice. In the first stage, the husk is separated from the paddy. In the second stage, the bran is separated and the rice is polished to obtain clean rice. Some of these rice mills specialize in milling special variety aromatic rice, mostly in areas where production of such rice is concentrated. They do a fairly decent job. There is, however, still much room for improvement. Just by switching from stone huller, they presently use, to rubber huller the percentage

of broken rice can be further minimized. Some modernization may also be necessary to improve polishing quality of these mills.

In the automatic rice mills, parboiling, drying, milling and polishing are all done by the machines with minimal human touch. Most of these mills were set up around late 1970's and early 1980's and therefore have modern machineries capable of producing internationally acceptable quality of rice. There were 77 such rice mills in 1988 (BBS 88). Their capacity ranges between 16 to 24 metric tons per 8-hour shift. A conservative estimate, which uses the lower end of their capacity range, puts the annual total capacity of these rice mills at 1.2 million metric tons in three shifts. Consistent with other industries, 330 operational days in a year has been considered for obtaining the estimate. The capacity of these rice mills are presently underutilized due largely to higher cost of milling and limited demand for bulk milling. It is economically infeasible for these mills to process a less than optimal quantity of rice in one run. This idle capacity can be put to beneficial use once export of rice becomes a viable venture.

Adequate transportation facilities are already available for moving rice from the producing areas to the ports. Different means of transports - road, water and railway - are used for moving foodgrains from one place to another. Road transports, i.e. trucks, appear to be the most popular means of transportation used for the purpose. They are popular for being faster as well as less prone to pilferage. The scope of using waterways, the next most popular means of transporting rice, is limited as many of the traditional routes used for carrying foodgrains in bulk during the rainy season are rendered non-navigational in the dry season. However, country boats are still a popular means of transporting rice for being cheaper and also for being the only means of transportation in the remote riverine areas. The railway happens to be the most despised means of transportation for its high rate of pilferage and misplacement of wagons.

Carrying cost of foodgrains can be considerably minimized by improving the management of the railway and water transport networks. However, a basic infrastructural facility like transportation encompasses a much larger area than foodgrain transportation and should therefore be addressed keeping the overall economic development of the country in perspective. Movement of foodgrains, including rice, will benefit in the process.

Quality and Grading

As Bangladesh shifts to a marginally surplus in rice production, more attention should be given on improving the quality of rice with a particular eye on the world market (see Knosa-ard and Juliano 1991). The international rice market is very skeptic about the ability of temporary or new exporters to deliver rice of specified quality (Siamwalla and Haykin 1983). Because of this credibility gap, such exporters face a great deal of difficulty in disposing of their surplus stock in the world market. Hence, overall quality control of rice should receive utmost attention before export is undertaken.

It is, however, difficult to generalize consumer preference for cooking quality as well as shape and length of rice. It varies from country to country and even among the different types of consumers within a country. For example, high-income consumers in Bangladesh prefer fine grade rice of soft texture and non-sticky nature as opposed to the preference of non-sticky coarse rice of hard texture by the low-income consumers (Toquero 1991). Countries contemplating to enter the world market with fine to special quality rice should focus on developing intermediate-amylose (20-23 percent) rices with high recovery rate of head rice (whole grain). Intermediate amylose together with medium gel consistency (41-60 mm) guarantee cooking quality of non-sticky soft texture in rice. Chalkiness and shape are the two other quality aspects the researchers or the breeders for that matter can improve upon through varietal developments.

At present there exists no grading system of milled rice in Bangladesh. It is therefore essential that the country establishes a grading system before it undertakes export of rice. It is not necessary that the grades to be introduced in Bangladesh have to match perfectly with that of Thai or American standards. Some latitude can be used in determining the physical features of standardizing rice based on the varietal and milling features of the rice produced in Bangladesh. For example, stipulated grain composition for Thai 5 percent broken rice is: 25 percent of extra long grain (with a tolerance of 5 percent more), 35 percent of long grain (with a tolerance of 5 percent more or less), and the rest shall be of medium grain for which not more than 10 percent of short grain are allowed (SGS 1982). For the fine variety Bangladeshi rice, which has been compared with that of Thai 5 percent broken rice, almost 100 percent long grain can easily be guaranteed as they are processed, milled and sold by genetic varieties. Absence

of extra long grain in such a standardization is likely to be more than compensated by uniform size and shape of the grain.

Two other Bangladeshi varieties, medium and coarse, have similar advantages over their compared Thai grades. As for the special aromatic variety, compared with Pakistani Basmati rice, Kalizira is short and slender but highly fragrant and Kataribhog is long. They are not comparable in length to Basmati rice which is extra long. However, the chemical properties they possess or their genotype which determine cooking quality and the aroma in the rice may be superior to Basmati rice. A large proportion of the market for Basmati rice is in the Middle East where consumers prefer Pilaf rice, treated with butter and vegetable oil (Eve 1973). Both the Bangladeshi aromatic varieties, Kalizira in particular, apparently have all the qualities of ideal Pilaf rice. As a matter of fact, Kalizira and white Kataribhog rice are used by the Bangladeshi consumers as Pilaf rice for cooking special dishes. Therefore while standardizing the aromatic varieties of rice, emphasis should be given on the properties which make them ideal fragrant Pilaf rice.

CONCLUSIONS

In view of the likely surplus situation of rice and accompanying wheat deficit by the end of the decade, it is important to explore the possibility of exporting Bangladeshi rice in the international markets. One of the main factors affecting competitiveness is going to be the quality of the rice exported. This observation motivated the analysis of import and export parity prices compared to domestic prices of different qualities of rice. Using the available information, it was shown that there is a scope for exporting aromatic varieties of rice, namely Kalizira and Khataribhog, to compete in the international market for Basmati rice. It was also shown that cross price effects among different varieties of rice and wheat are important determinants of the impact of swapping rice exports for wheat imports in the international markets. Rice swaps increase foodgrains consumption, mainly through increased consumption of wheat. Rice exports increase the domestic prices of foodgrains, including wheat. As long as the level of exports is low, namely less than 200,000 metric tons, the overall price and consumption effects are small. For higher level of exports, however, price increases may become relevant.

The feasibility of exporting rice depends on a set of policy measures. First of all, policy should create favorable conditions for the development of export markets, raising many of the objections present in the past. The recent abolition of anti-hoarding laws and trade restrictions are positive steps in the right direction. The process of export is to be kept simple to avoid any inordinate delay in completing paper works. Second, the existing infrastructure and equipment affecting transportation, storage, and milling should be updated and expanded. Third, a grading system should be introduced, to raise the average quality of rice consumed domestically, and to enhance the likelihood of exporting successfully in the international market. Finally, the opening of the international market should be done gradually, so that the negative effects deriving from instability imported from outside could be absorbed smoothly.

CHAPTER 7: CONCLUSIONS AND POLICY IMPLICATIONS

Two major features of Bangladesh foodgrain sector have emerged during the past two decades. First, growth of rice production, the main food staple of the country, has been sustained and increasingly stable, as the outcome of adoption of high yielding varieties and modern technology. In conjunction with structural change resulting in a lower population growth and rapid urbanization, the growth of rice production is moving the country towards rice self-sufficiency closing the gap between availability and requirements. Second, an increasingly favorable attitude towards the development of the private market has characterized the policy environment; several restrictions to domestic and international trade present in the past have been withdrawn and numerous public foodgrain distribution programs have been eliminated. This experience in market liberalization has been accompanied by a considerable degree of price stability, improvement in the poverty situation, and accelerated growth of rice production.

These new developments pose various problems to the management of the Public Foodgrain System of Bangladesh. Its role in the future has to be redefined, as many of the assumptions valid in the past do not hold any more. The foodgrain sector is increasingly commercialized, with a declining share of the government in the marketed surplus. The country is now in a better capacity of financing the imports of foodgrains than in the past. The level of rural infrastructure, even though still very low, is developing and performing its facilitating role in the exchange of information and goods, contributing to market integration. It seems that many of the reasons for the continuation of activities of the Public Foodgrain System as conceived in the past are not present anymore.

However, poverty is still affecting large groups of the population, implying the need to contribute to its alleviation. Growth of agricultural production depends heavily on the expansion of high yielding varieties and modern technology, suggesting the continuous public commitment to agricultural research and extension. The foodgrain sector is still vulnerable to major production shocks, such as heavy floods and droughts, requiring the storing of at least a minimum amount of foodgrain stocks for emergency and relief operations. But apart from these traditional roles of foodgrain policy, there are new issues that emerge from the current situation.

The continuation of the success of market reform will depend on the well functioning of the marketing system. There is still a large support for the concern that domestic markets may start to behave erratically generating excessive price instability detrimental to the population. Even the growth in production is seen as the possible source of a secular decline in rice prices with adverse effects on producers' income. There seems to be a general euphoria that the current gains in production will rapidly lead the country to a surplus situation. A major role of the government in supporting prices is sometimes voiced, but it is not clear how that could be sustained over time.

This report has examined some of these issues and concerns with the objective of understanding the changing role of the government in the new situation characterized by a movement towards rice self-sufficiency and market liberalization.

Four major conclusions have emerged from the study. First, foodgrain markets have proved to be efficient processors of available information, and have made a central contribution to the transmission of scarcity signals from one region to another. The foodgrain sector is characterized by a very dynamic private sector, with the majority of the population heavily dependent on the market for its foodgrain consumption. The marketing system has been effective in moving commodities both over time and over space without destabilizing prices, and exhibiting a moderate degree of market integration. The idea that traders, through their hoarding behavior cause unnecessary fluctuations could not be supported by the available evidence. Moreover, the reduced presence of public intervention in the foodgrain marketing system has not been accompanied by additional instability and inefficiency of market behavior.

Second, foodgrain prices have shown an increasing degree of stability over time, as the result of several factors. Technological improvements with the accompanying increase in cropping intensity have been reflected in a changed pattern of price seasonality, and a smoothing effect on price fluctuations. Private storage, both farm level and trading stocks, have contributed to the important function of moving commodities over time, with a positive effect on price stability. Similarly, market integration has reduced the price variability over spatially separated markets, by facilitating the transmission of price shocks. Finally, stock policy of the government has also had a beneficial effect in moderating the variability originated from seasonal and inter-year fluctuations. However, as a consequence of the increased price

stability, price stabilization has become largely irrelevant. Both its effects on economic welfare of the population and its effect on reducing poverty are negligible, even after taking into account risk aversion on the part of producers and consumers, and the concern for the distributional aspects of poverty.

Third, the concern that the withdrawal of price support activities in the form of domestic procurement may create negative incentives to farmers via lower prices, and therefore affect their incomes negatively, is largely exaggerated. Domestic demand appears capable to sustain prices at a level not significantly lower than the current one. The magnitude of the expected rice surplus is rather moderate, under reasonable assumptions. Even under a favorable scenario for rice yield growth, the expected rice surplus is less than 3 percent of production. The effectiveness of domestic procurement as an instrument to support rice prices has been very limited in the past, mostly because of its narrow coverage. In order to have any appreciable effect on aggregate prices, domestic procurement should increase at a level inconsistent with either available public storage capacity or budgetary constraints.

Fourth, the possibility of generating even a moderate exportable surplus of rice could help to sustain prices and contribute to improve the food security of the country if swap of rice for wheat in international markets are put in place. To this purpose, the best quality of rice have been found to have a comparative advantage in international markets.

The previous conclusions point to several policy implications, suggesting a changed role of the Public Foodgrain System. Three main features of this role are a reduced presence in some of the programs conducted in the past, such as price stabilization; the provision of some services supporting the development of the private sector, such as grading system and information systems; and the continuation and new emphasis on some of the investment policies pursued in the past, such as road infrastructure.

First, the goals of price stabilization and price support can be largely ignored, without compromising the overall goal of food security. Broad based programs such as subsidized distribution, open market sales, and domestic procurement could be either reduced substantially or even phased out, while at the same time better targeting existing programs specifically addressed to the poor, such as food for work, vulnerable group feeding, and other innovative programs such as food for education. Food

security stocks for emergency situations could be limited to a very moderate amount in order to provide relief to the population affected. A level of food security stock equal to three months average public distribution could ensure the attainment of such an objective. A flexible approach allowing both domestic procurement and imports of limited amount of foodgrains to fill the stock requirement for emergency situations and for targeted programs could minimize the budgetary costs involved in stock operations.

Second, the government could offer various services leading to the development of the marketing system such as allowing the private sector to use public storage facilities, extending credit to trade, and eliminating the remaining non-price barriers to the imports and exports of agricultural outputs and inputs. Moreover, a major effort should be done to promote the collection and analysis of reliable information upon which to base policy and investment decisions. For example, the availability of information related to the responsiveness of the domestic supply system, the prices of aromatic qualities of rice, and international markets could improve not only the design of policy, but also facilitate the penetration of foreign markets. But the critical effort to promote exports consists in the institution of a grading system for different rice qualities. The possibility of exporting rice is largely dependent upon the capacity of the country to offer high quality rice in the international markets. Grading systems and quality control for rice do not exist at present. The government could be pivotal in starting the process.

Finally, growth of agricultural productivity and performance of marketing system will depend on long term investments such as those related to road infrastructure, development and extension of new high yielding varieties and modern technology, improvement of port and modern storage facilities, and irrigation technology. By and large these investments are outside of the control and competence of only one ministry, be it either the Food Ministry or the Ministry of Agriculture. However, without them, the short term policies alone will be unable to generate a sustained and equitable growth that is ultimately the major determinant of the food security of the country.

APPENDIX 1: EFFECTS OF PROCUREMENT AND OFFTAKE ON FOODGRAIN PRICES

A simple model to estimate the effects of procurement and offtake on foodgrain prices is given by the following system:

$$S^r(p_r) = D^r(p_r,p_w) - Offt^r + Procu^r \qquad [55]$$

$$S^w(p_w) = D^w(p_r,p_w) - Offt^w + Procu^w \qquad [56]$$

where S^i, D^i, $Offt^i$, $Procu^i$ denote supply, demand, offtake, and procurement of grain i, respectively; p_i is the price of grain i; and the index i refers to either rice (r) or wheat (w).

By differentiating this system, one obtains:

$$\begin{vmatrix} \eta_{D^r}^{S^r} S^r - \eta_{p_r}^{D^r} D^r & -\eta_{p_w}^{D^r} D^r \\ -\eta_{p_r}^{D^w} D^w & \eta_{p_w}^{S^w} S^w - \eta_{p_w}^{D^w} D^w \end{vmatrix} \begin{vmatrix} \hat{p}_r \\ \hat{p}_w \end{vmatrix}$$

$$= \begin{vmatrix} -\hat{Offt}^r Offt^r + \hat{Procu}^r Procu^r \\ -\hat{Offt}^w Offt^w + \hat{Procu}^w Procu^w \end{vmatrix} \qquad [57]$$

where a hat over a variable denotes percentage change, the η^i_j denote elasticities of variable i with respect to variable j. For example η^{Dr}_{pw} is the rice demand elasticity with respect to wheat price.

The price changes $\hat{p}_i$ are the endogenous variables, and the changes in offtake, $\hat{Offt}^i$, and procurement, $\hat{Procu}^i$ are the exogenous variables. By solving the system with respect to the endogenous variables and keeping in turn each exogenous variable equal to zero, it is possible to obtain the effect of procurement and offtake on prices of rice and wheat.

For example, the elasticity of rice prices with respect to rice procurement, denoted by $\eta^{P_r}_{Procu^r}$ is given by

$$\eta^{P_r}_{Procu^r} = \frac{\dfrac{Procu^r}{S^r}}{\eta^{S^r}_{P_r} - \eta^{D^r}_{P_r}\dfrac{D^r}{S^r} - \dfrac{\eta^{D^r}_{P_w}\eta^{D^w}_{P_r}\dfrac{D^r}{S^r}}{\eta^{S^w}_{P_w}\dfrac{S^w}{D^w} - \eta^{D^w}_{P^w}}} \qquad [58]$$

APPENDIX 2: A MODEL OF PRIVATE STORAGE

Let s_t denote the stock of rice at the beginning of period t. If p_t is the price during period t and s_{t+1} is the stock that the trader wants to accumulate from period t to period t+1, he will try to maximize the expected sum of future profits or losses from storage activity. His problem can be formulated as follows:

$$V(s_1) = \max_{s_{t+1}\geq 0} E_1 \sum_{t=1}^{\infty} \beta^t [p_t(-s_{t+1}+s_t) - c(s_{t+1})] \qquad [59]$$

$$\text{subject to} \quad s_t \geq 0,\ s_1 \ \text{given},\ t \geq 1$$

$V(s_1)$ is the value function, which gives the maximized expected value of profits starting from an initial endowment of stock equal to s_1. $c(s_{t+1})$ is the storage cost function assumed to be convex in s_{t+1}. β is the discount parameter with $0 < \beta < 1$. E_1 is the expectation operator as of time t=1. The dynamic programming formulation of this problem is given by:

$$V(s_t) = \max_{s_{t+1}} [p_t(-s_{t+1}+s_t) - c(s_{t+1}) + \beta E_t V(s_{t+1})] \qquad [60]$$

$$\text{subject to} \quad s_{t+1} \geq 0$$

In this formulation, traders at time t decide to buy stocks s_{t+1} in order to maximize the sum of current profit $p_t(-s_{t+1}+s_t)-c(s_{t+1})$ and the expected value of future profits $V(s_{t+1})$ resulting from this period choice of s_{t+1}. The first order conditions for this problem are:

$$-\frac{\partial c}{\partial s_{t+1}} + \beta\, p_{t+1,t} - p_t \leq 0 \qquad [61]$$

$$= 0, \quad \text{if} \quad s_{t+1} \leq 0$$

where $p_{t+1,t}$ is the price expected to prevail at time t+1, as of time t. For an interior solution ($s_{t+1} > 0$) the first order conditions have the familiar interpretation according to which traders store rice until the marginal cost of storage (that is $\partial c/\partial s_{t+1}$) is equal to the expected marginal benefit (that is $\beta \cdot p_{t+1,t} - p_t$). Note that the discount factor may be assumed to incorporate the perceived relevant interest rate, and therefore the interest rate cost needs not to be taken into account inside the function $c(s_{t+1})$.

By choosing the storage cost as a convex function of s_{t+1},

$$c = b_0 + b_1 \cdot s_{t+1} + 0.5 \cdot b_2 \cdot s^2_{t+1} \qquad [62]$$

where b_i are constant with $b_0 > 0$, $b_1 < 0$ and $b_2 > 0$, it is possible to explicitly solve for s_{t+1}.

$$s_{t+1} = (\beta \cdot p_{t+1,t} - p_t - b_1)/b_2 \qquad [63]$$

In this formulation, desired stocks today respond to the differential between expected prices tomorrow and prices today.

Expectations

So far, the way expectations about future prices are formed has been left undetermined. An error in variable approach can be used to deal with this problem (see Wickens 1982). The expectational error is defined as

$$e_{t+1} = p_{t+1,t} - p_{t+1} \qquad [64]$$

A strong form of Informational Efficiency would suggest that the error e_{t+1} is uncorrelated with I_t, the information available at time t. Namely:

$$E\,(e_{t+1} \mid I_t) = 0 \qquad [65]$$

This condition guarantees that traders are unable to improve upon the market. If the correlation between the expectational errors and the information set were not equal to zero, then such an information could be utilized to improve profits. Given the assumptions of perfect competition and rational expectations, arbitrage would exploit such an opportunity.

The information available at time t, I_t, can be decomposed as follows:

$$I_t = \{ p_t \} \cup \Omega_t \qquad [66]$$

where Ω_t contains information different from p_t.

The hypothesis of informational efficiency can be expressed by saying that traders cannot exploit today's information to improve their forecast of prices tomorrow. With the additional assumption of linearity, the expectational error can be written as follows:

$$e_{t+1} = \gamma_1 \cdot \Omega_t + \gamma_2 \cdot p_t + \epsilon_{1,t+1} \qquad [67]$$

where $\epsilon_{1,t+1}$ are iid errors.

The hypothesis of informational efficiency can then be formulated as follows:

$$H_0 : \gamma_1 = \gamma_2 = 0 \qquad [68]$$

A weaker form of informational efficiency would be to see whether any of γ_1 or γ_2 are equal to zero. T hypothesis

$$H_1 : \gamma_1 = 0 \qquad [69]$$

can be interpreted as saying that traders are using all the information *different* from current prices efficiently. The hypothesis

$$H_2 : \gamma_2 = 0 \qquad [70]$$

can be interpreted as saying that traders do not overreact to current prices in forming their expectations about future prices. This can also be expressed as an hypothesis about the *non destabilizing* nature of price speculation.

Equations [64], [65], and [66] imply:

$$\Delta s_{t+1} = \frac{1}{b_1}[\beta\Delta p_{t+1} + (\beta\gamma_2 - 1)\Delta p_t + \beta\gamma_1\Delta\Omega_t] + \frac{\beta}{b_2}\Delta\epsilon_{1,t+1} \qquad [71]$$

Under the hypothesis of informational efficiency ($\gamma 1 = \gamma 2 = 0$), equation (71) says that the variation of desired stocks depends on the acceleration of inflation ($\beta\Delta p_{t+1} - \Delta p_t$).

Equilibrium

In equilibrium, the available supply of rice is either consumed, or flows into the stocks of the private and the government sector. The available supply sp_t is given by current production q_t plus imports m_t. Formally:

$$sp_t = C_t + \Delta s_{t+1} + \Delta G_{t+1} \qquad [72]$$

where $sp_t = q_t + m_t$, and q_t is production available at the beginning of period t, m_t are rice imports during period t, and G_t are government *opening stocks*.

Private demand is decomposed into demand for consumption C_t, and demand for storage Δs_{t+1}.

Data on either one of these two components are not available. In order to arrive at a relation that is estimable, both private stocks and private consumption are expressed in terms of observable quantities, such as prices, income, etc. For private stocks, this relation is given by equation [71]. For consumption C_t the following expression is postulated:

$$C_t = r_0 + r_1 p_t + r_2 p^w_t + r_3 Y_t \qquad [73]$$

where p^w_t is the price of wheat, to be considered as a substitute of rice, and Y_t is income. Putting together equations (71), (72), and (73), the following specification results:

$$p_t = \beta_0 + \beta_1 p_{t+1} + \beta_2 p_{t-1} + \beta_3 x_t + \beta_4 \Delta\Omega_t + \beta_5 \Delta G_{t+1} + \mu_t \qquad [74]$$

where x_t is the vector, the transpose of which is $x'_t = [sp_t\ p^w_t\ Y_t\ ]$, and $\beta_0 = -r_0/A$; $\beta_1 = -(\beta/b_2)/A$; $\beta_2 = [(\beta\gamma_2-1)/b_2]/A$; $\beta_3 = [\ 1\ -r_2\ -r_3\ ]/A$; $\beta_4 = -(\beta\gamma_1/b_2)/A$; $\beta_5 = -1/A$; $A = r_1 + (\beta\gamma_2-1-\beta)/b_2$.

The hypothesis of informational efficiency can now be expressed in terms of the coefficients β_i's. Hence, the hypothesis $\gamma_1 = 0$, is reformulated as $\beta_4 = 0$; the hypothesis $\gamma_2 = 0$, is reformulated as $\beta \cdot \beta_2 = \beta_1$.

APPENDIX 3: FOOD DEMAND PARAMETERS

This appendix estimates the food demand parameters necessary to evaluate the effects of price stabilization on poverty and economic surplus.

In an household survey with as many observations as the HES 1988/89, it is not unusual (see Deaton and Irish 1984) that many commodities are observed with a value of zero consumption. In this case, the application of the usual continuous techniques would result in biased and inconsistent estimates, because the random disturbances have non zero means and are correlated with the exogenous variables. Moreover, dropping those households with zero observations would dramatically reduce the sample size and still give inconsistent estimates (see Pitt 1983).

The limited dependent variable model of Tobin (1958) provides a method for estimating demand equations in this case since it permits a positive probability of observing zero consumption. The model is

$$y_i = X_i \cdot \beta + u_i \quad \text{if } X_i \cdot \beta + u_i > 0$$

$$y_i = 0 \qquad \text{if } X_i \cdot \beta + u_i \leq 0 \qquad [75]$$

where the y_i denotes the dependent variable, X_i is the matrix of independent variables, and β is a vector of parameters.

In this model zeroes arise if and only if the household genuinely does not purchase the good.

The model rules out the application of some specifications of the demand system. As it was pointed out by Pitt 1983, the use of expenditures or budget shares would be inconsistent with the behavior of marginal consumers, since for inelastic commodities there is a positive probability of consuming those commodities when their price is increasing.

A model with enough flexibility adapted from Pitt is:

$$q_i^h = \alpha_i^H + \sum_j \gamma_{ij}^H \ln p_j + \beta_i^H \ln\left(\frac{y^h}{p^*}\right) + \sum_j \delta_{hi}^H z_i^h + u_i^h \qquad [76]$$

where q_i^h is the consumption per capita of commodity i by household h, p_j is price of commodity j facing household h, y^h is total expenditure of household h, p^* is the index of prices used to deflate total

expenditures for household h, and the z^h_k's are k socioeconomic variables related to household h. The parameters have a superscript H to denote the quartile of interest.

In what follows the superscripts h and H are dropped for ease of notation.

Nine commodity groups are considered in this analysis: rice, wheat, pulses, fish, meat, vegetables, oils, spices, and sugar. Together, these commodities represent 81 percent of total food expenditures and 97 percent of total calories. Prices are derived from unit values, since it was not possible to get market prices. Consumption and expenditures are considered in per capita terms in the estimation. Expenditures are deflated by a Stone index constructed by weighing each price with the share of that commodity in the total expenditure.

Household characteristics included in the specification of the model are family size, percentage of children aged 0 to 7, percentage of adults, sex of household head, percentage of employed members of the household, percentage of household members employed within the household, education of the household head.

Results

Wald tests are used to test the null hypothesis that each of the underlying parameters of the demand equations is zero. Given the hypothesis H_0: $g(\theta) = 0$, where θ is the vector of parameters, and g is a J-dimensional vector of functions, then

$$\sqrt{T}\cdot[g(\hat{\theta}) - g(\theta)' \xrightarrow{d} N[\,0, \lim TF(\hat{\theta})'I(\hat{\theta})^{-1}F(\hat{\theta})\,] \qquad [77]$$

where $\hat{\theta}$ is the unrestricted ML estimator, and F is the Jacobian $\partial g'(\theta)/\partial\theta$, which is a matrix n x J computed for $\theta = \hat{\theta}$, and $I(\hat{\theta})$ is the information matrix. Under H_0 the Wald λ_w statistics is asymptotically distributed as a chi-square with J degrees of freedom, where

$$\lambda_w = [g(\hat{\theta})]'[F(\hat{\theta})'I(\hat{\theta})^{-1}F(\hat{\theta})]^{-1}[g(\hat{\theta})] \xrightarrow{d} \chi^2_{(J)} \qquad [78]$$

The test statistics indicate a considerable degree of price response for all foods. Of the 81 price coefficients for the nine food groups considered, almost half are significant at 90 percent level.

For rural households the price responsiveness is more pervasive, where pervasiveness of price response is measured by the percentage of price coefficients significantly different from zero. This is an interesting result because it indicates responsiveness to price overall the country, not just in urban areas. Finally, the higher is the income group the less pervasive becomes the price responsiveness indicating an increasing food price rigidity in upper classes.

The homogeneity hypothesis that the sum of the price coefficients is equal to zero was tested ($\Sigma_j \gamma_{ij} = 0$, for every commodity i). The violation of homogeneity of demand with respect to food prices suggests either some sort of money illusion on the part of consumers, or the exclusion of non-food prices from the analysis. The lack of support of homogeneity does not seem to have grave consequences for both the values and the significance of elasticities, as shown by a test on the equality of elasticities in the two cases when homogeneity is imposed and when homogeneity is not imposed. Therefore, in what follows only the estimates for the restricted model are reported, where homogeneity is imposed.

The hypothesis of varying coefficients across groups could not be rejected for either price coefficients or income coefficients. In fact, a Wald test on equality of coefficients among any pair of expenditure groups was strongly rejected. The more "distant" are the groups in terms of their expenditure per capita, the stronger is the rejection of the hypothesis of equal coefficients. This is true both in rural and urban areas, suggesting that treating demand parameters of different groups equally is not warranted.

Demand Elasticities

In the Tobit model of equation [75] the expected value of the dependent variable is given by

$$E(y_i) = \zeta \cdot \sigma \cdot \Phi(\zeta) + \sigma \cdot \phi(\zeta) \qquad [79]$$

where $\zeta = X \cdot \beta / \sigma$, $\phi(\cdot)$ is the density function and $\Phi(\cdot)$ is the cumulative distribution of the normal distribution function.

Then the elasticity of demand of food i with respect to variable v is given by

Note that this formula differs from the usual elasticity in the presence of the term $\Phi(\zeta)$ denoting the probability that positive consumption occurs. In other words, if there were no censoring this probability

$$\frac{\partial \log E(q_i)}{\partial \log v} = \frac{\Phi(\zeta)}{E(q_i)} \frac{\partial X\beta}{\partial v} \qquad [80]$$

would be equal to one.

In what follows only information on own price elasticity, expenditure elasticity, and cross price elasticity for rice and wheat is reported (see table 31).

For rice, income elasticities show a tendency to decline with income, confirming Engel's law. Moreover, they are higher in rural areas than in urban areas, suggesting that there is a tendency to diversify out of rice towards other foods in rural areas. Price responsiveness is quite high; in urban areas it is higher than in rural areas, suggesting higher substitution effects in urban areas. Moreover, there is a declining pattern for own price elasticities as income rises, confirming an observation made by other studies (for a review of the literature see Alderman 1987). As income increases, households become less responsive to variation in the price of the major staple commodity.

For wheat, the situation is rather different. For urban areas, the expenditure elasticities of wheat were not statistically different from zeros. In rural areas, only for poorer households is the expenditure elasticity significative at the 95 percent level, and negative. Even though wheat gives about 9 percent of the calorie intake of the average Bangladeshi diet, its consumption does not seem to vary with income too much, once the effect of price is taken into account. The main pattern emerging from these figures is that, once consumers are above a certain income per capita, their wheat consumption does not change. For price elasticities, there is a tendency for own price elasticities of wheat to decline with income, from an initially high absolute value to zero. The positive sign on the own price elasticity for the upper urban quartile is puzzling. The fit of the equation generating this result is nevertheless very low. It is therefore a result to be taken with caution. Finally, table 31 shows that in rural areas price responsiveness is less marked than in urban areas.

The cross price elasticities between rice and wheat point out that wheat prices do not affect rice demand significantly, whereas rice prices are strongly affecting wheat demand. As expected, wheat is a

substitute for rice. Moreover, as observed for own price and income elasticities, even cross price elasticities of wheat demand with respect to rice price are declining with income.

Table 1 - Growth Rates of Harvest prices of Rice and Wheat

Growth Rates	Index of Paddy Harvest Price	Index of Wheat Harvest Price	Index of General Wholesale Prices	Deflated Index of Paddy Harvest Price	Deflated Index of Wheat of Harvest Price
1972-90	8.4	8.4	9.9	-1.5	-1.5
(t-stat)	(9.6)	(7.3)	(18.8)	(-3.2)	(-1.8)
1972-80	9.5	8.6	12.1	-2.6	-3.5
(t-stat)	(2.1)	(1.4)	(4.6)	(-1.2)	(-0.8)
1981-89	7.9	7.2	9.1	-1.2	-1.9
(t-stat)	(7.9)	(13.1)	(19.8)	(-1.6)	(-2.4)

Source: Harvest prices compiled by Mahmud, Rahman, and Zohir (1993)

Note: Growth rates are computed by fitting semilogarithmic trends. The numbers in parenthesis are t-statistics.

Table 2 - Growth Rates and Variability of Foodgrains Production

	Aman	Aus	Boro	Total Rice	Wheat	Foodgrains
Growth Rates (Percent)						
70-80's	1.66	-0.42	6.91	2.54	14.76	2.9
70's	2.74	2.54	3.01	2.77	35.22	3.60
80's	1.52	-2.87	8.60	2.75	-1.75	2.46
Variability of Production (Percent)						
70-80's	6.9	6.3	9.4	4.1	194.4	3.9
70's	5.7	7.2	10.7	5.2	288.4	4.8
80's	7.9	6.0	8.9	3.3	14.2	3.0

Sources: Computed by author based on data from Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh*, various issues.

Note: Growth rates are computed with semilogarithmic trend. Variability of production is measured by the standard deviation of percentage differences between production figures and a quadratic trend.

The 70's refer to the period 1972/73 to 1981/82.
The 80's refer to the period 1981/82 to 1990/91.

Table 3 - Correlation of crop production.

	Aman	Aus	Boro	Wheat
Aman	1	-0.04	-0.30*	-0.18
Aus		1	-0.03	-0.47
Boro			1	0.21**
Wheat				1

Source: Computed by author based on data from Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh*, various issues.

Note: (*) denotes significance at 90% level.
(**) denotes significance at 99% level.
The correlations are based on residuals from quadratic trend regressions of crop production over time.

Table 4 - Growth of Yield, Acreage, HYV Acreage, and Irrigated Acreage

	Aus	Aman	Boro	Total Rice
Rice Yield Growth (Percent)				
70-80's	1.23	1.69	1.48	2.13
70's	2.46	2.59	0.06	2.16
80's	1.17	2.39	-0.04	2.72
Rice Acreage Growth (Percent)				
70-80's	-1.2	-0.05	5.16	0.39
70's	0.21	0.80	1.20	0.66
80's	-3.36	-1.29	8.38	-0.21
HYV Rice Acreage Growth (Percent)				
70-80's	6.75	7.85	9.03	7.86
70's	22.41	1.30	4.18	5.06
80's	-2.17	6.04	11.41	7.28
Irrigated Rice Acreage Growth (Percent)				
70-80's	6.36	5.33	4.12	4.39
70's	9.62	2.03	0.6	1.32
80's	1.82	1.82	8.59	7.28

Sources: Computed by author based on Data from Bangladesh Bureau of Statistics, *Statistical Yearbook*, various issues.

Note : The 70-80's refers to the period 1972/73 to 1990/91.
The 70's refers to the period 1972/73 to 1981/82.
The 80's refer to the period 1981/82 to 1990/91.

Table 5 - Acreage Level of Rice Yield, HYV Acreage Share and Irrigated Rice

	Aus	Aman	Boro	Total Rice
Rice Yield (Mt/Hectare)				
70-80's	0.99	1.29	2.25	1.34
70's	0.95	1.21	2.06	1.22
80's	1.03	1.37	2.43	1.45
Rice HYV Share (Percent)				
70-80's	13	10	68	22
70's	10	10	56	15
80's	16	21	80	30
Irrigated Rice Share (Percent)				
70-80's	3.74	2.51	86.73	14.27
70's	2.55	1.83	91.72	11.69
80's	4.92	3.19	81.74	16.85

Sources: Computed by author based on Data from Bangladesh Bureau of Statistics, *Statistical Yearbook*, various issues.

Note : The 70-80's refers to the period 1972/73 to 1990/91.
The 70's refers to the period 1972/73 to 1981/82.
The 80's refer to the period 1981/82 to 1990/91.

Table 6 - Extent of Government Intervention in the Foodgrain Sector

	70-80's	70's	80's
Availability of Foodgrains (million metric tons)	15.7	13.6	17.7
Ratio of Public Distribution to Availability (Percent)	13	14	11
Ratio of Public Distribution to Marketed Supply (Percent)	56	78	36
Ratio of Procurement to Production (Percent)	2.6	2.7	2.5
Ratio of Procurement to Public Distribution (Percent)	20.2	19.4	20.7
Ratio of Imports to Public Distribution (Percent)	94	92	93
Ratio of Monetary Distribution to Total Public Distribution (Percent)	75	86	65
Ratio of Open Market Sales to Total Public Distribution (Percent)	4.5	7.6	7.2
Ration Rice Prices as Percentage of Market Prices (Percent)	82	71	88
Ration Wheat Prices as Percentage of Market Prices (Percent)	90	85	93
Food Dependency (Percent)	37	54	22

Source: Computed by author based on data from *Statistical Yearbook of Bangladesh*, various issues.

Note: Availability is given by production net of 10 percent for wastage, feed, and seed. Marketed surplus is assumed to grow at constant rate from 15 percent of total production in 1972 to 50 percent in 1990.

Food dependency is the ratio of the foodgrain imports evaluated at world prices and the foreign receipts.

The 70-80's refers to the period 1972/73 to 1990/91.
The 70's refers to the period 1972/73 to 1981/82.
The 80's refer to the period 1981/82 to 1990/91.

Table 7 - Elasticities of Rice and Wheat Prices with Respect to Offtakes and Procurement

	Rice Offtakes	Wheat Offtakes	Rice Procurement	Wheat Procurement
Elasticity of Price of :				
Rice	-.08	-0.02	0.05	0.00
Wheat	-.16	-0.63	0.09	0.03

Note: Offtakes as a Ratio of Supply are 5 and 150 percent for rice and wheat, respectively.

Procurement as a Ratio of Supply is 3 and 7 percent for rice and wheat, respectively.

Own price supply elasticities for rice and wheat are 0.01 and 0.6, respectively.

Own price demand elasticities for rice and wheat are -0.6 and -0.8, respectively. Cross price demand elasticities for rice and wheat are 0.02 and 2, respectively.

Table 8 - Integration and Co-integration Test for Domestic and Border Prices of Rice and Wheat

	Integrated of Order 0	Integrated of Order 1	Co-Integration Factor (β)
Rice Domestic Price	-1.00	-6.73	
Rice Border Price	-1.64	-11.13	
Rice Co-integration			0.89
Equation Error (ϵ_t)	-3.12		
Wheat Domestic Price	-1.73	-12.88	
Wheat Border Price	-1.46	-11.84	
Wheat Co-integration Equation Error (ϵ_t)	-4.26		0.91

Source: Domestic Prices are wholesale Prices of Coarse Rice and Wheat.
Rice Border Price is derived from Thai 5% price.
Wheat Border Price is derived from World Bank, Commodity Price Series.

Note: The critical value of Dickey-Fuller Statistical 5 percent level is -2.89.
The co-integration equation is :

$$\text{Domestic Price}_t = \alpha + \beta \cdot \text{Border Price}_{rt} + \epsilon_t$$

Table 9 - Informational Efficiency Results

	Sample: July 1978 to June 1990		Sample: July 1973 to June 1990	
Variable	Coefficient	Probability > |t|	Coefficient	Probability > |t|
Constant	0.00837	0.87	0.02139	0.10
p_{t-1}	0.30871	0.01	0.31700	0.07
p_t	0.50887	0.00	0.82151	0.00
sp_t	-0.00001	0.00	-0.00080	0.00
p^e_t	0.17180	0.23	0.20350	0.11
Δp_{t-1}	0.11334	0.17	0.12080	0.05
ΔC_t	-0.00129	0.32	-0.00082	0.34
Δsp_{t-1}	-0.00003	0.78	-2.81e-5	0.41
ΔC_{t-1}	0.00210	0.72	0.00520	0.31
Degrees of Freedom	105		106	
R^2	0.848		0.783	
Kolmogorov-Smirnov	0.84	0.21	1.01	0.16
White	93	0.16	87.53	0.01
Ljung-Box(12)	18.06	0.19	21.54	0.04
Arch Lags	0		1	
Prime Informational Efficiency ($\beta_2 = \beta_1$)	1.80	0.18	3.33	0.08
Non-prime informational efficiency ($\beta_1 = 0$)	1.06	0.36	0.86	0.40
Strong informational efficiency ($\beta_2 = \beta_1$ and $\beta_1 = 0$)	1.07	0.37	1.26	0.23
Stock Mean Kg per capita	4.0		3.6	
Standard Deviation of Stock Kg per capita	1.0		1.0	
Coefficient of Variation of Stock	0.36		0.50	

Source: Computed by author based on price data from the Department of Agricultural Marketing and quantity data from the *Monthly Statistics Bulletin*, various issues.

Note: The subindex t refers to the month; Δ refers to the difference operator; p_t is the rice price; sp_t is the rice availability; p^e_t is the wheat price; C_t is the beginning public rice stock; spp_t is the rice production of the past three months; β_1 is the coefficient of p_{t-1}; β_2 is the coefficient of p_t; includes the coefficients of the informational variables Δp_{t-1}, ΔC_t, Δsp_{t-1}.

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Table 10 - Informational Efficiency Results and Liberalization

	Sample: July 1975 to June 1982		Sample: July 1982 to June 1990	
Variable	Coefficient	Probability > |t|	Coefficient	Probability > |t|
Constant	-0.002	0.469	0.006	0.41
p_{t-1}	0.367	0.067	0.349	0.013
p_{t-2}	0.518	0	0.573	0
sp_t	-0.001	0.004	-0.001	0.001
p^w_t	0.231	0.198	0.118	0.258
Δp_{t-1}	0.043	0.394	0.141	0.147
ΔG_t	-0.001	0.292	0	0.384
Δspp_{t-1}	0	0.384	0	0.128
ΔG_{t-1}	-0.002	0.381	0.003	0.384
Degrees of Freedom	80		80	
R^2	0.8		0.8	
Kolmogorov-Smirnov	0.055	0.17	0.806	0.271
White	47.08	0.348	40.707	0.814
Ljung-Box(12)	9.77	0.722	6.74	0.725
Arch Lags	0		0	
Price Informational Efficiency ($\beta_2 = \beta_3$)	0.208	0.849	0.75	0.389
Non-price Informational efficiency ($\beta_4 = 0$)	0.153	0.828	0.845	0.423
Strong informational efficiency ($\beta_2 = \beta_3$ and $\beta_4 = 0$)	0.123	0.974	1.255	0.128
Stock Mean (kg per capita)	4.2		2.8	
Standard Deviation of Stock (kg per capita)	1.7		1.4	
Coefficient of Variation of Stock	0.41		0.37	

Source: Computed by author based on price data from the Department of Agricultural Marketing and quantity data from the *Monthly Statistical Bulletin*, various issues.

Note: The subindex t refers to the month; Δ refers to the difference operator; p_t is the rice price; sp_t is the rice availability; p^w_t is the wheat price; G_t is the beginning public rice stock; spp_t is the rice production of the past three months; β_1 is the coefficient of p_{t-1}; β_2 is the coefficient of p_{t-2}; β_3 includes the coefficients of the information set variables Δp_{t-1}, ΔG_t, Δspp_{t-1}.

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Table 11 - Marketing Infrastructure and Production at district (zila) level in 1990/91.

Variable	ALL SAMPLE		FIRST THIRTILE		THIRD THIRTILE	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Road density (Km per square Km)	0.07	0.03	0.03	0.01	0.11	0.02
Railways density (Km per square Km)	0.02	0.02	0	0	0.04	0.01
Electricity Connections Density (Number per Square Km)	11	26	3	1	24	44
Telephone density (number per million people)	1035	2485	281	56	2343	4092
Post office density (number per million people)	13	6	8	2	20	6
Bank branches density (number per million people)	52	16	39	5	69	17
Rice production per capita (Kg per capita per year)	174	63	111	29	242	47
Wheat production per capita (Kg per capita per year)	10	12	0	1	23	12
Population density (inhabitants per square Km)	822	521	473	184	1232	712

Source: Computed by author based on market infrastructure data collected by IFPRI.

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Table 12 - Segmented Links: markets not cointegrated and less than 250 km apart.

Link	District i	District j	Cointegration Coefficient $_{bij}$	Cointegration Coefficient $_{bji}$	Distance	Correlation
1	PANCHAGA	LALMONIR	-2.15	-0.70	176	0.27
2	RANGPUR	LALMONIR	-2.41	-1.13	39	0.37
3	LALMONIR	NOAGAON	-2.18	-1.34	194	0.11
4	NILPHAMA	NOAGAON	-2.40	-0.98	212	-0.02
5	KURIGRAM	NOAGAON	-2.80	-0.98	205	0.19
6	BOGRA	JOYPURHA	-2.06	-2.86	87	0.25
7	BOGRA	GOPALGON	-2.50	-2.78	228	0.23
8	BOGRA	DHAKA	-2.34	-2.37	220	-0.04
9	RAJSHAHI	NOAGAON	-2.17	-1.82	88	0.16
10	RAJSHAHI	NAWABGON	-1.24	-2.39	48	0.09
11	RAJSHAHI	KUSHTIA	-1.71	-2.43	142	0.02
12	PABNA	MANIKGON	-2.81	-2.37	183	0.08
13	MAGURA	COMILLA	-2.28	-2.06	231	0.08
14	JHALOKAT	GOPALGON	-2.51	-2.18	121	0.22
15	JHALOKAT	DHAKA	-2.04	-2.80	153	0.05
16	JHALOKAT	MANIKGON	-1.82	-1.28	193	0.10
17	BHOLA	MUNSHIGO	-2.78	-2.59	202	0.42
18	NETROKON	MANIKGON	-2.88	-2.74	202	0.30
19	SHERPUR	MANIKGON	-2.47	-1.80	170	0.29
20	FARIDPUR	MANIKGON	-2.47	-2.85	54	0.06
21	RAJBARI	MANIKGON	-2.69	-0.95	44	0.41
22	MADARIPU	GOPALGON	-2.07	-2.85	69	0.35
23	MADARIPU	MANIKGON	-2.08	-1.75	123	0.14
24	GOPALGON	MUNSHIGO	-2.55	-2.22	154	-0.11
25	GOPALGON	MANIKGON	-2.54	-2.04	121	0.26
26	GOPALGON	COMILLA	-2.57	-1.59	211	-0.02
27	GOPALGON	B.BARIA	-2.15	-2.61	237	0.12
28	DHAKA	LAKSHMIP	-1.72	-1.70	194	0.10
29	GAZIPUR	LAKSHMIP	-2.82	-2.85	234	-0.03
30	MUNSHIGO	LAKSHMIP	-2.07	-1.59	206	0.01
31	MUNSHIGO	CHITTAGO	-2.89	-2.83	245	0.11
32	MOULVI_B	HOBIGONJ	-1.60	-2.77	46	0.16
33	MOULVI_B	SUNAMGON	-2.59	-2.38	128	0.23
34	COMILLA	LAKSHMIP	-2.19	-1.66	113	-0.08
35	B.BARIA	LAKSHMIP	-2.06	-1.78	204	-0.06
36	NOAKHALI	KHAGRACH	-2.21	-1.94	215	-0.10
37	NOAKHALI	BANDARBA	-1.70	-1.80	205	0.21
38	LAKSHMIP	FENI	-0.48	-2.89	48	0.24
39	LAKSHMIP	CHITTAGO	-1.66	-2.56	137	-0.02
40	LAKSHMIP	KHAGRACH	-0.24	-0.32	219	0.16
41	LAKSHMIP	BANDARBA	-1.92	-2.34	209	-0.20
42	FENI	KHAGRACH	-2.54	-1.63	171	-0.03
43	CHITTAGO	BANDARBA	-2.76	-1.90	72	0.09
44	COX'S_BA	KHAGRACH	-2.41	-1.80	230	-0.01

Source: Computed by author based on prices from Department of Agricultural Marketing and market infrastructure data collected by IFPRI.

Table 13 - Comparison of various measures of integration

Measure of Integration	Percentage of significant market links	Average of the Measure of integration over the significant market links	Standard deviation of the measure of integration over the significant market links
Correlation coefficient ρ	53	0.23	0.08
Cointegration coefficient b	56	0.68	0.14
Long term multiplier λ	35	0.61	0.25
Speed of adjustment τ	35	2.6	1.15
Composite measure μ	35	0.31	0.24

Source: Computed by author based on prices from Department of Agricultural Marketing and Market Infrastructure Data collected by IFPRI.

Note: Significant market links are those for which the relative measure of integration is significantly different from zero in both directions of each link.

TABLE 14 - DETERMINANTS OF MARKET INTEGRATION

	Correlation of Price Differences			Cointegration Coefficient			Long Term Multiplier			Composite measure			Mean of Independent Variable
	ρ			b			λ			ρ			
Variable	Coefficient	T-statistics	Correlation with Dependent Variable	Coefficient	T-statistics	Correlation with Dependent Variable	Coefficient	T-statistics	Correlation with dependent Variable	Coefficient	T-statistics	Correlation with dependent variable	
Constant	0.0765	3.06		0.6337	12.50		0.4391	5.56		0.135	3.19		
Distance	-0.0001	-5.72	-0.27	-0.0002	-3.79	-0.30	-0.0001	-1.46	-0.10	0	0.26	-0.02	310.822
Paved Road Density	0.6721	4.78	0.32	-0.2372	-0.83	0.05	0.5447	1.23	0.09	0.6741	2.84	0.11	0.140
Telephone Density	6.0815	1.69	0.07	-15.561	-2.14	-0.07	-32.0849	-2.83	0.03	-12.1121	-1.99	0.00	0.003
Bank Branches Density	-0.0007	-2.15	0.15	0.0013	2.05	0.03	0.0015	1.52	0.07	0.0009	1.68	0.06	85.684
Railways Density	0.0002	0.80	0.07	0	0.02	0.00	-0.0019	-2.90	-0.02	-0.0013	-3.78	-0.09	43.167
Number of Strikes	-0.0002	-2.61	-0.02	-0.0001	-0.42	-0.10	-0.0005	-2.61	-0.03	-0.0003	-2.91	0.15	237.368
Number of Shocks to Production	0.0003	2.99	0.12	0	-0.16	-0.10	0.0011	3.19	0.04	0.0002	1.04	-0.08	104.421
Degree of Dissimilarity in Production	0.0151	1.86	0.07	0.0131	0.79	-0.01	0.1024	3.98	0.19	0.0279	2.03	0.08	0.374
Degree of Price Stabilization	0.0605	4.59	0.33	0.0589	2.21	0.17	-0.1536	-3.69	-0.13	-0.0501	-2.24	0.02	6.938
Mean of Dependent Variable	0.1326			0.6582			0.3424			0.1364			
Valid Cases	361			361			361			361			
R^2	0.2845			0.1344			0.1167			0.1007			

Source: Computed by author based on prices from Department of Agricultural Marketing and Market Infrastructure Data collected by IFPRI.

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Table 15 - Summary effects of structural factors on measures of integration.

	Correlation of Price Differences	Cointegration Coefficients	Long Term Multiplier	Composite Measure	Congruence among measures
Distance	-	-	0	0	-
Paved Road Density	+	0	0	+	+
Telephone Density	0	-	-	-	-
Bank Branches Density	-	+	0	+	?
Railway Density	0	0	-	-	-
Number of Strikes	-	0	-	-	-
Degree of Price Stabilization	+	+	-	-	+/-
Degree of Dissimilarity in Production	+	0	+	+	+
Production Shocks	+	0	+	0	+
R^2	28.4	13.4	11.7	10.0	

Source: Computed by author based on prices from Department of Agricultural Marketing and Market Infrastructure Data collected by IFPRI.

Notes:

+ means significantly positive effect.
- means significantly negative effect.
0 means not significantly different from zero.
Congruence refers to the overall conclusion from the different measures of integration.
+/- means that it has a positive effect on correlation and cointegration coefficients and a negative effect on long term multiplier and composite measures.

Table 16 - Rice Price Variability.

Period	INTER-YEAR VARIATION Coefficient of Variation (Percent)	INTRA-YEAR VARIATION Coefficient of Variation (Percent)	AVERAGE FOODGRAIN STOCK PER CAPITA (kg per capita)
70-80'S	14.8	10.4	3.48
70'S	28.1	13.9	2.97
80'S	7.5	7.3	4.00

Source: Computed by the author based on Wholesale coarse rice price from the Department of Agricultural Marketing.

Table 17 - Number of People below the poverty line.

	Poverty Line at 2122 k.cal/day/person				Poverty line at 1805 k.cal/day			
	Rural		Urban		Rural		Urban	
Year	Millions	Percent of population	Millions	Percent of Population	Millions	Percent of Population	Millions	Percent of Population
1973-74	57.4	82.9	5.6	81.4	30.7	48.3	2.0	28.6
1981-82	60.9	73.8	6.4	66.0	43.1	52.2	3.0	30.7
1983-84	47.0	57.0	7.1	66.0	31.3	38.0	3.8	35.0
1985-86	44.2	51.0	7.0	56.0	19.1	22.0	2.4	19.0
1988-89	40.5	48.0	10.8	44.0	24.9	29.5	5.0	20.5

Source: *Report of the Household Expenditure Survey*, BBS (1991)

Table 18 - Conditions for Price Stabilization to reduce expected poverty.

	Average Calorie	Calorie Price Elasticity	LHS (α=1)	LHS (α=1.5)	LHS (α=2)	LHS (α=3)	LHS (α=4)	RHS
				Case 1: $\rho^{*}_{pr} = -1$				
Rural First Quartile	1677	-0.27	0	-0.14	-0.27*	-0.54*	-0.81*	-0.21
Urban First Quartile	1764	-0.34	0	-0.17*	-0.34*	-0.68*	-1.02*	-0.17
Rural Second Quartile	2040	-0.30	0	-0.15*	-0.30*	-0.60*	-0.90*	-0.04
Urban Second Quartile	2069	-0.26	0	-0.13*	-0.26*	-0.52*	-0.78*	-0.02
				Case 2: $\rho^{*}_{pr} = -1-\eta^{*}_{pr}$				
Rural First Quartile	1677	-0.27	0	-0.14	-0.27*	-0.54*	-0.81*	0.27
Urban First Quartile	1764	-0.34	0	-0.17	-0.34*	-0.68*	-1.02*	-0.23
Rural Second Quartile	2040	-0.30	0	-0.15*	-0.30*	-0.60*	-0.90*	-0.05
Urban Second Quartile	2069	-0.26	0	-0.13*	-0.26*	-0.52*	-0.78*	-0.03

Source: Computed by author based on Household Expenditure Survey (BBS/1991)

Note: Price stabilization reduces poverty if LHS is less than RHS, where

LHS=$(\alpha-1)*\eta^{*}_{pr}$, and RHS=$(1-z/x)*\rho^{*}_{pr}$.

* refers to those cases when price stabilization reduces poverty.

Table 19 - Price stabilization and expected utility

QUARTILE	Coefficient of Relative Risk Aversion R^c	Budget Share s_i	Income Elasticity η_{iy}	$s_i*(R^c+\eta_{iy})$	Price Elasticity η_{ii}
Rural First Quartile	-1	45	0.8	-0.09	-0.89
Rural Second Quartile	-1	41	0.71	-0.12	-0.71
Rural Third Quartile	-1	37.3	0.64	-0.13	-0.55
Rural Fourth Quartile	-1	26.2	0.03	-0.25	-0.39
Urban First Quartile	-1	37.3	0.58	-0.16	-1.02
Urban Second Quartile	-1	31.3	0.43	-0.18	-0.76
Urban Third Quartile	-1	24.7	0.19	-0.2	-0.38
Urban Fourth Quartile	-1	12.7	-0.03	-0.13	-0.5*
Rural First Quartile	-2	45	0.8	-0.54	-0.89
Rural Second Quartile	-2	41	0.71	-0.53	-0.71
Rural Third Quartile	-2	37.3	0.64	-0.51	-0.55
Rural Fourth Quartile	-2	26.2	0.03	-0.52	-0.39*
Urban First Quartile	-2	37.3	0.58	-0.53	-1.02
Urban Second Quartile	-2	31.3	0.43	-0.49	-0.76
Urban Third Quartile	-2	24.7	0.19	-0.45	-0.38*
Urban Fourth Quartile	-2	12.7	-0.03	-0.26	-0.5
Rural First Quartile	-3	45	0.8	-0.99	-0.89*
Rural Second Quartile	-3	41	0.71	-0.94	-0.71*
Rural Third Quartile	-3	37.3	0.64	-0.88	-0.55*
Rural Fourth Quartile	-3	26.2	0.03	-0.78	-0.39*
Urban First Quartile	-3	37.3	0.58	-0.9	-1.02
Urban Second Quartile	-3	31.3	0.43	-0.8	-0.76*
Urban Third Quartile	-3	24.7	0.19	-0.69	-0.38*
Urban Fourth Quartile	-3	12.7	-0.03	-0.38	-0.5

Source: Computed by author based on Household Expenditure Survey, BBS/1991)

Note: Price stabilization improves expected utility if :

$$s_i*(\eta_{iy}+R^c) < \eta_{ii}$$

A * refers to those cases when price stabilization improves expected utility.

Table 20 - Benefit to Producers

Coefficient of Relative Risk Aversion	Elasticity of supply	Elasticity of Demand	Coefficient of variation of total rice production	Total Benefit as percent of initial income
-1	0.2	-0.6	5	0.3
-1	0.4	-0.6	5	0.4
-1	0.2	-0.6	10	1.6
-1	0.4	-0.6	10	1.4
-1	0.2	-0.8	5	0.3
-1	0.4	-0.8	5	0.3
-1	0.2	-0.8	10	1.5
-1	0.4	-0.8	10	1.3
Average	0.3	-0.7	8	0.9
-2	0.2	-0.6	5	0.4
-2	0.4	-0.6	5	0.4
-2	0.2	-0.6	10	2
-2	0.4	-0.6	10	1.8
-2	0.2	-0.8	5	0.4
-2	0.4	-0.8	5	0.4
-2	0.2	-0.8	10	1.9
-2	0.4	-0.8	10	1.9
Average	0.3	-0.7	8	1.2
-3	0.2	-0.6	5	0.4
-3	0.4	-0.6	5	0.5
-3	0.2	-0.6	10	2.4
-3	0.4	-0.6	10	2.5
-3	0.2	-0.8	5	0.5
-3	0.4	-0.8	5	0.6
-3	0.2	-0.8	10	2.2
-3	0.4	-0.8	10	2.2
Average	0.3	-0.7	8	1.4
Average	0.3	-0.7	0.3	1.4

Source: Computed by author based on Statistical Yearbook Production data, and linear supply and demand as in Braverman et al. 1990.

Table 21 - Expected values of foodgrain Excess Demand, Prices, Consumption, and Growth.

Expected Excess Demand (Thousand metric tons)	Average	High rice yield growth	Low rice yield growth
Rice	-157	-583	275
Wheat	1535	1535	1535
Foodgrain	1377	941	1810
Expected price (Taka/maund)			
Rice	384	371	397
Wheat	263	263	278

Expected foodgrain consumption per capita (grams/person/day) and growth (percent)

	Average		High Rice Yield Growth		Low Rice Yield Growth	
	Consumption	Growth	Consumption	Growth	Consumption	Growth
Rural Quartile 1	442	0.93	448	1.11	435	0.76
Rural Quartile 2	532	1.19	541	1.39	523	0.99
Rural Quartile 3	565	0.81	572	0.97	557	0.65
Rural Quartile 4	561	0.17	567	0.30	554	0.04
Urban Quartile 1	443	1.16	451	1.38	435	0.94
Urban Quartile 2	504	1.44	518	1.80	490	1.09
Urban Quartile 3	483	0.52	488	0.64	478	0.40
Urban Quartile 4	433	-0.09	437	0.00	430	-0.18

Source: Computed by author based on data from *Statistical Yearbook of Bangladesh*, various issues, and Household Expenditure Survey, BBS (1981).

Note: A negative sign in excess demand refers to expected supply greater than expected demand. High rice yield growth is 2.5 percent; low rice yield growth is 2.1 percent.

Table 22 - Effects of Different Rice Procurement Scenarios

	Initial Condition	Rice Procurement Growth (Percent)		
		0	2.5	5
Expected Price of Rice (Taka Per Maund)	388	384	390	397
Expected Price of Wheat (Taka per Maund)	299	263	269	277
Expected Increase in Rice Stock (Thousand Metric Tons)	0	0	895	1918
Expected Ratio of Rice Procurement to Production (Percent)	4.2		4.1	5.3

Source: Computed by author based on data from *Statistical Yearbook of Bangladesh*, various issues, and Household Expenditure Survey, BBS (1991).

Table 23 - Ratio of world experts to world milled production of rice

	Production			
	Paddy Rice	Milled Rice	Exports	Export/Production Ratio
	('000 MT)		('00 MT)	(percent)
1975	359124	239416	77176	3.2
1976	350151	233434	89114	3.8
1977	371801	247867	108239	4.4
1978	387732	258488	95595	3.7
1979	377363	251575	116335	4.6
1980	399201	266134	129555	4.9
1981	412025	274683	130605	4.8
1982	423956	282637	120467	4.3
1983	451517	301011	115017	3.8
1984	469425	312950	128720	4.1
1985	472019	314679	114080	3.6
1986	471315	314210	130190	4.1
1987	464993	309995	129461	4.2
1988	490609	327073	121848	3.7
1989	517565	345043	148969	4.3
1990	518508	345672	120440	3.5
Annual trend growth rate [%]:				
1975-90		2.67	2.57	-0.1
1975-79		2.01	8.91	6.9
1980-84		4.16	-1.4	-5.57
1985-90		2.3	1.76	-0.56

Source: All production data from FAO Agrostat database, trade data from FAO up to 1989. 1990 trade data from ERS, USDA, rice situation and outlook report 1991. Milled rice figures have been obtained by applying a factor of 66.67 percent to paddy rice production.

Note: Trend growths have been computed using semi-logarithmic linear trend equation fitted to the time series data based on the least square method.

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Table 24 - Rice export levels, market shares, and ratios to milled production of major exporters

Year	Thailand	U.S.	Pakistan	Vietnam	Myanmar	Total
			--(percent)--			
Annual Growth Rates of Exports						
1975-90	8.6	0.61	2.54	39.46	-7.08	4.75
1975-79	19.56	2.24	14.85	23.15	8.29	10.42
1980-84	11.4	-9.83	-0.14	194.71	4.39	2.41
1985-90	2.86	5.04	-0.57	65.45	-30.38	5.36
Average Market Shares						
1975-90	29.2	21.0	8.4	1.8	4.4	64.7
1975-79	20.5	23.2	8.2	0.3	5.1	57.3
1980-84	28.5	21.2	8.7	0.3	5.8	64.4
1985-90	37.1	18.9	8.2	4.2	2.6	71.1
Market Share Annual Growth Rates						
1975-90	6.04	-1.98	-0.05	63.67	-9.7	2.18
1975-79	10.67	-6.63	5.83	-87.4	-0.76	1.51
1980-84	12.8	-8.52	1.24	142.86	5.93	3.85
1985-90	1.12	3.23	-2.38	63.94	-32.61	3.59
Average rice exports as a percentage of milled production						
1975-90	28.94	59.39	30.88	1.96	6.15	20.54
1975-79	20.16	61.16	27.04	0.46	7.76	18.32
1980-84	28.96	62.12	32.80	0.36	7.68	20.90
1985-90	36.23	55.63	32.43	4.55	3.53	22.10
Annual growth rates of rice exports as a percentage of milled production						
1975-90	6.45	-0.87	1.68	45.63	-10.12	2.12
1975-79	17.56	0.31	8.91	-79.29	4.50	8.17
1980-84	7.73	-2.75	-1.06	145.09	2.90	-0.22
1985-90	2.77	1.20	-0.87	60.49	-29.87	3.98

Source: FAO Agrostat database. ERS, USDA, Rice Situation and Outlook Report, October 1991.

Note: Growths rates have been computed using semi-logarithmic linear trend equation fitted to the time series data based on the least square method.

Table 25 - Paddy rice production and yields of major exporting countries and Bangladesh

Year	Thailand	U.S.	Pakistan	Vietnam	Myanmar	Bangladesh
			(percent)			
Annual growth rate of paddy rice production						
1975-90	2.16	1.47	0.85	4.15	2.91	2.5
1975-79	2.07	1.95	5.9	-0.38	3.75	1.02
1980-84	3.68	-7.09	0.93	7.45	1.48	1.66
1985-90	0.06	3.83	0.34	3.91	-0.65	4.71
			(MT/Hectare)			
Average paddy rice yields						
1975-90	1.95	5.58	2.41	2.50	2.69	2.12
1975-79	1.81	5.09	2.35	2.03	2.03	1.88
1980-84	1.97	5.27	2.53	2.43	3.01	2.07
1985-90	2.04	6.24	2.37	2.94	2.98	2.37
			(percent)			
Annual growth rate of paddy rice yields						
1975-90	1.07	1.83	-0.06	3.41	3.34	2.30
1975-79	0.47	-0.22	0.96	-2.78	6.03	1.13
1980-84	2.23	1.84	0.14	7.24	2.83	2.54
1985-90	-0.68	0.38	-1.84	3.07	-1.21	4.83

Source: FAO Agrostat data base. 1990 data from ERS, USDA.

Note: Trend growths have been computed using semi-logarithmic linear trend equation fitted to the time series data based on the least square method.

TABLE 26 - Average domestic, international, and export parity prices of various rice varieties

Period	Domestic Wholesale Price	International Market Price	Export Parity Price	Domestic Price as % of Export Parity Price
		(Taka per Metric Ton)		
		Fine Rice		
1975-91	8205	7622	6478	127
1975-80	4821	5455	4637	108
1981-86	8240	7734	6574	132
1987-91	12225	10086	8573	145
		HYV Coarse Rice		
1975-91	6723	6739	5728	119
1975-80	4067	4869	4138	103
1981-86	6845	6971	5926	121
1987-91	9763	8703	7398	134
		Aromatic Kalizira Rice		
1975-91	12069	16856	14327	87
1975-80	7102	9907	8421	92
1981-86	12140	18464	15694	78
1987-91	18011	23264	19775	91
		Aromatic Kataribhog Rice		
1975-91	10699	16856	14327	77
1975-80	6286	9907	8421	81
1981-86	10745	18464	15694	69
1987-91	15941	23264	19775	81

Sources: A Data Base on Agriculture and Foodgrains in Bangladesh (1947/48-1989/90) August 1991, Mohammad Abdul Hamid Ph.D.; Directorate of Agricultural Marketing, Ministry of Agriculture; World Rice Statistics 1990, International Rice Research Institute (IRRI). Kalizira and Khataribhog are based on 1991 wholesale prices collected from eight dealers based at Badamtali market, Dhaka and used to extrapolate prices in previous years by using factors in inter-year fluctuations in fine aman rice prices. International prices for basmati rice are from the Rice Export Corporation of Pakistan.

Notes: Domestic prices of fine are for fine variety aman rice. International fine prices are f.o.b. for Thai 5% brokens. International prices comparable to domestic HYV are f.o.b. for Thai 25% super. International prices comparable to the special aromatic varieties are for Pakistani Basmati rice. Export parity prices have been obtained by multiplying international market prices by a factor of 0.85. The remaining 0.15 accounts for cost and profit margin of the exporter.

TABLE 27 - Average domestic, international, and import parity prices of various rice varieties

Period	Domestic Wholesale Price	International Market Price	Import Parity Price	Domestic Price as % of Import Parity Price
		(Taka per Metric Ton)		
		Fine Rice		
1975-91	8205	7622	9355	88
1975-80	4821	5455	6842	75
1981-86	8240	7734	9534	90
1987-91	12225	10087	12396	100
		HYV Coarse Rice		
1975-91	6723	6739	8340	81
1975-80	4067	4869	5968	71
1981-86	6845	6971	8657	82
1987-91	9763	8703	10806	91

Sources: *A Data Base on Agriculture and Foodgrains in Bangladesh* (1947/48-1989/90) August 1991, Mohammad Abdul Hamid Ph.D.; Directorate of Agricultural Marketing, Inistry of Agriculture; World Rice Statistics 1990, International Rice Research Institute (IRRI). 1990-91 data are from IRRI.

Notes: Domestic fine prices are for fine variety aman rice and international fine rice prices are f.o.b. for Thai 5% brokens. International prices comparable to domestic HYV Course rice are f.o.b. for Thai 25% super. For computing import parity prices, first a freight cost of $20 per metric ton has been added across the board to derive an estimated C & F price for the concerned Thai grade. Then C & F prices have been multiplied by 1.15 to obtain the import parity prices.

Table 28 - Rice Price Variability of Domestic, International, and Border price.

Period	INTER-YEAR VARIATION Coefficient of Variation (percent)			INTRA-YEAR VARIATION Coefficient of Variation (percent)		
	Domestic Price	International price	Border Price	Domestic Price		Border Price
70-80'S	14.8	29.5	18.7	10.4	10.1	10.0
70'S	28.1	30.4	19.7	13.9	12.0	12.8
80'S	7.5	14.8	10.9	7.3	8.4	7.5

Source: Computed by the author based on Wholesale coarse rice price from the Department of Agricultural Marketing and 5% broken Thai export prices converted in Taka. from *World Rice Statistics*.

Note: The 70's refer to 1972-1980.
The 80's refer to 1981-1990.

TABLE 29 - Average percentage difference between domestic and international prices of rice varieties by month

Month	Domestic Fine/ World Fine	Domestic Medium/ World Medium
	(percent)	
Jan.	25.3	23.8
Feb.	28.1	28.8
Mar.	31.7	32.2
Apr.	37.6	37.6
May	38.2	37
Jun.	37.9	34.9
Jul.	40.2	37.9
Aug.	40.2	37.1
Sep.	45	40.1
Oct.	46.4	39.3
Nov.	33.3	25.8
Dec.	24.8	21.5

Sources: *A Data Base on Agriculture and Foodgrains in Bangladesh* (1947/48-1989/90), August 1991, Mohammad Abdul Hamid Ph.D. Directorate of Agricultural Marketing, Ministry of Agriculture. Foreign Agricultural Service, USDA.

Notes: Domestic fine is represented by aman fine. Domestic Medium is represented by aman medium. International fine is represented by Thai 5% broken. International medium is represented by Thai 15% broken. The averages are by month for the period, 1982-89.

Table 30 - Simulation of rice export swap

	Demand Elasticities				Supply Elasticities				Percent				
	H	L	W		H	L	W		H	L	W		Percent
High Quality	-0.50	0.0	0.00	High Quality	0.20	0.00	0.00	Price	11.71	0.00	-12.87	Total Foodgrain	0.78
Low Quality	0.00	-0.60	0.00	Low Quality	0.00	0.05	0.00	Demand	-5.39	0.00	14.77	Total Rice Production	-0.02
Wheat, W	0.00	0.00	-1.00	Wheat, W	0.00	0.00	0.60	Production	2.24	0.00	-7.93	Aggregate Rice Price	1.75
High Quality	-0.50	0.10	0.00	High Quality	0.20	-0.05	0.00	Price	12.95	5.28	6.19	Total Foodgrain	0.62
Low Quality	0.20	-0.60	0.00	Low Quality	-0.05	0.05	-0.05	Demand	-5.42	-0.65	17.89	Total Rice Production	-0.19
Wheat, W	1.00	2.00	-1.00	Wheat, W	0.00	-0.60	0.60	Production	2.20	-0.65	0.52	Aggregate Rice Price	6.48
High Quality	-0.50	0.10	0.00	High Quality	0.40	-0.10	0.00	Price	9.95	3.77	1.16	Total Foodgrain	0.94
Low Quality	0.20	-0.60	0.00	Low Quality	-0.10	0.20	-0.10	Demand	-4.28	-0.32	17.04	Total Rice Production	0.16
Wheat, W	1.00	2.00	-1.00	Wheat	0.00	-0.70	0.70	Production	3.48	-0.32	-1.77	Aggregate Rice Price	4.78
High Quality	-0.50	0.10	0.00	High Quality	0.10	-0.03	0.00	Price	15.05	5.74	9.25	Total Foodgrain	0.56
Low Quality	0.20	-0.60	0.00	Low Quality	-0.03	0.01	-0.03	Demand	-6.25	-0.54	17.74	Total Rice Production	-0.25
Wheat, W	1.00	2.00	-1.00	Wheat	0.00	-0.04	0.04	Production	1.27	-0.54	0.13	Aggregate Rice Price	7.14
High Quality	-0.80	0.40	0.00	High Quality	0.20	-0.05	0.00	Price	8.93	1.85	3.09	Total Foodgrain	0.68
Low Quality	0.20	-1.20	0.00	Low Quality	-0.05	0.05	-0.05	Demand	-5.93	-0.49	17.96	Total Rice Production	-0.13
Wheat, W	2.00	3.00	-2.00	Wheat	0.00	-0.60	0.60	Production	1.63	-0.49	0.73	Aggregate Rice Price	2.94
High Quality	-0.20	0.10	0.00	High Quality	0.20	-0.05	0.00	Price	25.14	7.93	8.94	Total Foodgrain	0.50
Low Quality	0.05	-0.30	0.00	Low Quality	-0.05	0.05	-0.05	Demand	-3.65	-1.16	17.90	Total Rice Production	-0.32
Wheat	0.50	1.25	-0.50	Wheat	0.00	-0.60	0.60	Production	4.19	-1.16	0.56	Aggregate Rice Price	10.57

Source: Computed by author.
Note: Export of high quality rice=200 thousand metric tons.

Table 31 - Rice and Wheat Elasticities

	Own Price Elasticity		Expenditure Elasticity		Cross Price Elasticity	
	Rural	Urban	Rural	Urban	Rural	Urban
Rice						
Quartile 1	-0.89 *	-1.02 *	0.8 *	0.58 *	0.04	0.26 *
Quartile 2	-0.71 *	-0.76 *	0.71 *	0.43 *	-0.01	-0.18
Quartile 3	-0.55 *	-0.38 *	0.64 *	0.19	0	-0.05
Quartile 4	-0.39 *	-0.5 *	0.03	-0.03	-0.09	0
All	-0.56 *	-0.59 *	0.39 *	0.15 *	0.01	-0.01
Wheat						
Quartile 1	-1.23 *	-2.79 *	-1.37 *	-0.21	3.14 *	3.91 *
Quartile 2	-0.99 *	-2.49 *	0.05	0.33	2.1 *	3.43 *
Quartile 3	-0.49	-0.86	-1	-0.02	1.31 *	2.03 *
Quartile 4	-0.21	0.94 *	-0.19	0.29	1.88 *	0.34
All	-0.82 *	-1.06 *	-0.44 *	-0.01	2.05 *	2.35 *

Source: Computed by author based on Household Expenditure Survey, BBS (1991).

Note: "*" indicates elasticities significant at 90% level.

APPENDIX 4:

ASSUMPTION FOR SIMULATIONS IN CHAPTER 6

Table 32 - Assumptions for the base year (1990/91) parameters used in the demand and supply projections

	Unit	Parameter
Production of rice	(Thousand metric tons)	17852
Production of Wheat	(Thousand metric tons)	1004
Rice Yield	(Metric tons per hectare)	1.71
Wheat Yield	(Metric tons per hectare)	1.67
Population in Base Year	(Million)	108.9
Outmigration Rate	(Percent)	1
Urbanization Rate in Base Year	(Thousand metric tons)	21
Procurement of Rice	(Thousand metric tons)	744
Procurement of Wheat	(Thousand metric tons)	53
Offtakes of Rice	(Thousand metric tons)	744
Offtakes of Wheat	(Thousand metric tons)	1464
Losses due to seed, feed and wastage	(Percent)	7.75
Rice Price	(Taka/maund)	388
Wheat Price	(Taka/maund)	299

	RICE		WHEAT	
Per Capita Intake	Rural	Urban	Rural	Urban
	(Grams/capita/day)			
Quartile 1	340	348	67	54
Quartile 2	414	394	66	53
Quartile 3	466	409	60	53
Quartile 4	504	384	48	53

Source: Computed by author based on data from Statistical Yearbook of Bangladesh, various issues.

Table 33 - Assumptions about growth and distribution of exogenous variables

		(percent)		
		Low	Medium	High
Population growth		1.5	1.86	2.0
Rice yield growth		2.1	2.3	2.5
Wheat yield growth		1.0	1.0	1.0
Distribution of income growth:				
		Rural	Urban	Total
	Low	0.58	0.58	1
No Urban Bias	Medium	1.58	1.58	2
	High	2.57	2.57	3
	Low	0.52	0.68	1
Urban Bias	Medium	1.41	1.83	2
	High	2.3	2.99	3

Acreage Elasticities	Rice Price	Wheat Price	Rice Yield	Lagged Wheat Acreage
Rice	0.01		0.15	
Wheat	-0.6	0.6		0.88

Source: Computed by author; Acreage Elasticities from Mahmud, Rahmon, and Zohir (1993).

Table 34 - Assumptions for the probability weights of different growth scenarios

	Probability
Production growth	
Low (2.4 percent)	1/3
Medium (2.7 percent)	1/3
High (3.0 percent)	1/3
Population growth	
Low (1.5 percent)	1/4
Medium (1.86 percent)	1/2
High (2.0 percent)	1/4
Level of per capita income growth	
Low (1 percent)	1/4
Medium (2 percent)	1/2
High (3 percent)	1/4
Distribution of per capita income growth	
No urban bias	1/5
Urban bias	4/5

Source: Computed by author.

Table 35 - Base year (1990/91) parameters used in the swap model simulations

Parameter	Units	Value
Margin of high quality over low quality	(percent)	15
Percentage of total rice production that is low quality	(percent)	85
Percentage of total rice production used for human consumption	(percent)	90
Price of low quality rice coarse rice	(Taka/Maund)	355
Price of high quality rice	(Taka/Maund)	408
Total production of rice	(Thousand Metric Tons)	17852
Production of wheat	(Thousand Metric Tons)	1004
Import of rice	(Thousand Metric Tons)	300
Import of wheat	(Thousand Metric Tons)	1234
International price of rice	(US $/MT)	320
International price of wheat	(US $/MT)	185
Share of total rice imports that are food aid	(percent)	30.4
Share of total wheat imports that are food aid	(percent)	67.7

Source: Computed by author, based on data from *Statistical Yearbook of Bangladesh*, various issues.

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Fig. 1_ Conceptual framework to understand the interrelation between private markets and the foodgrain system

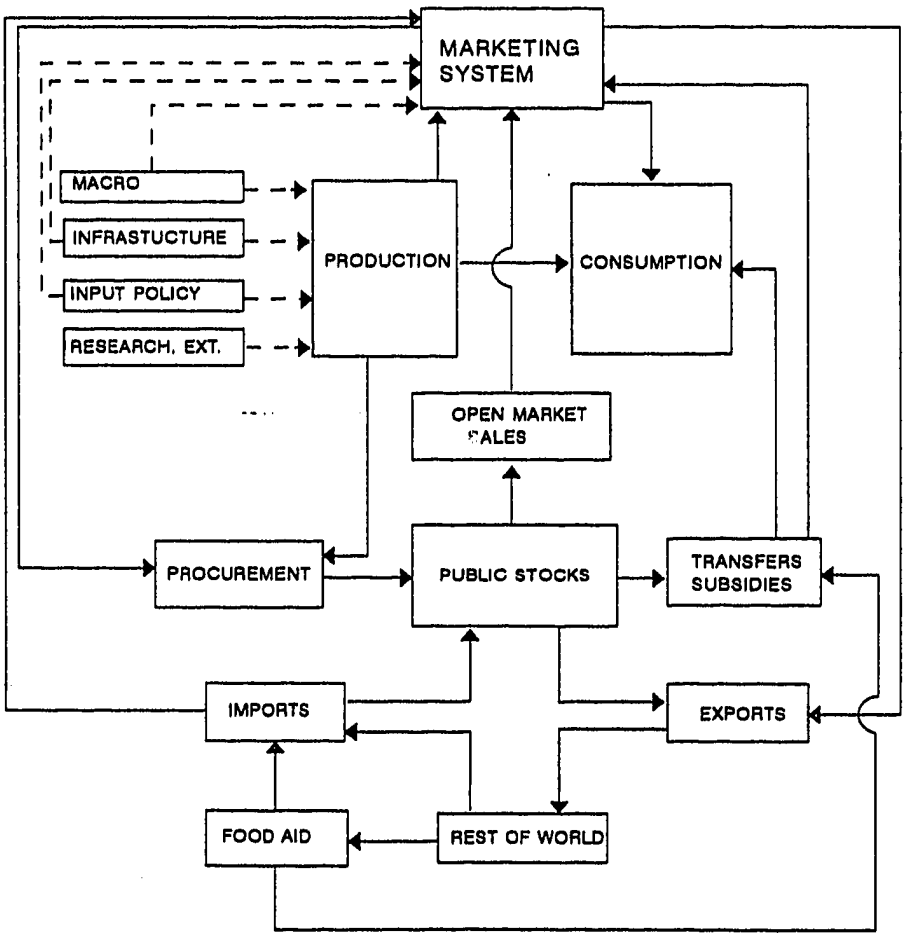


Fig.2--Price seasonality and rice crop share in the Seventies

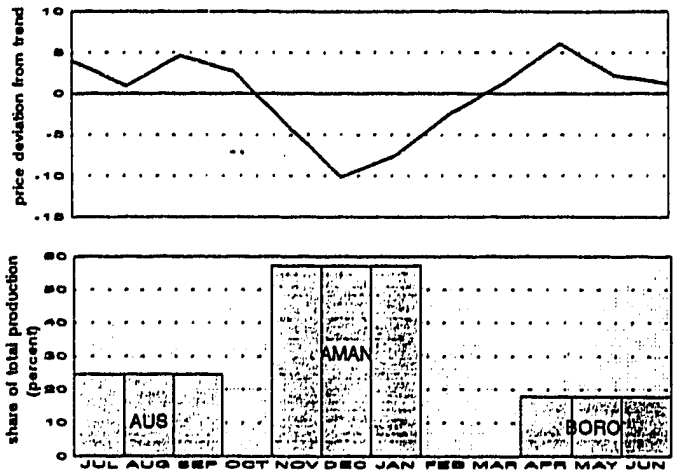
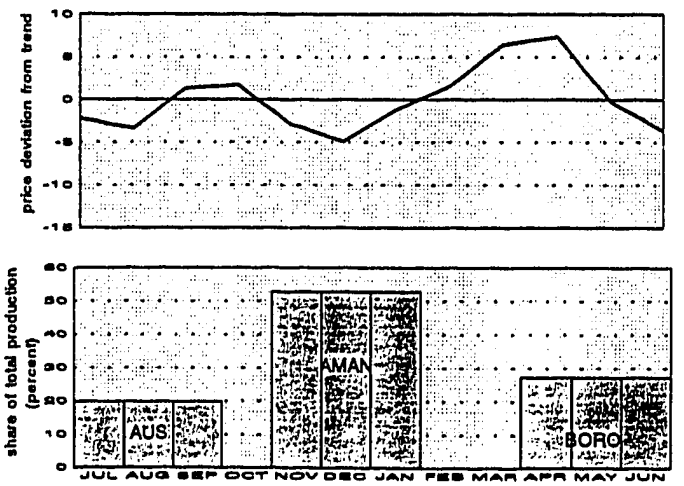


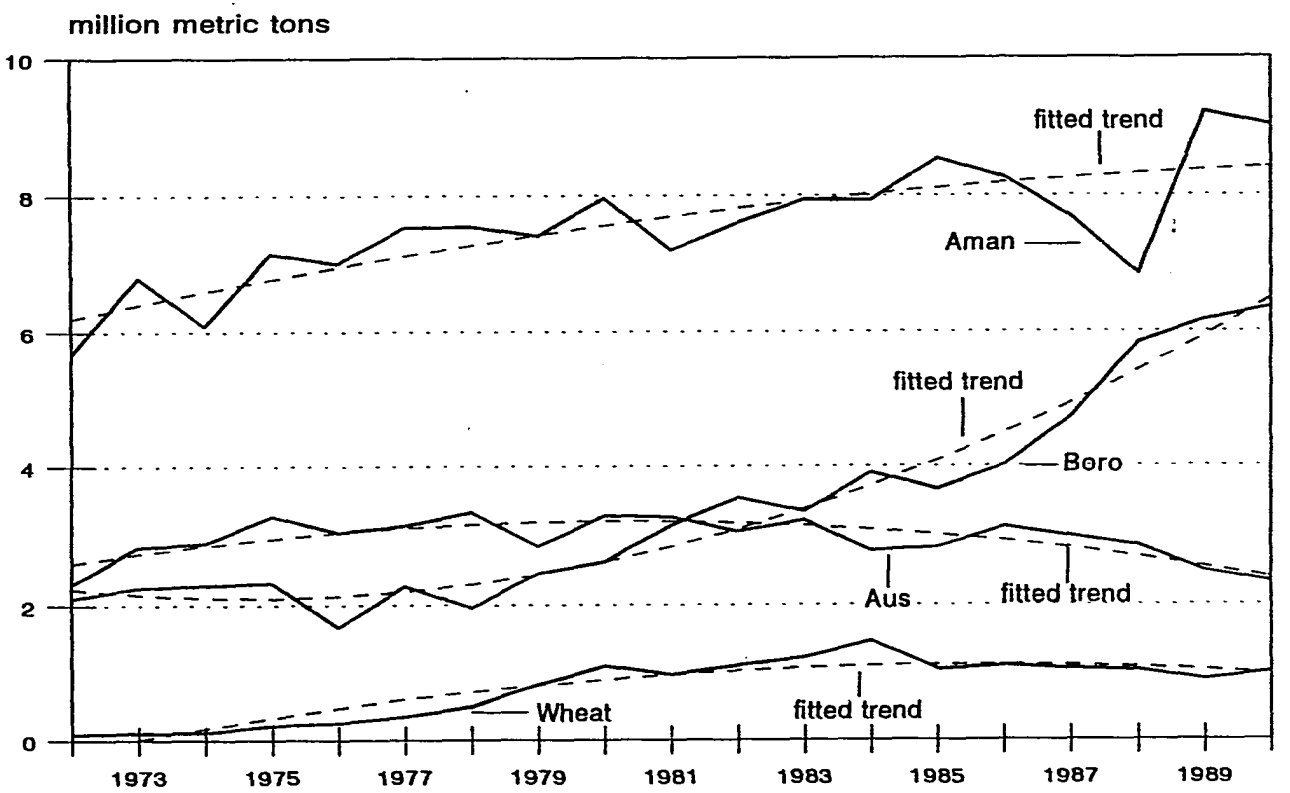
Fig.3--Price seasonality and rice crop share in the Eighties



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

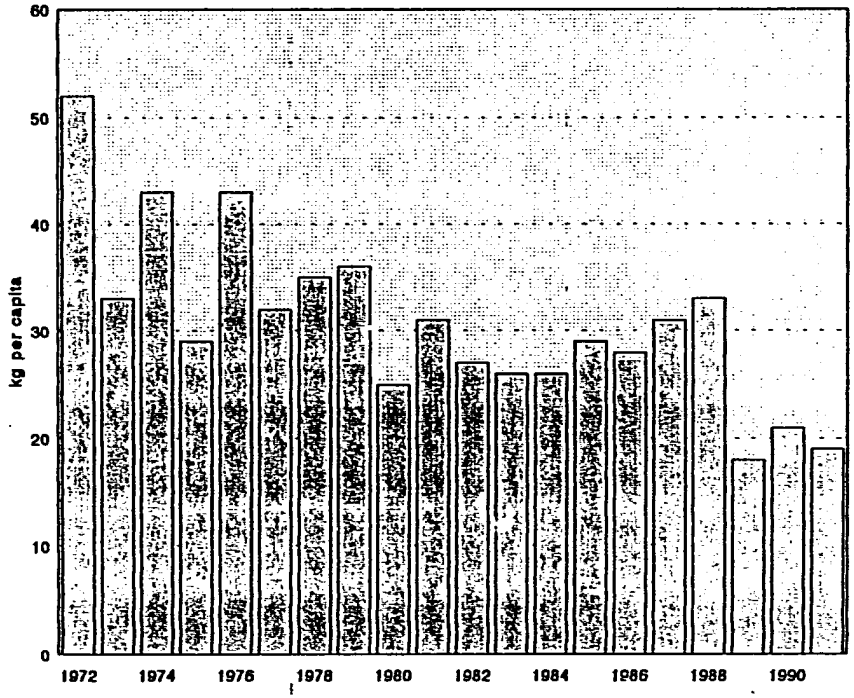
Note: The Seventies refer to the period July 1972 to June 1980. The Eighties refer to the period July 1980 to June 1990.
Seasonality is computed with X11.

Fig.4--Rice and wheat production



Source: Statistical Yearbook of Bangladesh, various issues.

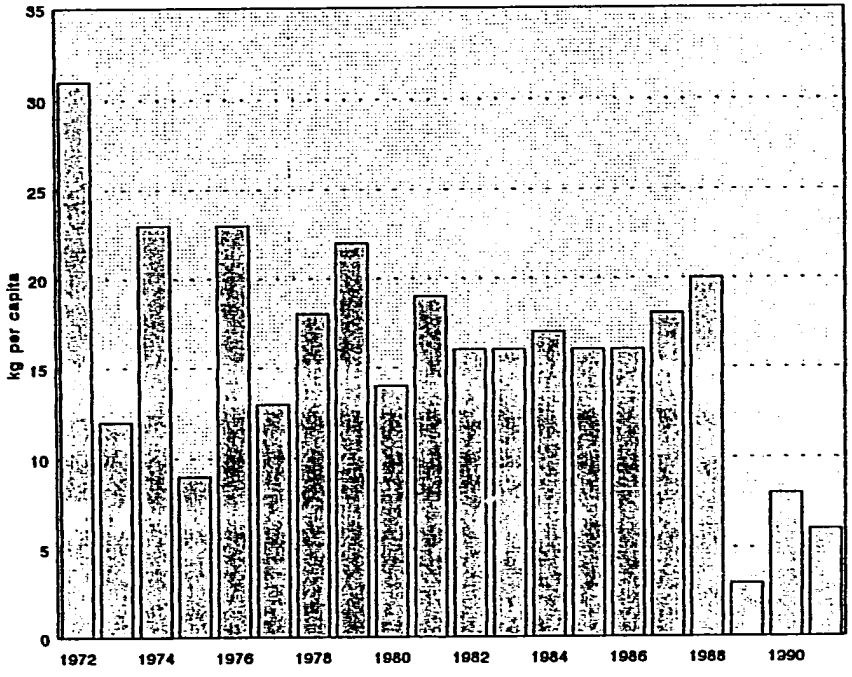
Fig. 5--Foodgrain Gaps



Source: Statistical Yearbook of Bangladesh, various issues.

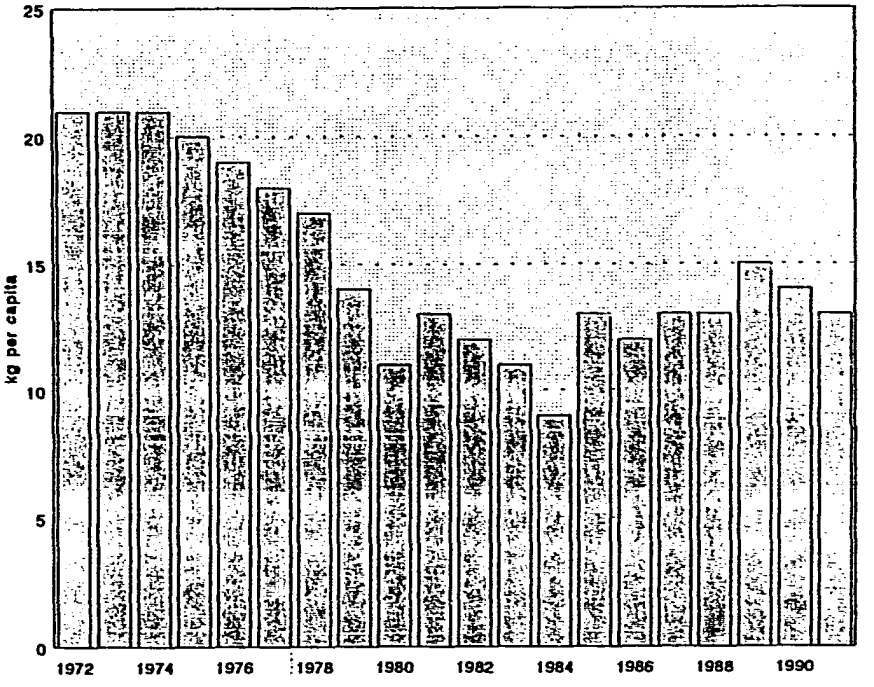
Note : The calorie requirement standard is 2200 cal/day/person. Of this amount 75% is provided by rice and wheat. Rice provides 88% of total foodgrain calories. These assumptions entail a yearly rice requirement of 153 kg/person and a yearly wheat requirement of 21 kg/capita.

Fig. 6--Rice Gaps



Source: Statistical Yearbook of Bangladesh, arious issues.
Note : The calorie requirement standard is 2200 cal/day/person. Of this amount 75% is provided by rice and wheat. Rice provides 88% of total foodgrain calories.These assumptions entail a yearly rice requirement of 153 kg/person and a yearly wheat requirement of 21 kg/capita.

Fig. 7–Wheat Gaps



Source: Statistical Yearbook of Bangladesh, various issues.

Note : The calorie requirement standard is 2200 cal/day/person. Of this amount 75% is provided by rice and wheat. Rice provides 88% of total foodgrain calories. These assumptions entail a yearly rice requirement of 153 kg/person and a yearly wheat requirement of 21 kg/capita.

FIG. 8: CONDITIONAL VARIANCE OF PRICES

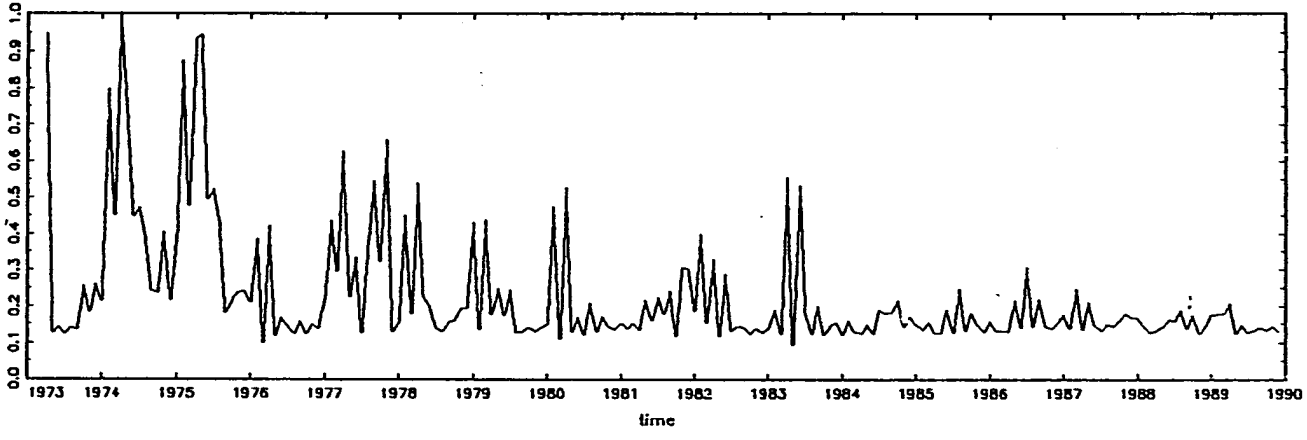
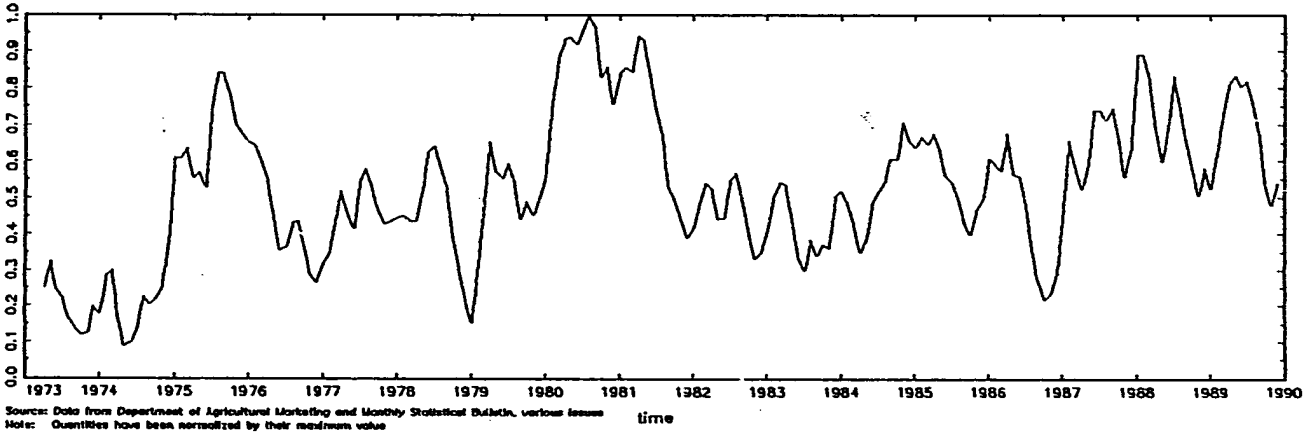


FIG. 9: TOTAL PUBLIC FOODGRAIN STOCK



Source: Data from Department of Agricultural Marketing and Monthly Statistical Bulletin, various issues
Note: Quantities have been normalized by their maximum value

Fig. 10 FOOD POVERTY: Function W(p,σ,α)
The parameter α is 1

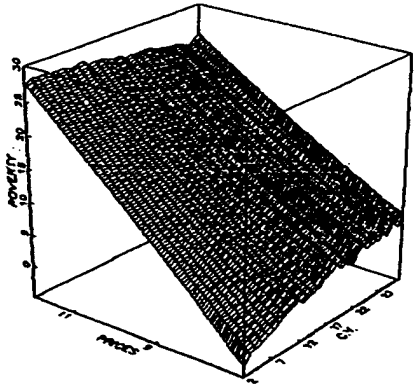


Fig. 11 FOOD POVERTY: Function W(p,σ,α)
The parameter α is 2

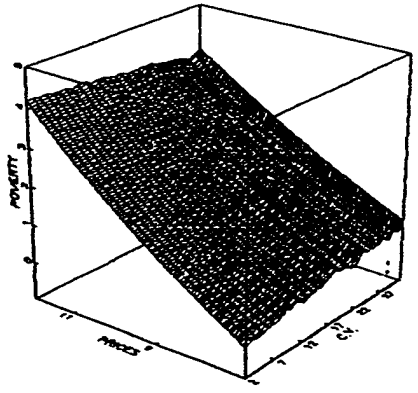


Fig. 12 FOOD POVERTY: Function W(p,σ,α)
The parameter α is 3

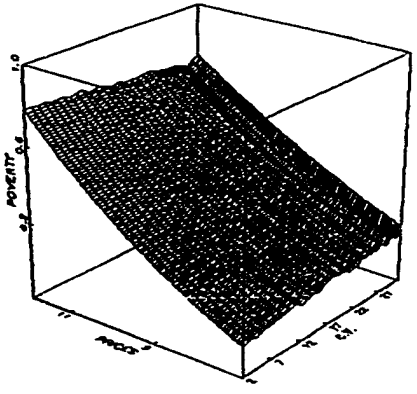


Fig. 13 FOOD POVERTY: Function W(p,σ,α)
The parameter α is 4

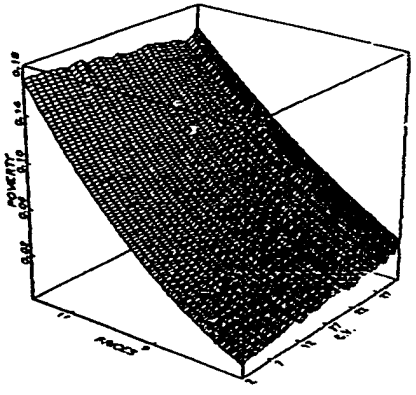


Fig. 14: EXPECTED POVERTY

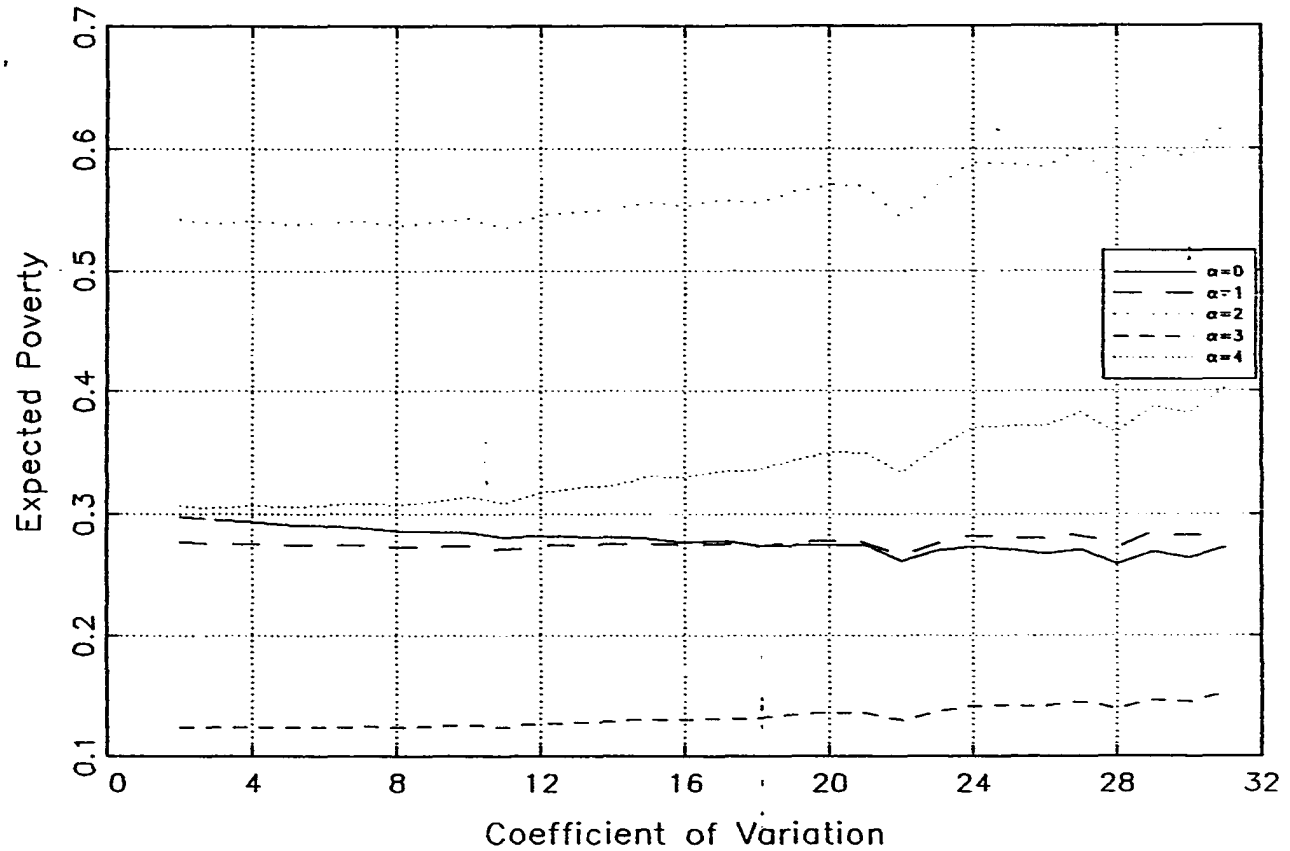
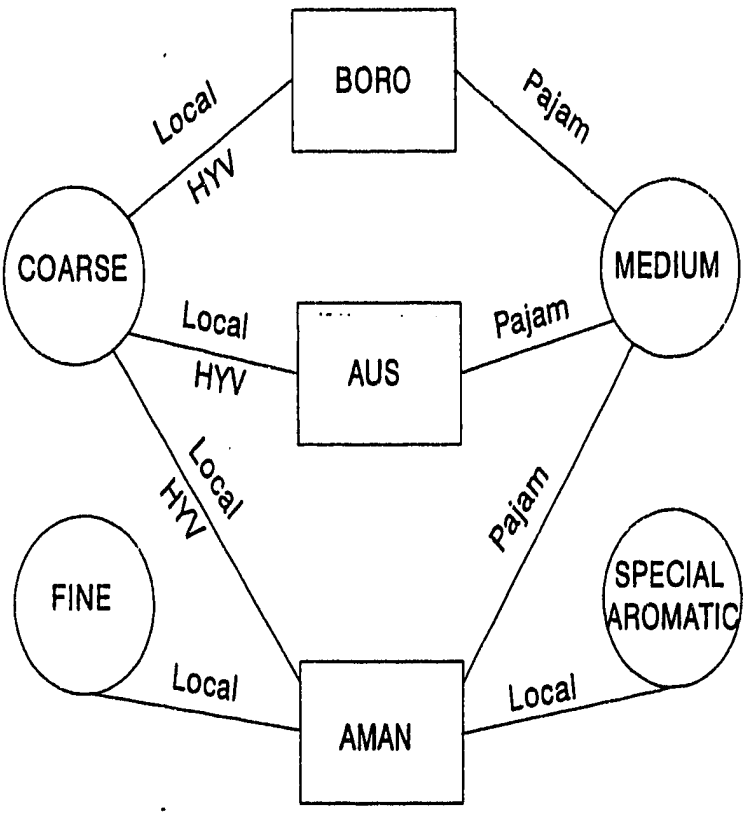



FIG. 15: RICE VARIETIES