FLUCTUATIONS IN THE PRICE OF RICE IN INTERNATIONAL MARKETS IN THE 1970S

By

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To my wife, Ortrud, and my daughter, Suzanne.

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A simultaneous equation model of the world rice market is developed for major producing and consuming countries as well as for the world. The model is supplemented to include wheat and the coarse grains--corn, oats, rye, barley, sorghum and millet. The model consists of supply, demand, stocks and the price of fertilizers and is specified to explain the unprecedented price increase of 1973 and 1974, which was followed by a decrease during 1975.

The system of structural-form equations is estimated by the three-stage-least-squares method. All models perform well, not only tracking rice, wheat and coarse grain prices up in 1973 and 1974, but also following them down in 1975 in out-of-sample forecasts.

Results of the reduced form equation of each model indicate that the most important variable affecting the

international prices of rice, wheat, and coarse grains is the price of fertilizer containing nitrogen, phosphate and potassium. The fertilizer equations of all models show that the price of fertilizers is determined by the price of oil multiplied by the ratio of nitrogen fertilizer to total consumption of nitrogen, phosphate and potassium fertilizers; and by the industrial capacity utilization ratio of the anhydrous ammonia industry. Other factors affecting the price of grain are the amount of stocks lagged one year and per capita income.

The two last variables in the reduced form equations are the nominal interest rate and a time trend, which serves as a proxy for changes in technology and the labor market.

CHAPTER I

INTRODUCTION

Statement of the Problem

During the 123 years since 1860 that the Economist (16) has maintained a commodities price index, it never rose more rapidly than from 1971-1974. During this short period, the price index rose 159%. The next highest three-year increase occurred from 1914-1917, 101%, and the closest yearly change was in 1949-1950, 48%. Prices for most commodities, including agricultural products began to rise rapidly in 1972. They hit their peaks in late 1973 and into the spring of 1974. The Economist dollar index of twenty-eight commodities hit its high in May 1974 and was 115% above the level of just two years earlier. It then declined in 1975 as rapidly as it had risen before.

Alarm about world food, which has been a recurrent theme ever since Malthus, rose again and a pessimistic wave swept the world as a new era of rapidly rising demand placed pressure on agricultural resources, causing real grain prices, especially that of rice, to surge.

Grains occupy more than 70% of the world's cropland. Four out of five people consume rice or wheat as a staple food. Rice represents the staple for the more than half of the world population living in the developing countries.

Rice is virtually the sole staple for many Asiatic countries and is the preferred staple in most of the countries in the Far East. Thus it is not surprising that the drastic rise in the international price of rice attracted the attention of several analysts. Was it a deterioration in the world balance of supply and demand that caused the sharp increase in the prices of rice in late 1973 and the beginning of 1974? During that period prices increased steadily to unprecedentedly high levels in April 1974 of 488% of the price levels two years before. Thereafter, prices fell almost as drastically as they had risen though not back to pre-1972 levels. The main purpose of this study is to clarify the causes of the surge in the price of rice in the international market during the period 1973-74.

Several studies have attempted to explain the nature of and reasons for the increase in food prices during 1972-74. D. E. Hathaway (29) and R. N. Cooper and R. Z. Lawrence (14) indicated that supply shortages due to weather conditions in the USSR and Southeast Asia were largely responsible for the rise in prices of cereals. Worldwide, the production of rice in 1972 declined by 12.2 million metric tons, or 3.4% below the previous year. The annual average price of rice rose by 124.6% during the following year, despite the strong recovery in rice production by 8% in 1973. During 1974 the annual average price rose further by 64% and reached the highest ever monthly peak of $625 per metric ton (white rice, 5% brokens, Bangkok f.o.b.) in April 1974, compared with only $129 in April 1972. Based on past experience, this striking price rise could not be attributed entirely to shortfalls in supply of rice. For example, in 1965, similar bad weather conditions caused a shortfall in world rice production amounting to 12.55 million tons, or 4.7%. The next year rice prices increased by 19.7% followed by another 26.2% increase in 1967. Thereafter, prices declined as production recovered. On these occasions, the international market for rice absorbed the production shortfalls with a rather modest increase in prices. Thus, the instability of rice supply due to bad weather conditions alone could not account for the striking price rise of 1973-74.

B. P. Bosworth and R. Z. Lawrence (9) and D. E. Hathaway (29) indicated that rising world income or affluence in the world increased the consumption of meat and livestock products and thus the need for feedgrains. Rice is not classified as a feedgrain; rather, it is considered to be king of all foodgrains, since its price per unit is the highest of all grains. A close look at the demand side for rice is necessary, however, to see whether there is evidence of a demand explosion related to world income growth. In late 1973, the Oil Producing and Exporting Countries quadrupled the price of oil and this could possibly have accelerated the growth rate of rice consumption demand in the world.

Anxiety about the future of rice supplies was strong and it seemed that purchases ran way ahead of normal demand in a manner indistinguishable from that of speculation and expectation for reselling at a profit. It seems improbable that the elasticity of demand for rice would have been low enough to explain fully the soaring prices that were observed during 1973 and 1974. D. G. Johnson (34) and F. H. Sanderson (55) considered, among other factors, that the depletion of stockpiles of rice was the major factor for their soaring prices. Stockpiles of rice will be examined in order to investigate their role in price increases in the international market.

Usually, when demand is exceptionally high, a rapid increase in price acts as a useful rationing device, inducing some buyers dropping out of the market. On the other hand, rapid price increases can also act as a destabilizing factor, inviting purchases with the objective of riding the price up to its crest and then selling. This is, therefore, an indication of the existence of speculative demand for rice and other grains in late 1973 and early 1974.

Speculation by definition involves attempts to profit from future shortages or from future excess supplies, and if stockpiles had been large enough to satisfy any expected demand that might have developed, then prices would probably have been much less than they actually were.

The idea of a buffer stock of grain is as old as the story of Joseph in Egypt. Basically, stocks would be built up when prices were low at harvest and released only when prices were abnormally high. That happened in the past when crop failure occurred in the USSR in 1963 and in 1965 and in India 1965-66 and 1966-67. Poor harvests were the major factors causing grain stocks to decline and stocks had succeeded in playing their normal role of meeting crop shortfalls without significant price increases. At lower stock levels, some price instability may have to be borne. This is not totally undesirable, in that it will signal agricultural producers around the world to make production adjustments and consumers to make substitutions for rice. The combined results of both movements will usually keep prices from rising as much as they would otherwise.

Why did the act of holding stocks fail to ensure reasonable stability of supplies and prices in 1973-1974, though it was adequate to meet such contingencies as those experienced in 1965? What makes the situation in 1973-74 different? Were these events a result of market fundamentals which can be explained by the conventional theory of supply and demand, whereby the level of stocks plays an important role? Or is it possible that the market was pushed by speculative demand which increased prices to an unprecedentedly high level?

The era of the rice price movement of 1972-74 coincides with changes in the international monetary system. During the 1950s and early 1960s over much of the world dollar holdings were more desired than gold since they were readily exchangeable into gold and brought interest to their holders. But during the 1960s and early 1970s, the United States went through a period of accelerating inflation and rapid deterioration in its balance of payments. These caused increases in international liquidity and US financial obligations and raised doubts about the role of the United States as world banker.

On August 15, 1971, the United States announced the legal suspension of dollar convertibility into gold. This represented an abandonment of the Bretton Woods agreement, the end of the gold exchange standard, and caused the dominance of the dollar as the most important international reserve asset to wane. Holders of portfolios containing dollars and other assets attempted to reduce the weight of dollar-denominated assets in these portfolios. An individual who had divided his holding of liquid assets between foreign and domestic assets depending on the level of interest rates at home and abroad started to shuffle his portfolio holding according to the new circumstances to reach a new equilibrium distribution to his portfolio of assets between domestic and foreign. At any given asset level, a change in the exchange rate of foreign currencies will produce a redistribution of assets. Speculation against the dollar was active, thus encouraging a shift of private capital from one country to another and causing sharp fluctuations in exchange rates. Holding currencies became risky and uncertain.

The U.S. dollar devaluation and its repercussions in the international monetary system probably affected the international rice market in two ways: (1) A shift from holding foreign currencies toward holding commodities (in order to hedge against uncertainty in holding foreign currencies and to avoid the unpredictable movement into flexible exchange rates) could have caused the demand for rice to increase. (2) Assuming that the depreciations of the dollar were reflected fully and immediately in the dollar price of rice, and the price of rice in international market was determined largely outside the United States,* the depreciation of the U.S. dollar would be reflected in the international market for rice, and cause its dollar price to rise.

In a closer look, from December 1971 till July 1973, the U.S. dollar went through three sequential devaluations summing to about 27 %, but the dollar rice prices in Bangkok rose during the same period by more than 152 %. If this exchange-rate assumption holds for dollar appreciation as well, the following upward movement of the dollar should have caused a decline in the price of rice, all other things being the same. But while the U.S. dollar was appreciating from July 1973 until January 1974, the price of rice

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*This is symbolized by the fact that international prices are quoted in Bangkok, Thailand, the largest exporter of rice and located in the midst of the chief rice consumer countries.

continued to rise steadily until 1974 when it reached its peak. By that time, the dollar was again depreciating. But the currency speculation hypothesis and its effect on the surge of commodity prices during that era find support from H. S. Houthakker (32) and D. G. Johnson (36). Houthakker attributes the increase in commodity prices to monetary imbalances that developed after the shift to the flexible exchange rate which followed the breakdown of the Bretton Woods system (32). D. G. Johnson agrees in principle, and suggests that the effects of the overvaluation of the dollar in the international monetary markets accounted for 15% of the grain price surge of 1973-74.

Cooper and Lawrence (14) studied the importance of movements in exchange rates to the prices of raw material for industrial goods. They concluded that movements in exchange rates during 1973-75 had not so much a direct effect as a psychological effect from the impact of fluctuating exchange rates on the speculative demand for commodities.

The precarious situation in world grains markets of 1973-74 has been the subject of several other studies. None, however, includes empirical estimates of what seems to be a highly significant relationship among oil prices, fertilizer production and grain prices. Decades of cheap petroleum had encouraged the widespread use of fertilizer. When the price of oil, the major input for nitrogen fertilizer rose, nitrogen became expensive. After the new industrial capacity was installed the price of fertilizer fell even though the price of oil remained high. With this drop in the price of fertilizer the prices of grains, which had become heavily dependent on fertilizer as an input, returned to lower levels.

In this dissertation a model was estimated and then tested to see whether it explained the high prices of 1973 and 1974. The model was estimated with data which excluded 1973, 1974, and 1975, and then used to "predict" these years. When subjected to this out-of-sample test, the model performed well, not only tracking grain prices up in 1973 and 1974, but also following them down in 1975. Thus, a model was developed and then estimated from data exclusively from years other than the early 1970s. This model in turn explained most of the price surge in grain markets of the early 1970s.

CHAPTER II

BASIC FEATURES OF THE IMPORTANCE OF RICE AND ITS ROLE IN THE DIET OF WORLD POPULATION

The Economic Aspects of Rice

Although the exact place of the origin of rice cannot be determined, it is generally agreed that rice was first cultivated in Southeast Asia (Copeland, 15).

Rice, in most countries of the Far East, South and Southeast Asia, is one of the most important commodities economically and politically. It is produced by millions of peasants in both the agrarian and industrialized countries of Asia and it is the staple food for the people.

Rice can be grown under a wide variety of climatic and soil conditions. However, it is produced predominately in the area known as monsoon Asia. Monsoon Asia extends across the southeastern part of the continent from India to Japan and includes practically all of the adjacent tropical and subtropical islands. It is characterized by a maximum rainfall in summer and a minimum rainfall in winter with seasonal reversal of wind direction.

The climatic and soil conditions of monsoon Asia are best suited for rice production and poorly suited for many other grain. It has a hot moist climate and wide stretches of land which are either flooded seasonally or irrigated easily by inexpensive means. Neither wheat, barley, nor oats can thrive as summer crops under such conditions of moisture and heat. Millet, sorghums and maize cannot tolerate the heavy rainfall. Moreover, none of these grains can be stored as successfully as rice in a hot moist climate, and none can produce as much food per unit of land in this climate.

The dense population and scarcity of urbanized and industrialized centers have necessitated a small scale, subsistence agriculture as the main profession. Millions of farm families use their available resources of land, labor and a little capital to produce food, mainly for home consumption, selling a relatively small amount of farm produce for cash to purchase other kinds of goods and commodities (19).

Motivation is strong to concentrate upon a crop that will provide abundant food from little land and intensive labor use, that involves a minimum risk of crop failure and that provides food that can be best stored under existing climatic conditions. Rice can be grown by farmers operating a few acres without draft animal power; it is a way of adapting to circumstances of abundance of labor and relative scarcity of land and capital. Rice, then, of all cereals, is a crop extremely well suited to the economy of the moist parts of monsoon Asia.

In addition, the heavy rainfall of the monsoon causes erosion of soils, which, if uncontrolled, could render the land useless for any kind of agriculture. Rice cultivation has provided a natural control against soil erosion and enables the population of monsoon Asia to survive and increase over hundreds of years. Growing rice requires water conservation which indirectly insures soil conservation and prevents soil erosion. If the people of the area had attempted to live by any other cereal, they could not possibly have maintained such high densities of population over thousands of years.

According to Food and Agricultural Organization (FAO) studies (58) in most districts of the rice producing areas of Asia rice growers would not change to the production and consumption of any cereal other than rice. The ideal conditions for rice culture prevalent in the area have made it, over the years, the most important area of commercial rice production in the world.

The Role of Rice in the Diet of the World Population

In resource terms, cereals occupy more than 70% of the world cropland, and in developing countries cereals dominate all other foodstuffs as sources of protein and food energy. Cereals account for 80% of all major staples, root crops make up 10% and the remaining 10% consists of peanuts and pulses (see Table 1). Among the cereals, rice and wheat constitute the staple diet for 4 out of 5 persons for the world's population. Rice, in contrast to wheat, has been considered largely a subsistence crop: half of the rice produced in the world is consumed on the farms where it is grown (Efferson, 17). Rice is the staple diet for more than half the population of the world. Although rice is the staple food in the Far East, the predominant food varies from area to area within the given countries. Rice is usually supplemented by other cereals, root crops or pulses.

The relative distribution of the production of major diets or staples in developing countries by region is shown in Table 1. The pattern of production of staples varies widely. Still, cereals largely dominate the scene in Asia (83.4%), North Africa/Middle East (91.3%) and Latin America (80%). In Sub-Saharan Africa cereals account for only 55.1%; other staples, particularly root crops, are important. The table indicates also that rice comprises about 60% of all cereal production in Asia, followed by coarse grains and then wheat. Wheat predominates in the daily diets of large parts of India and Pakistan. Maize, starchy roots and sweet potatoes are important in Indonesia, Taiwan, and the Philippines. Coarse grains and millet are supplementary or main foods of many poor people in areas of Asia.

In the North Africa/Middle East region wheat, maize, barley and millets are consumed in addition to rice. Wheat production ranks first with 55% of the total cereal production, coarse grains 39% and rice only 6%.

TABLE 1: RELATIVE DISTRIBUTION OF THE PRODUCTION OF MAJOR STAPLES IN DEVELOPING COUNTRIES, BY REGION 1975/76 IN PERCENT

MAJOR STAPLES	ASIA	NORTH AFRICA/ MIDDLE EAST	SUB SAHARAN AFRICA	LATIN AMERICA	ALL DME*
Cereals	83.4	91.3	55.1	80.0	79.9
Rice (milled)	49.1	5.1	5.5	9.6	28.3
Wheat	14.7	50.2	1.6	15.5	18.1
Coarse grains	19.6	36.0	48.0	54.9	33.5
Selected Crops	16.6	8.7	44.9	20.0	20.1
Root crops	5.4	2.2	30.0	13.1	10.0
Pulses	4.7	3.6	6.3	5.2	5.4
Groundnuts	5.5	2.9	8.6	1.7	4.7

*Developing market economies

Source: International Food Policy Research Institute, Research Report #3 , December 1977. Food Needs of Developing Countries: Projections of Production and Consumption to 1990 (22).

The African Savannah consumes mostly millets, sorghum and maize. While consumption of cassava, yams and cocoyams is concentrated in West and Central Africa, rice is the staple diet in West African coastal areas. The pattern in East Africa is diverse: plantations are very popular and maize is the cereal consumed.

In Latin America maize constitutes one of the important staple foods, along with beans, bananas and cassava. Wheat is important, mostly consumed in the plains of the south, while rice is the staple in the tropical coasts and plains.

The ranking of rice consumption in developing countries varies according to their geographic location. In Asia rice ranks number one among all cereals, followed by wheat, other grains and maize. In the Middle East wheat ranks first followed by maize, then rice. In Africa millet, barley, and sorghum come first followed by wheat, maize and finally rice. Generally, wheat and maize share the first rank in Latin America: rice is third followed by other grains. However, maize is the predominant cereal in the diet of many countries, for instance, Mexico, Colombia and Ecuador. Rice ranks first in Brazil and Cuba.

Although rice is the most widely consumed cereal in the developing countries, its consumption is also increasing in North America, Europe and the Soviet Union as will be discussed in detail in the next chapter.

CHAPTER III

WORLD SUPPLY OF AND DEMAND FOR RICE

The objective of this chapter is to elucidate the trends in the world supply of and demand for rice during the period of the study, 1960-1980. This review of rice supply and demand is important to determine whether a structural change in the world rice supply and demand occurred during this period. Accordingly, a suitable methodological approach will follow in the determination of the structural and reduced forms of the model in this study.

The World Supply of Rice

World rice production has been steadily expanding in nearly all countries of the tropical, subtropical and warm climates where growing conditions are suitable. From 1960 to 1980 world production of rice increased from 235 million metric tons of paddy rice to 391 or by 68%. Table 2 outlines world total production of rice, divided into eight major regions. It indicates that rice production in the world is concentrated in Eastern, Southeastern, and Far Eastern Asia and Oceania. This region produced 92.3% of the world's rice crop in 1960 and 90.5% in 1980. The seven other regions produced 7.7% and 9.5% respectively of world production.

TABLE 2: WORLD PRODUCTION OF PADDY RICE BY REGIONS

REGION	PRODUCTION THOUSAND M.T.			PERCENTAGE OF WORLD PRODUCTION		
	1960	1970	1980	1960	1970	1980
1- Far, South & South East Asia and Oceania	216,666	287,231	354,077	92.3	91.6	90.5
2- South America	7,041	9,260	14,196	3.0	3.0	3.6
3- Africa	4,819	7,222	8,536	2.1	2.3	2.2
4- United States	2,477	3,801	6,625	1.1	1.2	1.7
5- Eastern Europe & USSR	334	1,487	2,615	0.1	0.5	0.7
6- Central America & Carribean	1,094	1,394	1,889	0.5	0.4	0.5
7- Middle East	999	1,541	1,751	0.4	0.5	0.4
8- Western Europe	1,291	1,562	1,684	0.5	0.5	0.4
Total	234,719	313,498	391,373	100.0	100.0	100.0

Source: Compiled from Foreign Agricultural Circular, Grains, FG-38-80, USDA Foreign Agricultural Service, Washington D.C., December 19, 1980 (23)

South America is the second largest rice producing region in the world, after Asia, with a total of 3.6% in 1980, up from 3.0% in 1960. Production of rice in South America has more than doubled during this period and is mainly concentrated in Brazil, Venezuela, Ecuador, Peru, Argentina, Guyana, Uruguay and Surinam.

Africa's share was 2.1% in 1980, unchanged from 1960, placing Africa third in world rice production. In Africa, rice is produced predominantly in Egypt, Madagascar, Nigeria, Liberia, Tanzania, Sierra Leone and in some of the francophone countries such as Ivory Coast, Mali, Zaire and Senegal. The greatest increase in rice production during 1960-1980 was in Nigeria, in Zaire (where production more than doubled), and in the Ivory Coast, Liberia, and Tanzania.

The United States' rice production, which was 2,477,000 tons in 1960, has increased steadily due to government programs that since 1954 have affected rice price levels (34). Among the most important of these programs were acreage allotments and price supports. The drastic changes in the international price of rice in 1973 and 1974 have caused unprecedented rises in the acreage and production of rice in the United States. During these two years United States' acreage of rice increased by 30% and its rice production increased by about 38%. However, U.S. rice production accounted for only 1.6% of the world's total in 1980.

Rice is grown in the Soviet Union, predominantly in Central Asia, specifically Turkistan and Transcaucasia. Other Russian producing areas are the southern Ukraine, the Northern Caucasus and the far eastern Maritime provinces. In 1960 total production of rice amounted to 186,000 metric tons, produced from an acreage of 95,000 hectares. Following a drastic increase in demand for rice in the Soviet Union, expansion in the cultivation of rice increased to 650,000 hectares in 1980. Production of 2,400,000 metric tons was more than twelve time the production in 1960. However, the total rice production of the USSR and Eastern European countries amounted to only 0.6% of world total production in 1980. Other rice producing countries in Eastern Europe in 1980 included Romania (65,000 metric tons), Bulgaria (61,000 m.t.), Hungary (48,000 m.t.) and Yugoslavia (42,000 m.t.).

Rice production in the remaining three regions of the Middle East, Central America (including the Caribbean) and Western Europe has also been increased from 1960 levels. However, each region's percentage of total world production remained almost constant between 1960 and 1980.

Rice production in the world suffered a sharp reversal in 1965 when weather conditions were unfavorable in most Asian producing countries. As a result, the world rice production decreased from 184.2 million metric tons of milled rice to nearly 173.4 million tons, a decline of 10.8 million tons or 5.68%. World production in the following years increased steadily until 1972 when it dropped about 3.81% below the 1971 level of 214.9 million tons of milled rice. The decrease was largely due to an unsatisfactory monsoon season which brought a long drought period, in addition to other factors such as floods, plant disease and the disrupting effect of military activities in Asia. Most of this crop decrease was experienced in India, China, Thailand, Cambodia and the Philippines. The 1973 rice crop reached a record of 222.6 million tons, 7.7% higher than in 1972. World production increased further in the following years, 1974 and 1975, by 2.1% and 6.9%, respectively. A slight reverse occurred in 1976 and in 1979, but production increased at a modest rate of 2.68% annually.

In conclusion, one could say that, except for some fluctuations in the world supply of rice due mainly to bad weather conditions (especially in monsoon Asia), production of rice in the world was stable over the twenty-one year period for which data were collected to estimate the supply functions of this study.

No large shift in the pattern of rice production from one region to another or even within the same region of world rice production exists. Rice production still finds its home in monsoon Asia and that will probably remain the same in the future. Asia's share in the world's rice production slipped only about 1.8% from 92.3% in 1960 to 90.5% in 1980.

World Demand For Rice

Factors influencing the quantity demanded of rice include income, population growth, and price effects. Income and population growth have been, traditionally, the most important factors in the increasing demand for rice, especially in developing countries. The world quantity of rice demanded increased from 159.0 million metric tons of milled rice in 1960 to 266.0 million metric tons in 1980, or 67%, exactly the same rate of increase as that of the world supply of rice for the same period. The annual quantity of rice supplied and demanded and the rate of change each year from 1960 to 1980 are indicated in Table 3. During this period, world demand for rice increased at an average rate of 2.64%. Following the setback in world production of rice in the years 1965 and 1972, the quantity of rice demanded decreased at rates of 4.36% and 2.57%, respectively. For all other years, the quantity of rice demanded has shown a positive rate of increase, fluctuating from about 1% to 5% annually.

Following the world oil boom of 1973, the average rate of increase in the quantity of rice demanded amounted to 2.71% annually, no change from the overall average rate since 1960. Taking a closer look, however, there has been a steady increase in the quantity of rice demanded in OPEC countries, which has been balanced by a decrease in other parts of the world, so that the overall rate of increase in the demand for rice has remained the same.

TABLE 3: WORLD SUPPLY AND DEMAND FOR RICE AND PERCENTAGE ANNUAL CHANGES (MILLION METRIC TONS OF MILLED RICE)

YEAR	SUPPLY	%CHANGE	DEMAND	%CHANGE
1960	158.6	--	159.0	--
1961	162.9	2.71	163.9	3.08
1962	165.0	1.29	165.1	0.73
1963	172.6	4.61	170.9	3.51
1964	184.2	6.72	181.1	5.97
1965	173.4	-5.86	173.2	-4.36
1966	179.3	3.40	180.7	4.33
1967	193.8	8.09	190.7	5.53
1968	195.1	0.67	191.9	0.63
1969	203.4	4.25	201.4	4.95
1970	211.0	3.74	211.5	5.01
1971	214.9	1.85	217.7	2.93
1972	206.7	-3.82	212.1	-2.57
1973	222.6	7.69	220.7	4.05
1974	227.3	2.11	228.9	3.72
1975	243.1	6.95	235.5	2.88
1976	236.2	-2.84	237.5	0.85
1977	248.9	5.38	242.8	2.23
1978	259.2	4.14	255.1	5.07
1979	253.4	-2.24	257.3	0.86
1980	265.7	4.85	266.0	3.38

*Preliminary

Source: Compiled from Foreign Agricultural Circular, Grains, FG-46-91 USDA Foreign Agricultural Service, Washington D.C., December 1981 (23).

The pattern of demand trends for world rice is best shown by the amount of milled rice consumed per capita, as indicated in Table 4. This table shows the trends in per capita rice consumption for some 37 selected countries, at five year intervals from 1960 to 1980. The top of the table includes countries with consumption rates of over 300 pounds per capita annually. The geographic location of all these countries is South, Southeast and Far East Asia, with the exception of Madagascar, which is located in Africa.

In the traditional rice consuming countries of the Far East, such as Laos, Thailand and Burma, rice consumption seems to reach a saturation point at 300-400 pounds per head annually. Countries with consumption rates of 200-300 pounds per capita are located in the same geographic region as above, with Liberia and Gambia in the African Continent. The next category, from 100-200 pounds per head, includes countries in Asia, such as Japan, India, Hong Kong and Singapore; in Africa, such as Senegal, Guinea, Ivory Coast; in the Middle East, such as Kuwait and Saudi Arabia; and in Latin America, such as Brazil, Cuba and the Dominican Republic.

The countries in the last category, under 100 pounds per capita rice consumption, are spread all over the world. The pattern of food consumption in the developing countries from 1960 to 1980 shows a shift in favor of rice in some

TABLE 4: PER CAPITA RICE CONSUMPTION IN SELECTED COUNTRIES

COUNTRY	1960	1965	1970	1975	1980
	more than 300 pounds of rice annually (1980)				
Madagascar	278	365	397	394	416
Thailand	392	416	464	431	398
Burma	282	432	388	399	374
Laos	388	430	485	465	397
Bangladesh	-	-	372	324	335
Korea, (South)	278	280	326	311	335
Vietnam	-	-	370	397	304
Indonesia	264	220	253	273	302
	200-300 pounds of rice annually (1980)				
Liberia	207	223	297	269	271
Malaysia	236	253	240	286	247
Sri Lanka	253	229	256	200	242
Nepal	292	296	249	275	227
China, Peoples Rep.	156	176	196	207	213
Philippines	203	200	212	196	209
Gambia	198	181	196	141	205
	100-200 pounds of rice annually (1980)				
Japan	278	264	247	212	198
India	170	161	170	141	181
Kuwait	141	234	112	90	163
Hong Kong	247	202	194	170	156
Senegal	117	156	130	123	156
Singapore	260	225	181	150	165
Guinea	165	134	143	119	132
Ivory Coast	90	132	121	104	139
Brazil	110	99	108	104	119
Saudi Arabia	49	60	50	68	117
Cuba	132	53	128	106	110
Dominican Rep.	55	84	75	99	101
	Less than 100 pounds of rice annually (1980)				
Colombia	42	53	46	73	95
Iraq	49	32	51	46	84
Iran	51	62	60	73	77
Pakistan	51	51	75	62	55
Nigeria	12	10	11	15	29
Syria	13	12	15	24	24
U.S.A.	11	12	14	14	18
USSR	1	6	11	12	16
Italy	14	13	12	13	13
Australia	1	8	13	9	9

Source: Calculated from various sources (23, 24, 25, 59) countries and little or none in others. For example, data of the per capita consumption indicated in Table 4 show that a shift away from rice occurred in Japan, Hong Kong, Singapore and Guinea. In contrast, the quantity of rice demanded has increased steadily in China, Ivory Coast, Liberia, Senegal, the Dominican Republic, Indonesia and South Korea. Other countries, such as the USSR, Australia, Saudi Arabia, Colombia and Nigeria more than doubled their per capita consumption of rice from 1960 to 1980. The traditional rice consuming countries, such as Thailand, Laos and Burma, have experienced little or no change in their per capital rice consumption. In the United States consumption has also increased steadily from 11 pounds per capita in 1980 up to 18 pounds per capita in 1980. But it varies according to the ethnic group in question. Orientals consume the highest amount followed by blacks, Latin Americans and then whites. Rice consumption in the Soviet Union has been significantly increasing, from only one pound per capita in 1960 to 16 pounds in 1980. Rice consumption in the European community is stable, but slightly low at about 7.5 per capita in 1980.

Increases in income are associated with increases in the consumption of rice. The income elasticity of demand for rice for some Asian countries has been estimated to be 0.5 in Sri Lanka, 0.6 in urban India, 0.64 in rural India, 0.4 in Brazil and 0.6 in Ecuador (1). In Japan, a significant decline in the demand for rice has been observed during the last few decades. Wheat consumption was encouraged by the government at the expense of rice. After reaching a peak of about 310 pounds per capita in 1920 rice consumption fell to about 247 pounds in 1970, then decreased further to only 198 pounds in 1980. This resulted in the coefficient of income elasticity dipping below zero (1).

Changes in the diet of people in the developing countries depend not only on individual food hierarchies, but also on consumer preferences and price relationships to other staples. Rice and wheat are in the top half of the scale of food preferences in the developing countries; corn, millet, sorghum, barley and others are in the bottom half. As income rises consumers are usually able to ascend the scale and improve their dietary patterns. Changes in the composition of a diet do not necessarily involve any direct substitution. Poor people may sometimes add other dishes to their meals without dropping their traditional staples. Moreover, the opportunities for substitutions depend upon the range of foods available for consumer choice, the form in which they are prepared, and other factors.

In Africa, for example, the largest widespread change in diet is an increase in the consumption of rice and wheat, particularly in urban areas, instead of bulky, perishable staples such as yams, sweet potatoes and bananas.

Price Elasticity of Demand for Rice

The price elasticity of demand for any individual good is closely related to the availability of substitutes. The first effect of any price change is on expenditures. A rise in the price of one staple food reduces the amount of money available for the purchase of other non-staple foods and less essential items. Cost increases may sometimes be met by shifts to cheaper grades of the same food. In many rice-consuming countries this is the usual trend, especially shifts to purchasing the same type of rice but of an inferior (containing a higher percentage of broken grains) and cheaper grade. In general, the price elasticity of the local staple food is much lower than that of supplementary foods. The demand for rice is inelastic with relation to price increases: the absolute value of the elasticity of demand probably is below 0.5 in the rice eating countries of the Far East, but could be 1.0 or higher in the countries of Africa, the Middle East and Latin America where other foods are the staples. On the other hand, since food customs and general living habits govern the demand for rice, when prices of rice show some increases no drastic change in the pattern of consumption takes place, unless it is reinforced by consumer education in cooking methods, nutritional advantages, or the like.

CHAPTER IV

INTERNATIONAL TRADE AND THE PRICE STRUCTURE OF RICE

International Trade

Asia is not only the largest producer, but it is also the largest consumer of rice. It is estimated that about half the rice produced in the Far East is consumed by the growers themselves, who, in most regions of Asia, grow rice primarily to supply their domestic needs and store a part for future consumption should the next crop be insufficient. The remaining rice is moved to other regions and urbanized centers within the country for local consumption. Only a small proportion of rice enters the international markets. In 1960 4.1% of the world's total milled rice production moved across national borders in international trade. This rate has fluctuated from as low as 3.6% in 1975 to 5% in 1980.

In 1960 world rice exports amounted to 6.5 million tons of milled rice and increased to 8.7 million at the end of the decade despite some small annual decline as in 1966 and 1967. From 1975 rice started to appear in increasing amounts in international trade. The reason was that potential rice producing countries, stimulated by higher prices in international markets and the increasing demand for rice, expanded their local production. As a result, world rice exports increase by 48% from 1975 to 1980.

Asia, the principal rice producer in the world, is also the main rice exporter. The largest amounts of rice in 1960 came from the traditional rice exporting countries of Asia. Burma exported 26.2% of the world's total, Thailand 24.3% and China 6.8%. The three countries together accounted for 57.3% of total world export. The United States exported 14.1% of total world rice export in 1960.

Thailand later entered a longstanding competition with Burma for first place; in world rice export. Thailand became the biggest exporter in 1963 and 1964 with 24% of total exports. In 1967 the United States surpassed Thailand, which remained second largest until 1971 when the latter shipped about 24.3% of all world exports. Then the United States slipped to second place: its exports accounted for 16.3%.

Surprisingly enough, China and Japan emerged in 1971 as the third and fourth largest exporters, with 17.9% and 10.5%, respectively. The role of China as a rice-exporting country drastically increased into the 1970s. By 1972 China became the leading rice exporter: it shipped 2,595,000 tons or 31.3%, in that year, 2,552,000 tons or 30.4% in 1973 and 1,975,000 tons or 25.3% in 1974. However, the United States regained the leading position in 1975, exporting 23%, followed by Thailand at 20.8% and China at 16%. While the

TABLE 5: MAJOR WORLD RICE IMPORTING COUNTRIES
(IN 1000 METRIC TONS OF MILLED RICE)

YEAR	6-OPEC	11 NON-OPEC	TOTAL 17	WORLD TOTAL IMPORTS	%OF 17 TO TOTAL WORLD
1960	1,103	1,808	2,911	5,459	53.32
1961	1,244	2,078	3,322	6,323	52.24
1962	1,203	1,911	3,114	5,971	52.16
1963	1,301	2,626	3,927	7,485	52.46
1964	1,165	2,633	3,798	7,968	47.56
1965	405	2,732	3,137	7,415	42.30
1966	533	2,380	2,913	7,165	40.66
1967	501	2,257	2,758	6,362	43.35
1968	796	2,068	2,864	6,857	41.77
1969	786	2,317	3,103	6,744	46.01
1970	1,304	3,319	4,623	7,949	58.16
1971	891	3,192	4,083	7,956	51.32
1972	1,094	2,854	3,948	7,171	55.06
1973	2,291	2,477	4,768	8,282	57.57
1974	1,875	2,291	4,166	8,008	52.02
1975	1,450	2,256	3,706	7,4147	49.97
1976	2,532	2,339	4,871	8,288	58.77
1977	3,351	2,435	5,786	9,434	61.33
1978	3,569	2,320	5,889	10,326	57.03
1979	3,709	2,585	6,294	11,031	57.06
1980	3,850	3,389	7,239	12,360	58.57

Source: Calculated from Foreign Agriculture Circular, USDA, Foreign Agricultural Service, Washington D.C. 1980, 1981 and 1982 (23, 24, 25) role of Burma as a traditional exporting country was declining, the United States became a leading rice exporter in world markets. By 1980 the United States' exports ranked again number one (2.9 million tons), Thailand was second (2.8 million tons), and both together accounted for 42.9% of the world's total. Other major rice exporting countries of the region are Pakistan (1,200,000 tons), Japan (900,000) and Australia (420,000).

Among major rice importing countries of the world, Indonesia became the largest in 1973, when it imported 1,660,000 tons, 20% of world imports. Its rice imports decreased to only 673,000 tons in 1975, but increased sharply to 2 million tons, or 16.2% of the world total in 1980. This constituted a three-fold increase in the imported amounts of rice in a 5 year period. The annual average rate of rice imports in Indonesia accounted for about 17% of the world's total between 1976 and 1980. The oil boom has increased the consumption demand for rice, not only in Indonesia but in other OPEC countries. For example, one-third of world rice imports during the last five year period, 1976-1980, went to 6 OPEC countries. These were ranked according to the amounts of rice they received: Indonesia, Iran, Saudi Arabia, Nigeria, Iraq and Kuwait. These countries' imports of rice averaged 15.3% of world total imports during 1960-75. Other major rice importing countries in Asia in 1980 were South Korea (1,007,000), South Vietnam (1,000,000), Hong Kong (360,000), Malaysia

(273,000), Sri Lanka (260,000) and Singapore (186,000)

From 1960 to 1980 Africa imported more rice than it exported, with the exceptions of 1968 and 1969, when the reverse occurred. Africa's total exports amounted to 848,000 tons, or 12% of the world's total, and 751,000 tons, or 10%, in 1968 and 1969, respectively. Ninety percent of these exports came from Egypt. Egypt still is the major rice exporter in Africa, exporting 150,000 tons of total African exports of 154,000 tons, or 1.2% of total world exports in 1980. Africa's imports of rice amounted to 2,071,000 tons of milled rice, or 16.3% of total world imports in 1980. This constitutes an increase of 263% from 766,000 tons, or 10% of the world's imports in 1974. Since the oil boom of 1974 Nigeria emerged to be the largest rice importer in Africa. In that year total imports into Nigeria amounted to only 8,000 tons of rice. This increased to 400,000 tons in 1980 and 600,000 tons in 1981. To meet increasing consumption demand Nigeria succeeded in doubling its rice production from 1974 to 1980. However, because consumption demand tripled during the same period, the difference had to be imported. The import demand for rice has increased substantially, especially in Africa. Many people are substituting rice for their national diets of minor grains and root-crops. Rice quickly became the favored staple for the residents of the new urban areas which began to grow rapidly during the 1970s. Other major rice importing countries of Africa are Senegal (325,000), Ivory Coast (230,000) and Madagascar (150,000) in 1980.

Demand for rice imports in the Middle East has increased by 477% in 20 years, from 309,000 tons in 1961 to 1,784,000 tons in 1980. Most of this increase occurred directly after the oil boom in 1974. This area's total imports of rice amounted to 529,000 in 1973 and had increased by 116.6% to 1,146,000 tons in 1975. Major rice importers of the regions are Iran, Saudi Arabia, Iraq, Kuwait, Syria and the Democratic Republic of Yemen. In the Soviet Union rice imports increased very sharply from only 20,000 tons in 1960 to 500,000 tons in 1980. So did rice imports to South America, which amounted to 70,000 in 1961 and increased to 571,000 in 1980, after reaching a record high of 923,000 tons in 1979. Total imports to Central America and the Caribbean increased by 84% during the same period and those to Western Europe doubled.

A review of rice imports and exports reveals a reversal of international rice trade patterns between 1960 and 1980. Japan, which was a major rice importer, became an exporter. India and the Philippines were rice importers and became self-sufficient. Malaysia, Singapore, Sri Lanka and Hong Kong were still importing a considerable amount every year. Cambodia and Brazil, which were rice exporters, became rice importers.

TABLE 6: MAJOR RICE EXPORTING COUNTRIES (IN 1000 METRIC TONS OF MILLED RICE) 1960-1980

YEAR	U.S.	THAI-LAND	PAKI-STAN	CHINA	BURMA	AUSTRA-LIA	JAPAN	ITALY	TOTAL	WORLD TOTAL	%
1960	825	1,576	49	444	1,669	51	-	131	4,745	6,547	72.5
1961	835	1,271	124	578	1,591	62	-	259	4,720	6,469	73.0
1962	1,050	1,418	128	640	1,744	58	-	209	5,247	7,296	71.9
1963	1,197	1,896	102	784	1,712	57	-	176	5,924	7,759	76.4
1964	1,317	1,895	164	753	1,413	65	-	80	5,687	8,020	70.9
1965	1,549	1,508	135	1,264	1,335	64	-	119	5,974	7,661	78.0
1966	1,347	1,483	213	1,198	1,128	99	-	108	5,576	7,408	75.3
1967	1,801	1,068	140	967	546	97	-	222	4,927	6,801	72.4
1968	1,846	1,023	81	811	352	124	-	279	4,816	7,108	67.8
1969	1,851	1,064	135	986	561	111	361	280	5,349	7,821	68.4
1970	1,695	1,576	130	1,474	674	165	597	594	6,905	9,642	79.9
1971	1,415	2,116	196	1,556	811	143	912	473	7,622	8,719	87.4
1972	1,965	849	300	2,595	524	158	183	372	6,946	8,306	83.6
1973	1,589	1,046	771	2,552	133	145	517	247	7,000	8,447	82.9
1974	1,702	933	478	1,975	210	185	308	461	6,252	7,845	79.7
1975	2,070	1,870	498	1,441	288	218	10	451	6,848	9,112	75.2
1976	2,045	2,915	945	1,023	636	260	-	396	8,220	10,602	77.5
1977	2,270	1,573	860	1,373	690	337	50	275	7,428	9,421	78.8
1978	2,261	2,696	825	942	375	400	91	409	7,999	11,580	69.1
1979	2,263	2,600	1,366	1,000	600	450	575	475	9,329	12,700	73.5
1980*	2,900	2,800	1,200	1,000	550	420	740	600	10,210	13,300	76.8

*Preliminary

Source: Foreign Agriculture Circular, Grains, FG-38-80, Washington D.C. 1980, 1981 (23, 24)

The United States and China emerged as the leading rice exporting countries. Burma's role as an exporter is declining. Australia, inspired by increasing prices in the international markets, expanded its production and became an important rice exporting country. A closer look at the share of major rice exporting countries, however, reveals that eight countries contributed 76% of the total world exports of rice throughout the entire period between 1960 and 1980. These countries (in alphabetical order) are Australia, Burma, China, Italy, Japan, Pakistan, Thailand and the United States. From 1960 to 1973 the amount of rice exported by these countries amounted to 75.6% of the world total from 1973 to 1980; after the sharp increase in the international price of rice, their share was 77%, about the same.

There are seventeen major rice-importing countries. A major rice importing country is defined as one that imported 100,000 metric tons of milled rice or more in 1980. In this study these are divided into 6 OPEC countries -- Indonesia, Iran, Iraq, Kuwait, Nigeria and Saudi Arabia -- and 11 non-OPEC countries -- Madagascar, Malaysia, Philippines, Senegal, Hong Kong, Ivory Coast, Singapore, South Korea, Sri Lanka, Syria and the USSR. From 1962 to 1973 the quantity of rice imported by these 17 countries amounted to 50% of total world imports. After 1974, when prices of oil quadrupled up to 1980, the 6 OPEC countries increased their rice imports by 165%. In contrast, the 11 non-OPEC countries increased theirs by only 48%. However, the share of both groups taken together averaged 56.4% of total world imports of rice from 1974 to 1980.

It may be concluded that, despite sharp competition in the world market, the amount of rice which found its way into international markets from 1960 to 1980 was relatively stable, fluctuating only between 4 to 5% of total world production. The share of major rice exporting countries in the world market averaged 75.6% during 1960-1973. From 1974 to 1980 this share was 76.1%.

The major rice importing countries' share during the same periods accounted for 50% and 56.3%, respectively. The slight increase in the import demand for rice was a direct result of income increases, especially in the 6 OPEC countries following the oil boom of 1974. This implies that no structural changes in the pattern of the international rice trade have taken place during the period of the study. The volume of rice traded in international markets was steady at the same rate of 4-5% of total world production.

Price Structure of Rice

Factors affecting the price of rice

Rice is consistently higher priced than other cereals such as barley, oats, rye, sorghum, millet maize, and wheat. In general, the international price of milled rice is quoted as 2-3 times higher than the international price of wheat, while the price of wheat is 10-45% higher than the prices of all cereals in the coarse-grain group--maize, barley, rye, oats, sorghum and millet. Prices of coarse grains differ only within a smaller range.

The year to year fluctuation in the price of rice is followed by similar trends for the price of wheat and all other coarse grains. The magnitude of price increases or decreases from 1960-80 may differ, but the general trend follows the prices of other grains. For example, while the price of milled rice per metric ton amounted to $147.12 in 1972, the price of wheat was $69.69 and the composite price of all coarse grains was $53.12. In 1973 the price of rice rose by 125%, wheat by 107% and the coarse grain composite price by 63%. Similar trends followed in 1974 when the price of rice increased by 64%, the wheat price by 35% and that of coarse grains by 28%. When the price of rice decreased in 1975 wheat and coarse grain prices followed the trend. The rice prices rose again in 1980 and prices of wheat and all other grains also increased. Current prices of all grains (from 1960 to 1980) are shown in Table 7.

Generally, rice prices are more variable than wheat prices because soil and climate conditions are not suitable to grow other crops in the areas usually associated with rice cultivation. This leaves rice growers, especially in the monsoon regions, with no alternative to rice production.

TABLE 7: PRICES OF RICE, WHEAT, AND COARSE GRAINS IN DOLLARS PER METRIC TON

YEAR	RICE	WHEAT	CORN	BARLEY	RYE	OATS	SORGHUM
1959	132.20	58.91	46.1	52.31	49.79	50.04	37.9
1960	124.70	58.54	43.3	48.70	44.55	50.10	37.7
1961	136.51	59.77	45.9	56.42	47.24	47.93	42.6
1962	152.78	63.93	51.4	55.35	47.90	48.85	45.6
1963	143.35	63.69	54.7	50.96	51.18	50.24	48.6
1964	137.73	67.12	55.8	52.02	50.59	48.02	48.2
1965	136.34	60.50	55.0	58.25	45.27	51.18	47.2
1966	163.24	65.40	59.4	61.09	47.04	50.89	51.7
1967	205.98	65.65	49.9	59.21	46.03	50.85	50.4
1968	201.64	62.71	49.1	54.24	44.95	47.77	46.5
1969	186.88	59.89	53.9	51.33	45.47	44.68	50.1
1970	144.00	57.57	58.4	51.98	44.29	46.88	51.8
1971	128.96	61.12	58.4	55.23	41.63	47.12	55.7
1972	147.12	69.69	56.0	56.38	40.38	49.89	56.0
1973	330.42	144.04	98.0	91.55	70.76	72.46	93.0
1974	542.02	194.74	132.0	114.94	115.71	110.23	121.0
1975	363.07	159.47	119.6	110.69	109.74	113.73	111.9
1976	254.59	136.07	112.4	109.35	114.00	117.24	105.2
1977	272.20	108.52	95.3	86.81	97.12	99.44	88.4
1978	367.51	133.01	100.7	81.33	105.18	93.58	93.8
1979	334.19	163.39	115.5	94.27	97.47	108.22	108.1
1980	433.70	179.55	125.3	108.70	108.59	122.12	128.9

Source: Collected from various sources and years from references of the bibliography No. 13, 16, 31, 33, 46, 50, 53, and 64). For more information about the listed variables, grades and destination of the grains see table 13, page 65.

Prices of rice are quoted for clean milled rice of different grades (long, medium and short) from a given country. Quoted prices reflect largely the content of brokens, color, uniformity of grains, amount of foreign matter, number of chalky grains, unevenness of type and general appearance. Prices also are influenced greatly by consumer preference for one flavor over another, based upon tastes that have been developed over generations.

World rice prices are quoted, worldwide, according to the different varieties and qualities of rice. High quality rice includes U.S. NO. 2 long grain, milled, white; the Italian Originario, 3% brokens; Pakistani Basmati; the 100% 1st grade white Thailand, and 100% 2nd grade Thai white. The medium quality grains include Thailand, white 5% brokens, Thailand husked 100% , U.S. medium grain and short grain. The lower quality grains include Thailand, white rice 25% brokens, People's Republic of China 35% brokens and Burma, Ngasein, 42% brokens.

From 1960 to 1965 world rice prices were stable at around $160 per ton f.o.b. Bangkok for high quality, $140 per ton for medium quality, and $120 per ton for lower quality. From 1965 to 1967 rice prices increased significantly because of a sharp weather indiced drop in production. The price of high, medium and low quality then jumped to $200, and $170 per ton, respectively. These price levels were the highest in international markets since the Second

World War Shortage. However, prices declined sharply in 1971, reaching their lowest levels since 1960. For example, the price of Thailand white (5% brokens, f.o.b. Bangkok, Thailand), which has been established as a good indication of international rice prices, declined from around $200 per ton in mid-1969 to $113 per ton in April, 1971.

Import demands for rice decreased in 1971 as a result of the third consecutive year of increasing production in the world. Competition among rice exporters intensified, resulting not only in price reductions but also in greater availability of concessional payment terms. Only the United States and Japan engaged in concessional transactions before 1970, but in 1971 Thailand started them. As a result, the share of commercial sales in total exports declined while that of concessional transactions increased to 30%. In 1972 world production of paddy rice fell 3.4%, about 12.2 million tons, because of failure of the monsoon rains and bad weather conditions in the rice producing countries. The decline in rice production was most felt in the developing countries of Asia. However, output of rice outside the Far East has actually increased by 2%. On the whole, rice production was lower by about 6 million tons in exporting countries and about 9.5 million tons in importing countries. World export supplies were reduced and keen competition among importing countries for the limited export supplies pushed prices sharply up. The export price

TABLE 8: EXPORT PRICES OF MILLED RICE AT THAILAND BY MONTHS, WHITE 5% BROKENS F.O.B. BANGKOK 1971-80[1]

Month	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Jan.	139	124	179	541	398	274	259	338	299	395
Feb.	125	130	198	575	404	253	257	374	300	399
Mar.	115	130	204/2	598	396	248	261	396	314	415
Apr.	113	129	-	629	400	246	252	411	316	419
May	124	132	-	625	388	246	257	409	318	433
June	127	136	-	596	344	242	264	404	324	442
July	129	138	-	519	327	244	272	384	327	442
Aug.	132	160	-	521	348	243	275	366	349	442
Sept.	140	161	-	514	358	266	275	369	360	442
Oct.	139	168	-	499	353	270	278	360	362	442
Nov.	136	176	-	453	330	259	294	315	364	463
Dec.	134	184	-	430	307	258	324	294	379	470

1/ Milled rice includes export premium, export tax and cost of bags. Packed in bags of 100 net kilogrammes. 2/ Export prices for one week only. Beginning March 7 thru Dec. 31, 1973 prices were not quoted. May-Oct. average for 5% brokens estimated at $330.42 per metric ton.

Source: Compiled from the Rice Situation, 1972-78 (52) and Rice Outlook and Situation 1981(53).

of Thai white rice, 5% brokens, f.o.b. Bangkok (a good indicator of world prices) reached an average of $330 per ton in 1973, up 125% from the average of $147.12 in 1972. In 1974 the average price of the same rice quality increased further to $542.02 per ton. In April 1975 the price of the same type reached a record of $629 per ton, compared to $112.80 in April 1971 (see Table 8). Prices of rice had been decreasing during 1975 and 1976 when the price of the same type reached $254.95 per ton. In 1977 and 1978 this price increased to $367.51 per ton. The sharp increase in the commodity prices from 1979 to 1980 also affected the price of rice, which rose significantly from $299 per ton to $470, an increase of 57%.

World Stocks of Rice and Other Grains

Stockpiles of milled rice, wheat and coarse grains and the ratio of marketing year ending stocks to total utilization in the world are listed in Table 9. In 1960 world stocks of rice amounted to a total of 8.7 million tons and the ratio was 5.5%. World stocks of wheat were much higher, amounting to 79.3 million metric tons and a higher ratio of 33.7%. Amounts of ending stocks of coarse grains were even higher, 109.7 million metric tons, and the ratio was smaller than that for wheat and higher than that for rice, amounting to 25.1%.

Following the decrease in world grain production due to bad weather conditions in 1965, stocks of wheat and coarse grains dropped sharply from 73.4 million metric tons and

90.0 million metric tons, to 55.3 and 75.1, respectively. Rice stocks decreased slightly from 12.8 m.t. to 11.4 m.t. in the following year. At the end of 1967 stockpiles of all grains including rice started to increase and their prices to decrease in the international markets. However, the droughts and floods which occurred in the monsoon region of Asia which resulted in declining world rice, wheat and coarse grain production in 1972, also had an effect on stocks. Stocks of rice decreased from 16.3 million tons in 1971 to only 10.9 million tons, or a decrease of one third in 1972. Stocks of wheat decreased from 81.1 million metric tons to 62.6 m.t., or 30%, and the stocks of coarse grains from 85.8 to 68.2 million metric tons, or about 25%. Consequently, the possibility for supply augmentation in 1973 was limited, one of the factors which probably affected the soaring prices of rice, wheat and all other grains in the following two years. The ratio of ending stocks to total utilization accordingly decreased from 7.5% to 5.1% in 1972 for rice, from 23.7% to 17.3% for wheat and from 13.9% to 10.8% for coarse grains. World production of rice recovered in 1973 and 1974, but stock-levels were still tight and unable to recover to their pre-1972 level. However, the 1975 stock- levels reached a high of 18.9 million tons and exceeded the pre-1972 level for the first time.

In 1973, world production of wheat and coarse grains recovered from its low level of 1972, but for the next two years production decreased, then recovered sharply in 1976.

TABLE 9: WORLD STOCKS OF RICE, WHEAT AND COARSE GRAINS IN MILLION METRIC TONS AND THEIR PERCENTAGE RATIO OF UTILIZATION OF THE SAME YEAR

YEAR	RICE (MILLED)		WHEAT		COARSE GRAINS	
	ENDING STOCKS	STOCKS AS AS % OF UTILI-ZATION	ENDING STOCKS	STOCKS AS % OF UTILI-ZATION	ENDING STOCKS	STOCKS AS % OF UTILI-ZATION
1960	8.7	5.5	79.3	33.7	109.7	25.1
1961	7.8	4.8	67.5	28.3	94.7	21.0
1962	7.7	4.7	71.9	28.7	92.7	20.1
1963	9.4	5.5	65.3	26.8	97.9	21.1
1964	12.5	6.9	73.4	27.6	90.9	18.9
1965	12.8	7.4	55.3	19.6	75.1	15.0
1966	11.4	6.3	82.1	29.1	76.1	14.6
1967	14.5	7.6	90.5	31.4	85.2	15.7
1968	17.7	9.2	114.8	37.8	89.2	16.2
1969	19.6	9.7	97.6	29.9	89.2	15.4
1970	19.1	9.0	74.1	21.9	72.2	12.2
1971	16.3	7.5	81.1	23.7	85.8	13.9
1972	10.9	5.1	62.6	17.3	68.2	10.8
1973	12.9	5.8	70.4	19.3	63.5	9.4
1974	11.3	4.9	63.9	17.6	57.3	9.0
1975	18.9	8.0	62.8	17.9	56.7	8.8
1976	17.6	7.4	98.8	25.7	75.6	11.0
1977	24.5	10.1	81.5	20.3	84.2	12.2
1978	28.6	11.2	100.9	23.5	90.9	12.2
1979*	24.7	9.6	79.3	17.9	89.9	12.1
1980*	24.4	9.2	74.5	16.8	77.4	10.5

*preliminary

Source: Foreign Agriculture Circular, Grains, FG-46-81, Foreign Agricultural Service, USDA, Washington D.C., December 15, 1981 (24)

Consequently, the level of stocks for wheat and coarse grains was about the same as the 1972 level. In 1978, the level of rice stocks reached 28.2 million metric tons the highest position in 21 years. A similar trend was shown in stocks of wheat and coarse grains, which reached their highest level since the late 1960s. Afterwards, and to 1980, the stock levels of rice, wheat and all coarse grains showed declining levels.

A comparison of the ratio of ending stocks and total utilization of grains during the two decades showed a sharp decline from about 30% to 20% for wheat and from 18.3% to 11.0% for coarse grains. In the case of rice this ratio increased slightly from an average of 6.8% during the decade of the 1960s to an average of 7.9% during the 1980s. On the whole, however, the ratio for world total grains has decreased sharply from an average of 19.3% during the 1960s to only 13.1% during the 1970s. This decline indicates that the amount of food reserve had decreased, thus making the price of grains more susceptible to fluctuations in the 1970s than during the 1960s.

CHAPTER V

A THEORETICAL FRAMEWORK AND THE BASIC ECONOMIC MODEL

This chapter is devoted to setting up the conceptual development of the basic economic model of the study. The first section gives an overview of the theoretical background and the formulation of the model. Particular attention is given to the matter of the existence of substitutes for rice. In the second section the economic model is formally specified and presented. The goal of this theoretical analysis is to model the major relations existing among the economic variables which determine the price of rice in the international market.

Theoretical Background

The main purpose of this theoretical section is to devise a model which can be implemented empirically to trace the movements in the international prices of rice. A major difficulty in the formulation of this model is knowing what to do about products for which rice is a substitute. Rice and wheat are generally classified as food grains, while corn, sorghum, millet, rye, oats, and barley are classified as feedgrains. In many parts of the developing world, however, corn sorghum and millet are the common grains for human consumption, simply because people are too poor to afford rice or wheat. Rice and wheat are in the top half of the scale of food preference in the developing countries and millet, sorghum, corn and others are in the bottom half. This suggests that the demand for rice, DX, depends on the price of rice and the prices of all other grains in an equation of the type:

$$DX = a_1 + a_2PX + a_3PY + a_4PZ + \text{etc.}$$

where PX is the price of rice, PY the price of wheat, PZ the price of corn, etc. Similarly, the demand for wheat is a function of the price of wheat, the price of rice, the price of corn, etc., and the chain goes on for all relevant grains. A total of seven different major grains are considered to be potential substitutes for rice. Their inclusion separately, in addition to the other determinants of the price of rice in the model, would require giving up a large number of degree of freedom out of the 21 available observations (from 1960-1980) for the study. Since this is undesirable, a preliminary analysis will be undertaken to look for alternative specifications.

One possibility would have been to undertake a factor analysis of the various grains other than rice, and then place the one or two main factors in the rice regression equation. The problem here is that it is difficult to give much intuitive meaning to such factors. Modeling the world markets for all relevant grains separately is beyond the scope of this study. Instead aggregation of some or few grains according to their degree of substitutability will be tried. The following simple method or process will be used for determining how grains should be aggregated.

If goods are substitutes, then a decrease in the supply of one will cause an increase in the demand for another. One factor which affects the supply of all grains is the price of fertilizer. If the residuals from regressions of the logarithm of prices of these grains on the logarithm of the price of fertilizers are correlated, that makes it more likely these grains are in fact substitutes although it does not prove that they are, since the residuals could be correlated because of factors other than fertilizer causing supply or demand shifts, such as time or income levels. All one can say is that if their prices were not correlated aside from the correlation with fertilizer prices, then we would be less willing to believe that they are substitutes. Suppose that one would like to determine the international price of a cereal P_t at time t using a regression model which includes one constant variable PF_t, the price of fertilizers. This would be associated with movements in the prices of cereals as follows:

$$P_t = a + b\ PF_t + E_t$$

This equation has an additive error term that accounts for the unexplained variance in P_t, i.e., it accounts for that part of the variance of P_t that is not associated with PF_t.

TABLE 10: OLS REGRESSIONS OF GRAIN PRICES ON THE PRICE OF FERTILIZER

EQUATION NUMBER	DEPENDENT VARIABLE	INTERCEPT	log PF_t	R^2	F-VALUE
1-	log PWR_t	2.117 (0.394)	0.740 (0.091)	0.78	65.98
2-	log PW_t	1.117 (0.288)	0.769 (0.067)	0.88	133.24
3-	log PC_t	1.554 (0.314)	0.617 (0.073)	0.79	72.12
4-	log PO_t	1.382 (0.292)	0.638 (0.067)	0.82	89.30
5-	log PB_t	2.024 (0.227)	0.501 (0.052)	0.83	91.05
6-	log PS_t	1.372 (0.345)	0.641 (0.080)	0.77	64.67
7-	log PRY_t	1.190 (0.318)	0.672 (0.073)	0.81	83.54

Names and description of all variables are listed in table 13.
Standard errors are in parentheses.

A preliminary regression analysis was run to estimate the importance of the price of fertilizer in explaining the movement in the prices of major cereals, including rice, wheat, corn, oats, rye, barley and sorghum over a period of 21 years, from 1960 to 1980. The estimated coefficients of the price of fertilizer, as indicated in table 10, were significant at the 1% level. The t statistics ranged from 8.04 to 11.54 and R-squared from 0.77 to 0.88. The coefficients were all positive indicating a positive correlation between the prices of grains and the price of fertilizer. It is interesting to note that the price of fertilizer has explained an average of over 80% of the variance of the international prices of each grain, including rice. An analysis of the residuals of the above equations was carried out to determine the magnitudes and the signs of the correlation coefficients between pairs of grains. Results are shown in Table 11. All correlation coefficients (ρ-values) are positive, indicating substitutability between any two grains is possible. As table 11 indicates, the correlation coefficient between rice and wheat was higher (0.6826) than between rice and any other grain, followed by sorghum, corn and barley. Oats and rye are not grown in the tropics, and therefore their correlation coefficients with rice are small and statistically insignificant.

As expected, within the group of coarse grains, the correlation coefficients are high, indicating a closer

TABLE 11: ANALYSIS OF RESIDUALS OF RICE, WHEAT AND ALL COARSE GRAINS

	RESID 1 RICE	RESID 2 WHEAT	RESID 3 CORN	RESID 4 OATS	RESID 5 BARLEY	RESID 6 SORGHUM	RESID 7 RYE
Resid 1 Rice	1.0000 (0.0000)	0.6826 (0.0007)	0.5316 (0.0131)	0.3459 (0.1245)	0.461 (0.0324)	0.6157 (0.0030)	0.4036 (0.0696)
Resid 2 Wheat		1.0000 (0.0000)	0.8649 (0.0001)	0.6747 (0.0008)	0.7618 (0.0001)	0.8954 (0.0001)	0.6773 (0.0001)
Resid 3 Corn			1.0000 (0.0000)	0.7659 (0.0001)	0.7966 (0.0001)	0.9632 (0.0001)	0.7612 (0.0001)
Resid 4				1.0000 (0.0001)	0.7720 (0.0001)	0.7603 (0.0001)	0.9240 (0.0001)
Resid 5 Barley					1.0000 (0.0000)	0.8145 (0.0001)	0.6980 (0.0004)
Resid 6 Sorghum						1.0000 (0.0000)	0.7037 (0.0001)
Resid 7 Rye							1.0000 (0.0000)

Numbers indicate the correlation coefficients, and the number in parentheses indicates the Prob > $|R|$ under H_o: Rho = 0.

substitution within the group. The highest rho-value is between corn and sorghum (0.9632) and the second is between oats and rye (0.9240).

After establishing that wheat may be the closest substitute for rice, the question arises as to what degree the price of wheat alone could explain the price of rice. A regression of the price of rice on the price of wheat and time (see equation #8 in Table 12) indicates that wheat is statistically significant but time is insignificant. Adding the price of each individual grain as a regressor in a subsequent equation yielded no additional statistical significance. Even pooling the prices of all coarse grains in one index (weighted according to their annual world production) yielded an insignificant result (see equation 14 in Table 12) in explaining the price of rice. Finally, as indicated in equation 15, the addition of all individual prices of corn, barley, oats, rye, and sorghum+millet as explanatory variables, beside the price of wheat, proved to be statistically insignificant. The calculated F-value (1.26) was less than the tabulated value at the 5% level of significance, indicating that there is not enough evidence to reject the null hypotheses: $B_3=B_4=B_5=B_6=B_7=0$. The calculated F-value for equation 9-14 was also insignificant where the null hypothesis was $B_3=0$.

To recapitulate, results of the multiple regression analysis represented in equations 8-15 indicate that adding the prices of other grains (either individually as a subse-

Table 12: OLS REGRESSIONS OF RICE PRICES ON THE PRICE OF WHEAT AND ALL COARSE GRAINS, 1960-1980

EQ. #	DEPENDENT VARIABLE	INTERCEPT	EXPLANATORY VARIABLES			R^2
8-	log PWR_t	-11.971 (18.014)	0.878 log PW_t (0.138)		0.007 T (0.009)	0.884
9-	log PWR_t	-28.806 (21.295)	1.335 log PW_t (0.335)	-0.687 log PC_t (0.492)	0.0158 T (0.011)	0.895
10-	log PWR_t	-11.910 (18.419)	1.017 log PW_t (0.328)	-0.217 log PB_t (0.463)	0.007 T (0.010)	0.885
11-	log PWR_t	-12.227 (18.430)	0.992 log PW_t (0.287)	-0.134 log PRY_t (0.290)	0.007 T (0.010)	0.885
12-	log PWR_t	-16.298 (18.382)	1.123 log PW_t (0.266)	-0.336 log PO_t (0.312)	0.009 T (0.010)	0.891
13-	log PWR_t	-38.886 (31.571)	1.346 log PW_t (0.471)	-0.736 log PS_t (0.709)	0.021 T (0.017)	0.891
14-	log PWR_t	-26.659 (20.960)	1.340 log PW_t (0.415)	-0.765 log $PWCGR_t$ (0.587)	0.015 T (0.011)	0.894
15-	log PWR_t	-62.536 (44.694)	1.303 log PW_t (0.477)	-1.227 log PC_t (0.956)	0.787 log PB_t (0.715)	
			-1.606 log PO_t (0.780)	-0.057 log PS_t (1.429)		
			1.296 log PRY_t (0.681)	0.033 T (0.023)		0.921

Names and description of all variables are listed in Table 13 quent regressor, or all in one index, or all of them separately) provides no significant increase in explanatory power after the price of wheat is accounted for in determining the price of rice. These results mean that rice is probably more closely related to wheat than to the other grains, an important result which will be used in the model specification as illustrated in the following section.

While the analysis of the fluctuation in the price of rice in the international markets constitutes the basic goal of this study, other grains which are substitutes for rice could not be neglected. The substitutability of these grains for rice constitutes an important basic feature in the price structure of rice and should be considered in the formulation of the model.

Therefore three approaches will be used in this study:

approach 1: assuming that all grains are perfect substitutes;

approach 2: assuming that wheat and rice are perfect substitutes, so that they can be considered one composite commodity, but this composite commodity is not a substitute for any other grain;

approach 3: assuming that rice is not a substitute for any other grain.

Effectively, these three approaches amount to placing prior constraints on regressors in a full model, containing all the prices of grains. That is, a full model which have log prices of all other grains as regressors in the demand for rice or in the reduced form. In the structural form of the demand equation, approach one amounts to assuming that the "true" log prices of other grains are perfectly correlated and that the observed prices are imperfectly collinear only because of difference in the timing of harvests or similar measurement problems, so that forming a price index for all grains is a way of "averaging out" measurement errors in the prices of individual grains. The second approach amounts to assuming this same perfect correlation for rice and wheat only, and that the prices of feed grains do not affect the demand for food grains. The third approach amounts to assuming that the coefficients of all other prices are zero. With respect to the reduced form equation of the model, approach one assumes that the coefficients of log prices of other grains are all unitary. The second approach, assumes that of the log price of wheat is unitary and all others zero; the third approach assumes that all are zero.

These three different approaches will be pursued with the same structural form of the model, to see whether the chief results are robust with respect to these changes in specification. If they are, we may have greater confidence in the results obtained.

The Model

The model of this study consists of four structural equations and an identity. The basic framework of the model is shown in the following equations:

The supply equation:

$$PR_t = a_o + a_1 \; P_t + a_2 \; PF_t + a_3 \; T + E_{1t} \tag{16}$$

This equation formulates the supply of grains, PR_t as a function of its own price P_t, prices of input fertilizers Pf_t, a time trend T and random disturbances E_{1t}. The hypothesized signs are consistent with the traditional production theory, Supply is a positive function of the current price and is negatively related to the prices of fertilizers as factor inputs in the production of grains. The time trend serves as a proxy for changes in technology and the labor market. The effects of climate conditions on the production of grains are included in the error term and could not be accounted for, because of the diversity of countries covered in the analysis.

The demand equation:

$$D_t = b_o + b_1 \; P_t + b_2 \; Y_t + E_{2t} \tag{17}$$

Traditionally formulated equations link demand to income and price. The general specification for this study will not be different; demand is a linear function of relative prices, per capita income Y_t and a disturbance term E_{2t}. Total demand is hypothesized to be a negative function of the price and a positive function of per capita income.

The stock equation:

(18) $$S_t = c_o P_t + c_1 S_{t-1} + c_3 R_t + E_{3t}$$

The third equation of the model states that the amount of the current year's stock is a function of the current prices of grains. It also has the amount of stocks as a negative function of the current interest rate, and as a positive function of last year's stocks. To the extent that the distributed lags in the model are consistent with the formulation of expectations in relative price changes, some aspects of speculative inventory behavior may be captured.

The fertilizer equation:

(19) $$PF_t = d_o + d_1 \ NOIL_t + d_2 \ CU_t + E_{4t}$$

The fourth equation of the model relates the price of fertilizer to the price of oil through the proportion of nitrogen fertilizer consumption to total world fertilizer consumption of nitrogen, phosphate and potassium.* The variable $NOIL_t$ is the product of that ratio and the price of

*The relationship between the prices of oil and nitrogen fertilizers is explained in detail in chapter VIII.

crude oil in international markets in year t. The variable CU_t represents the industrial capacity utilization of anhydrous ammonia as a basic indicator of bottleneck in the nitrogen fertilizer industry. Both regressors are hypothesized to be postively correlated to the price of fertilizers.

<u>The identity equation</u>

(20) $$S_t = PR_t - D_t + S_{t-1}$$

The identity equation indicates that the amount of grain stocks this period is equal to the difference between the production of grains and demand for grains this period plus the amount of grain stocks of last period.

To recapitulate, the four basic structural equations and the identity equation of the model are shown in the following:

$$PR_t = a_o + a_1 \; P_t + a_2 \; PF_t + a_3 \; T + E_{1t}$$

$$D_t = b_o + b_1 \; P_t + b_2 \; Y_t + E_{2t}$$

$$S_t = c_o \; P_t + c_1 \; S_{t-1} + c_2 \; R_t + E_{3t}$$

$$Pf_t = d_o + d_1 \; NOIL_t + d_2 \; CU_t + E_{4t}$$

$$S_t = PR_t - D_t + S_{t-1}$$

By substitution, the four structural equations could be solved for the reduced form (the solution will not be imposed here, since it is long and complex) in which the price of grain is a function of the exogenous variables as indicated in the following:

$$P = f(NOIL, CU, Y, S\text{-}lag, R, T)$$

The basic assumptions of the model are as follows:

1- There exists only one international market for grains; the two types of international trade, namely the government to government trade and the private trade, are assumed to be a single economic activity.

2- Grains are assumed to be produced by millions of farmers and consumed by millions of people all over the world. Any country can enter the market as an exporter or importer without any discrimination in the international markets, and no single exporter or importer can affect the international markets. This means we assume a purely competitive market in the international trade of all grains.

3- Even though governments intervene in local and international markets of grains, no single government is large enough to have a substantial effect on the price. Governments (especially those of the developing and socialistic countries) tend to buy "perversely" intervening to buy when the price is high and sell locally at a subsidized price. Therefore, the estimated price elasticity coefficients will include the effect of governmental intervention and are not necessarily the same as they would be without such intervention. Through this action the elasticities are expected to be relatively low in absolute value.

4- Each grain is represented by a single price or an average of three as in the case of wheat) in the international market. These prices are quoted f.o.b., in U.S. dollars, net of transportation and other marketing costs.

CHAPTER VI

RESULTS OF THE ESTIMATED MODEL

Data and Methodology

In this chapter the results of estimation of the model formulated in Chapter V are presented. This is done for two sets of data: (1) an aggregation of the 25 major rice consuming and trading countries, and (2) the world. The results for the major countries warrant more confidence than those for the world because the data for them are more accurate. The full world estimates are provided simply for comparison, as a test of the robustness of the results. The 25 selected countries incorporate all major rice exporting countries and accounted for 76% of all exports in the 1972. These are Thailand, the United States, Burma, Pakistan, The Peoples Republic of China, Italy, Australia and Japan. There are 17 rice-importing countries that are divided into two groups. The first consists of six OPEC countries: Indonesia, Iran, Iraq, Saudi Arabia, Kuwait and Nigeria. The second consists of 11 non-OPEC countries: Hong Kong, Ivory Coast, Korea, Malaysia, Madagascar, The Philippines, Senegal, Singapore, Sri Lanka, Syria, and the Soviet Union. These countries accounted for 57% of all world imports of rice in the 1970s.

Data used for the estimation of the models are annual time series from 1960-1980 inclusive. The sources of these data are publications of the Foreign Agricultural Service of the United States Department of Agriculture, publications of the Food and Agricultural Organization of the United Nations, the International Financial Statistics of the International Monetary Fund, and other documents on rice and grains published by the U.S. Department of Agriculture. All data used for this analysis including annual production, demand and amounts of stocks of all 25 countries are presented in Appendix No. 1. The exact sources for all data are indicated at the bottom of each table.

A Laspeyres index was used to aggregate different kinds of grains by taking 1960 as a base year. Indices for the total supply, demand and amount of stocks were so generated for all grains, fine grains and coarse grains for the selected countries as well as for the world coarse grain model. A composite price index was also calculated for all grain prices, fine grain prices and coarse grain prices, according to their weight in total annual production.

The index number of per capita gross domestic product published in the Statistical Yearbook of the United Nations (64) has been used to indicate world per capita income YW_t.* An index number for per capita gross domestic product for the selected 25 countries was generated as follows. The

*This index excludes the People's Republic of China, the People's Republic of Korea and Viet Nam.

gross domestic product of each country was taken in its own currency units without converting it into U.S. dollars. It was then deflated by each country's consumer price index each year and divided by the total population of the country to obtain per capita income for that year.* A time series index of per capita gross domestic product from 1960 to 1980, taking 1970 as the base year was calculated for each country. Then the overall weighted per capita income index YS_t, for the 25 countries each year was calculated as follows:

$$YS_t = \sum_{i=o}^{n} \frac{n_{it} Y_{it}}{n_t}$$

Where

YS_t = aggregate per capita income for the 25 countries of the model in year t;

y_{it} = per capita income of the ith country in period t;

n_{it} = population of the ith country in period t;

n_t = summation of the 25 countries' population in year t.

Stocks data were quoted form Foreign Agriculture Circular (25, 26, 27) and represent the best available statistical estimates of foreign governments, reports of the United States Agricultural Attaches and Foreign Service Office

*This was done to avoid the effect of the United States dollar's depreciation and the appreciation, especially during the first part of the 1970s, which would unrealistically decrease or increase the per capita income of an individual country if local currencies were converted into dollars first and then an aggregate per capita income for the 25 countries were calculated.

and other Foreign service materials. Grain stocks data are not available for all countries, especially the People's Republic of China, the Soviet Union and other Eastern European countries. Therefore, world stock levels are adjusted for estimated year-to-year changes and do not pretend to include the entire absolute world stocks.

The price series on oil were quoted from the International Financial Statistics of the International Monetary Fund. Oil prices used here represented an average of three quoted prices in the International Markets: Saudi Arabia (Ras Tanura), Libya (Es Sidra) and Venezuela (Tia Juana).

The capacity utilization index of the anhydrous ammonia industry in United States, a basic indicator for the nitrogen fertilizer industry, was obtained from the Fertilizer Institute, Washington, D.C. (20). Statistical data on thid index started first in 1973. Therefore, the chemical capacity utilization index was used to complete the time series before that year.

Data on world consumption of nitrogen, phosphate and potassium fertilizers were taken from the Annual Fertilizer Review of the Food and Agriculture Organization of the United Nations (6).

All price series were deflated by the consumer price index of the United States and real prices only were used in the regression analysis.

A description of all variables used in the estimation of the models is lested in Table 13.

TABLE 13: DESCRIPTION OF THE VARIABLES OF THE MODELS

VARIABLES	DESCRIPTION
CU	Industrial capacity utilization of anhydrous ammonia in the U.S.
D	Total demand for a grain in million metric tons
DAGR	Demand for all grains in the selected countries indexed
DFGR	Demand for fine grains in the selected countries indexed
DSCGR	Demand for coarse grains in the selected countreis indexed
DWCGR	World demand for coarse grains indexed
DSW	Demand for wheat in the selected countries
DWR	World demand for rice
DSR	Demand for rice in the selected countries
NOIL	Proportion of nitrogen to total nitrogen, phosphate and potassium consumption of the world multiplied by the price of oil
PAGR	Price of all grains indexed in the Selected Countries
PSCGR	Price of coarse grains indexed in the Selected Countries
PFGR	Price of fine grains indexed in the Selected Countries
PWCGR	World price of coarse grains indexed
PWR	Price of rice, 5% brokens at Bangkok, Thailand f.o.b.
PW	Price of wheat, an average of three prices quoted in international market of U.S., Canada and Australia
PC	Price of corn, U.S. No. 3 yellow corn up to October 1972 and for corn No. 2 yellow afterwards, f.o.b. Gulf ports
PO	Price of oats, No 2 heavy white at Minneapolis
PB	Price of barley, No. 3 or better at Minneapolis

(continued)

TABLE 13 - continued

VARIABLES	DESCRIPTION
PS	Price of sorghum, No. 2 yellow at Kansas
PRY	Price of rye, No. 2 at Minneapolis
PF	Composite price index of a combination of nitrogen phosphate and potassium at their annual ratio of consumption worldwide
PFAGR	Price of fertilizer indexed in selected countries' all grain model
PFFGR	Price of fertilizer indexed in selected countries' fine grain model
PFSR	Price of fertilizer indexed in selected countries ' rice model
PFSW	Price of fertilizer indexed in selected countries' wheat model
PFSCGR	Price of fertilizer indexed in selected countries' coarse grain model
PFWR	Price of fertilizer indexed in world rice model
PFWCGR	Price of fertilizer indexed in world coarse grain model
PRAGR	Supply of all grains indexed in the selected countries
PRFGR	Supply of fine grains indexed in the selected countries
PRCGR	Supply of coarse grains indexed in the selected countries
PRWCGR	World supply of coarse grans indexed
PRWR	World supply of rice
PRSR	Supply of rice in the selected countries
PRSW	Supply of wheat in the selected countries
PR	Supply of a grain in million metric tons
R	Interest rate (Nominal)(6-months Treasury bill rate of the U.S.)

(continued)

TABLE 13 - continued

VARIABLES	DESCRIPTION
SAGR	Stocks of all grains indexed in the selected countries
SFGR	Stocks of fine grains indexed in the selected countries
SSCGR	Stocks of coarse grains indexed in the selected countries
SWCGR	World coarse grains stocks indexed
SSW	Stocks of wheat in the selected countries
SWR	World stocks of rice
SSR	Stocks of rice in the selected countries
T	Time trend variable, 1960 = 1
YS	Per capita income index for the selected countries
YW	World per capita income

Note: all the data are annual.

The basic model is a simultaneous one and is specified to be linear in terms of its coefficients. Some equations of the structural form of the model include endogenous variables on the right-hand side. Consequently, the three-stage least squares (3SLS) procedure was chosen to estimate the structural parameters in order to obtain consistent estimators (27, 40).

Results of the Structural-form Equations of all Models

The empirical results and implications of the estimates of the structural form equations of the models are discussed in this section. The main goal is to evaluate the underlying theoretical framework of the model as well as the implications of the results whenever possible.

The structural equations of each model were estimated in linear form with three stage least squares. The estimated models follow the three approaches discussed in chapter V. These models were supplemented to include wheat, the second component of the fine grain model, as well as a model for the group of coarse grains. In all seven model were estimated, as follows:

1- All grain model, in accordance with the first approach that assumes all grains to be perfect substitutes.

2- Fine grain model, representing the second approach that assumes that tice and wheat are perfect substitutes.

3- Rice model, representing the third approach that assumes rice to be not substitutable for other grains.

4- World rice model, supplementing the third approach to include all countries of the world.

5- Wheat model, supplementing the second approach with a closer look at wheat, the second component of the fine grain model.

6- Coarse grain model, estimating the validity of the model within the group of coarse grains.

7- World coarse grain model, supplementing the above by including all countries of the world.

Estimates of the structural equations, (classified in supply, demand, stock and fertilizer groups) of all models are listed in Table 14 for each equation. Discussion of the results obtained in the structural equations of all models in general, and more specifically inrice models, as well as the implications of these results will follow.

Among major determinants of grain supply are their prices, the price of fertilizers and a time trend. In every supply equation the estimated coefficient of the (composite) price was positive. In all grain and coarse grain models of the selected countries, these coefficients were significant at the 5% level. In the fine grains model and its two components, the rice and wheat models, as well as in the world coarse grain model the estimates of the coefficients were insignificant at the 5% level. Specifically the response to changes in the price of rice in international markets to changes of current supply is not as strong as the similar response in the all grain equation.

Table 14: STRUCTURAL-FORM ESTIMATES OF ALL MODELS
1960-1980

EQ #	DEPENDENT VARIABLE	EXPLANATORY VARIABLES, ESTIMATED COEFFICIENTS, AND STANDARD ERRORS			
	SUPPLY EQUATIONS				
21-	$PRAGR_t$	-6974.220 (747.034)	0.303 $PAGR_t$ (0.159)	-0.228 $PFAGR_t$ (0.114)	3.603 T (0.383)
22-	$PRFGR_t$	-7374.810 (659.929)	0.095 $PFGR_t$ (0.099)	-0.087 $PFFGR_t$ (0.112)	3.810 T (0.338)
23-	$PRSR_t$	-7256.240 (330.453)	0.005 PWR_t (0.028)	-0.040 $PFSR_t$ (0.049)	3.749 T (0.169)
24-	$PRSW_t$	-10001.000 (1835.853)	0.472 PW_t (0.401)	-0.318 $PFSW_t$ (0.285)	5.167 T (0.939)
25-	$PRCGR_t$	-5774.880 (1086.769)	0.805 $PSCGR_t$ (0.293)	-0.327 $PFCGR_t$ (0.110)	2.982 T (0.557)
26-	$PRWR_t$	-9602.00 (652.977)	0.056 PWR_t (0.048)	-0.062 $PFWR_t$ (0.077)	4.976 T (0.334)
27-	$PRWCGR_t$	-7015.96 (550.604)	0.104 $PWCGR_t$ (0.150)	-0.058 $PFWCGR_t$ (0.056)	3.627 T (0.282)
	FERTILIZER EQUATIONS				
28-	$PFAGR_t$	-515.485 (108.285)	0.034 $NOIL_t$ (0.019)		6.751 CU_t (1.287)

(continued)

TABLE 14:-continued

EQ. #	DEPENDENT VARIABLE	EXPLANATORY VARIABLES, ESTIMATED COEFFICIENTS, AND STANDARD ERRORS		
29-	$PFFGR_t$	-505.655 (108.880)	0.039 $NOIL_t$ (0.019)	6.621 CU_t (1.294)
30-	$PFSR_t$	-541.956 (108.474	0.033 $NOIL_t$ (0.019)	7.057 CU_t (1.289)
31-	$PFSW_t$	-512.927 (108.907)	0.037 $NOIL_t$ (0.019)	6.711 CU_t (1.294)
32-	$PFSCGR_t$	-535.195 (103.607)	0.035 $NOIL_t$ (0.018)	7.009 CU_t (1.228)
33-	$PFWR_t$	-533.101 (107.076)	0.034 $NOIL_t$ (0.019)	6.967 CU_t (1.271)
34-	$PFWCGR_t$	-431.622 (94.336)	0.047 $NOIL_t$ (0.015)	5.744 CU_t (1.112)
	DEMAND EQUATIONS			
35-	$DAGR_t$	91.464 (4.997)	-0.006 $PAGR_t$ (0.078)	0.387 YS_t (0.050)
36-	$DFGR_t$	91.378 (4.890)	0.012 $PFGR_t$ (0.051)	0.393 YS_t (0.050)
37-	DSR_t	84.607 (4.172)	0.031 PWR_t (0.028)	0.298 YS_t (0.042)
38-	DSW_t	115.800 (7.451)	-0.128 PW_t (0.129)	0.646 YS_t (0.080)

(continued)

TABLE 14:-continued

EQ. #	DEPENDENT VARIABLE	EXPLANATORY VARIABLES, ESTIMATED COEFFICIENTS, AND STANDARD ERRORS					
39-	$DSCGR_t$	91.355 (5.970)		-0.027 (0.148)	$PSCGR_t$	0.354 (0.055)	YS_t
40-	DWR_t	14.697 (8.201)		-0.006 (0.019)	PWR_t	1.434 (0.082)	YW_t
41-	$DWCGR_t$	1.342 (3.288)		-0.015 (0.037)	$PWCGR_t$	0.993 (0.036)	YW_t
	STOCK EQUATIONS						
42-	$SAGR_t$	0.162 (0.087)	$PAGR_t$	0.863 (0.074)	$SAGR_{t-1}$	-1.294 (1.378)	R_t
43-	$SFGR_t$	0.111 (0.082)	$PFGR_t$	0.878 (0.089)	$SFGR_{t-1}$	-0.682 (1.961)	R_t
44-	SSR_t	0.002 (0.005)	PWR_t	0.868 (0.115)	SSR_{t-1}	0.142 (0.225)	R_t
45-	SSW_t	0.079 (0.047)	PW_t	0.832 (0.084)	SSW_{t-1}	-0.430 (0.653)	R_t
46-	$SSCGR_t$	0.326 (0.121)	$PWCGR_t$	0.834 (0.077)	$SSCGR_{t-1}$	-2.423 (1.193)	R_t
47-	SWR_t	0.021 (0.008)	PWR_t	0.918 (0.128)	SWR_{t-1}	-0.455 (0.382)	R_t
48-	$SWCGR_t$	0.198 (0.091)	$PWCGR_t$	0.905 (0.055)	$SWCGR_{t-1}$	-1.379 (0.842)	R_t

Details on all variables of the table are listed in table 13, page 65

This is due probably to government interference in local markets which includes subsidies, taxes and various agricultural trade policies. Government actions affect the quantity supplied, the quantity demanded and the final price of a grain within the country. This keeps a distortion of price movements in international markets from being reflected in local markets (and vice versa) and leads to a market segmentation phenomenon which will be looked at in more detail in Chapter IX.

The price-of-fertilizer variable was negatively correlated with the supply of grains in all estimated equations, meaning that supply of grains increases when the price of input fertilizer decreases. The estimated values of the coefficients were statistically significant at the 5% level in all grain and coarse grain models of the selected countries, and insignificant in the fine grain model and its two components, rice and wheat. That is due probably to intensive government subsidy of the price of fertilizaers to local growers in the developing countries to encourage rice and wheat production and to achieve self-sufficiency within the country. Governments of many developing countries prefer to subsidize input fertilizers and imported grain. Through local subsidization of fertilizers, governments would be able to save more foreign exchange than if governments pursued a policy of subsidizing imported rice or wheat. For more detail see Chapter IX and Chapter VIII which provide quantitative examples.

The time trend variable, which serves as a proxy for changes in technology and the labor market, has, as expected a positive (and significant at the 1% level) estimated coefficient, implying a rightward shift of the supply curves for rice and for other grains over the time of this study. This result is expected and occurs due to the sue of new technology, new high yielding varieties of seed, insecticides, herbicides, irrigation and drainage systems as well as other changes in the cultivation of grains especially in the developing countries.

The fertilizer equations of all models indicate that the price of fertilizers is determine mainly by the price of oil, multiplied by the ratio of nitrogen to combined nitrogen, phosphate, and potassium in total world consumption, as well as by the industrial capacity utilization of anhydrous ammonia. Both variables have positive coefficients which are significant at the 1% or 5% level.

The fertilizer equation constitutes one of the highlights of this study. It shows a significantly positive link between the prices of nitrogen fertilizer and crude oil in the international market. Also the coefficient of capacity utilization variable is, as expected, positive and significant at the 1% level.

Though capacity is intended to be a proxy for world capacity utilization, the measure employed here is actually for the United States representing the industrial countries where major production of world fertilizer is located. For the developing countries, indices of capacity utilization have limited economic meaning, since the true constraints are often not the plant and equipment per se, but shortages of managerial skills, bottlenecks inpower supplies and transportation networks, insufficient organization of labor, and other factors which are not captured by published gauges of capacity.

In the demand equations, the estimated coefficients of prices were statistically significant only in the selected countries models for all grains, coarse grains and wheat. The estimated coefficients in the rice, world wheat, and coarse grains models were insignificant. The magnitudes of the coefficients were very small, especially in the rice models, indicating that the demand for rice is very inelastic. The low price elasticity of demand for rice obtained in the two models is due mainly to governmental intervention in local markets which succeeded in insulating domestic prices from international prices. More detail on market segmentation will be presented in chapter IX.

The variable income as a regressor in the demand equations for grains and rice was statistically significant at the 1% level and positively correlated in all equations. All demand equations indicate that increases in per capita income were asociated with increases in the consumption of grains and rice, suggesting that the income elasticity of demand for grains is, as expected, positive. While the estimated income elasticity of demand for grain in the world models appears to be high (0.997 in the coarse grain model and 0.935 in the world rice model), those of the selected countries models are very realistic. They vary from 0.286 in the rice model up to 0.434 in the wheat model. The relationship between income and grain and rice consumption is difficult to estimate in a country or a group of countries. Few estimates of the income elasticity of demand of food and specifically of rice are published in the literature. One of the most reliable sources is the study carried out by the Food and Agriculture Organization of the United Nations (1). This Study estimated the income elasticity of rice demand for Asian countries as 0.5 in Sri Lanka, 0.6 in urban India, 0.65 in rural India, 0.4 in Brazil, and 0.6 in Ecuador. Although the estimated coefficients of the income variables obtained in this dissertation are similar, it should be noted that the income variable used in this model is also a proxy for time, which could not be included as a separate regressor in the demand equation because of collinearity. The income variable was represented as per capita income. Since per capita income and population have increased over time the estimated coefficients do not represent income elasticities only, but include the impact of population growth and other changes correlated with time.

The stock equations indicate that changes in the current amount of stocks are sensitive to changes in the prices. The estimated coefficients of the current prices were positive and significant at the 1% or 5% levels except for the fine grain model for the selected countries and its components the rice and wheat models.

The stock equations indicate further a positive correlations between current and lagged stocks. This relationship was highly significant at the 1% level in all selected countries models as well as in the world models. A negative correlation between current stocks and the interest rate was also found in all models except rice model in Selected Countries. This correlation was statistically significant only in the coarse grain group where government intervention in local markets is probably the least.

The Reduced-Forms of the Models

The reduced forms of all models are presented in this section. The major implications of these equations for the price of grains and specifically for rice in the international market are also discussed. The reduced form equations were derived from the structural equations of the models and express the endogenous variable price as a linear function of predetermined variables and an error term after accounting for the interdependence among current endogenous variables. Thus, a given reduced-form coefficient indicates the total effect of a change in the corresponding predetermined variables on the price assuming that other predetermined variables are held constant. In contrast, a structural form coefficient indicates only a partial direct effect on the respective endogenous variable. The reduced form coefficients are quite useful for the out-of-sample prediction providing the structural parameters of the model are constant over the period of the study. As indicated in the section on world supply and demand for rice, no drastic changes occurred during the two decades 1960 to 1980 which precludes the use of the reduced form coefficient for their predictive implications. In fact, the out-of-sample prediction is one way of testing whether the structure of the model was the same over the entire period of the study.

The reduced form equations of all models, as in the case of the structual form equations, are in linear form. OLS estimation was used, yielding the results shown in Table 15. These results indicate that the most important variables affecting the international prices of rice, wheat and coarse grains are the price of fertilizers containing nitrogen, phosphate and potassium, the amount of stocks lagged, per capita income, the interest rate and a time trend. The price of fertilizers, as indicated in the fertilizer equations of the structural form of the models, is determined by the $NOIL_t$ and CU_t variables. Both of these variables are in the reduced form of the model and are, except in few cases, statistically significant. Rice and other grain prices are expected to be affected by higher price of fertilizers in two ways:

TABLE 15: REDUCED-FORM ESTIMATES OF ALL MODELS 1960-1980

Eq. #	DEPENDENT VARIABLE	INTERCEPT	EXPLANATORY VARIBLES $NOIL_t$	CU_t	S_{t-1}	YS_t YW_t	R_t	T	R^2
	SELECTED COUNTRIES' MODELS:								
49-	$PAGR_t$	1010.78 (4749.96)	0.018 (0.025)	4.899 (0.858)	-0.403 (0.223)	0.202 (0.299)	1.113 (1.616)	-0.681 (2.410)	0.957
50-	$PFGR_t$	-1977.69 (7321.95)	0.021 (0.051)	7.420 (1.653)	-0.481 (0.305)	0.159 (0.535)	3.339 (3.033)	0.747 (3.730)	0.927
51-	$PSCGR_t$	544.49 (1943.51)	0.016 (0.008)	2.784 (0.284)	-0.267 (0.095)	0.143 (0.101)	-1.237 (0.566)	-0.364 (0.718)	0.985
52-	PWR_t	-22602.90 (13387.50)	0.074 (0.092)	8.467 (3.245)	-12.243 (5.649)	-0.561 (0.842)	9.392 (5.619)	11.252 (6.895)	0.897
53-	PW_t	-766.29 (3825.40)	0.010 (0.022)	5.722 (0.632)	-0.274 (0.357)	0.128 (0.259)	0.077 (1.229)	0.177 (1.945)	0.969
	WORLD MODELS								
54-	PWR_t	-16614.83 (41884.69)	0.037 (0.057)	7.334 (3.316)	-8.608 (3.437)	-0.133 (5.728)	13.970 (7.313)	8.248 (21.657)	0.903
55-	$PWCGR_t$	-592.68 (4560.79)	0.023 (0.007)	2.846 (0.292)	-0.290 (0.115)	0.170 (0.594)	-1.543 (0.632)	0.211 (2.348)	0.985

Names and description of all variables are listed in table 13.

First: Increasing the price of factor inputs usually leads to an increase in the price of output.

Second: Since the increase in the price of fertilizer affected the prices of all other grain-substitutes for rice in the same direction, as indicated by their price movements, rice consumers could not shift to a cheaper substitute. The net result was a further increase in the price of rice, implying that the substitution effect is small, when allowance is made for changes in the prices of other grains. The importance of fertilizers to grain production as well as the relationship between the surge of oil prices following the October war of 1973 and the sruge in fertilizer prices will be discussed in more detail in Chapter VIII.

The variable stocks lagged one year was correlated negatively with the prices of grains. This correlation was significant in the two rice models, in the all grain model and in the two coarse grains models. The inverse relationship between prices and the amount of grain stocks illustrates the important effect of sticks on grains prices in local as well as in international markets. Many authors have indicated the importance of keeping stockpiles to stabilize the prices of grains. Among these authors are: W. R. Bailey, F. A. Kutish and A. S. Rojko (7), Bladford D.

and Seon Lee (8) B. P. Bosworth and R. Z. Lawrence (9), D. E. Hathaway (29), D. G. Johnson (36), D. Paarlberg (46), A. S. Rojko (54), W. Sc. Steele (60), and R. L. Walker and J. Sharples (67). Since stock holding is a frequently recommended policy for price stability, chapter X is devoted to this topic.

A positive relationship between per capita income and the price of grains is indicated in the reduced form equations of all models except the rice models. However, none of the estimated coefficient are statistically significant.

The estimated coefficients of the nominal interest rate are positive and statistically significant in the rice model for the selected countries and in world rice model. In the two Coarse grain models an inverse relationship is found. The estimated coefficients of the interest rate are positive or negative but insignificant in all other models. The controversial relationship of this variable may be due to changing relationships between nominal and real interest rates or to other causes. The last variable in the reduced form equations is the time trend. The estimated coefficients are positive and statistically significant only in the rice model for the selected countries. In all other models they are statistically insignificant.

CHAPTER VII

APPLICATION OF THE ESTIMATED MODELS

Out-of-Sample Prediction Models of the Price Estimation for the Years 1973, 1974 and 1975

The estimated models of chapter V are used in this section to predict out-of sample the sharp increase in the international prices of rice and other grains of 1973 and 1974 as well as the decrease in those prices that followed in 1975.

To achieve this goal, OLS regression analyses of the reduced forms of the models are run for the time series data from 1960 to 1972 and from 1976 to 1980, skipping data for the years of the out-of-sample prediction. The price for these three year are then predicted using the resulting estimated coefficients of the variables in the reduced models. The outcome of this experiment is shown in Table 16 for all models.

Coefficient estimates of all variables are generally similar to those presented in the previous chapter. The skipping of the data for 1973, 1974, and 1976 results in some changes, as expected, since each regression has three fewer degrees of freedom.

The R-square values remain high, ranging from 0.882 in the world rice model up to 0.988 in the all grain model of the selected countries.

TABLE 16: REDUCED-FORM ESTIMATES USED TO FORECAST THE 1973 and 1974 SURGE AND THE 1975 DECLINE IN THE INTERNATIONAL PRICES OF RICE, WHEAT AND COARSE GRAINS

EQ. #	DEPEN-DENT VARIABLE	E X P L A N A T O R Y V A R I B L E S INTERCEPT	$NOIL_t$	CU_t	S_{t-1}	YS_t YW_t	R_t	T	R^2
	SELECTED COUNTRIES MODELS:								
56-	$PAGR_t$	6179.242 (2263.062)	0.022 (0.012)	1.243 (0.627)	-0.372 (0.102)	0.603 (0.145)	0.309 (0.794)	-3.170 (1.143)	0.988
57-	$PSFGR_t$	8627.290 (3954.570)	0.026 (0.026)	0.297 (1.331)	-0.454 (0.149)	0.968 (0.286)	1.899 (1.644)	-4.376 (1.998)	0.974
58-	$PSCGR_t$	1349.571 (1862.991)	0.018 (0.008)	2.055 (0.423)	-0.251 (0.094)	0.210 (0.099)	-1.483 (0.567)	-0.745 (0.942)	0.985
59-	PWR_t	-3986.012 (9689.196)	0.092 (0.062)	-3.470 (3.201)	-11.004 (3.686)	0.803 (0.609)	5.477 (3.857)	2.237 (4.943)	0.939
60-	PW_t	3454.024 (2630.795)	0.016 (0.015)	2.946 (0.704)	-0.291 (0.228)	0.429 (0.180)	-0.479 (0.884)	-1.863 (1.331)	0.983
	WORLD MODELS								
61-	PWR_t	-19343.17 (64698.76)	0.093 (0.071)	2.758 (4.529)	-4.801 (7.017)	-0.999 (9.700)	7.409 (8.185)	9.917 (33.557)	0.882
62-	$PWCGR_t$	-7980.489 (8796.164)	0.024 (0.008)	2.324 (0.439)	-0.151 (0.151)	-0.765 (1.149)	-1.567 (0.671)	4.042 (4.544)	0.981

Names and descriptions of all variables are listed in Table 13

Out-of-Sample Prediction Performance of the models

This section tests how well the models track the unprecedented surge in the price of rice and other grains in 1973-74 and the sharp decrease which followed in 1975. This is achieved by getting measures of the performance of the reduced-form equations of the models; that is, of how well the out-of-sample forecasts conform with the observed annual data for international prices for rice and other grains.

The percentage deviation of the estimated price obtained using the reduced form equations from the actual price is calculated for each model for the three years 1973, 1974, and 1975. The percentage deviation from the observed value indicates the "goodness of fit" of the estimated models.

Predicted prices using the models, the actual prices in the international markets, and the deviations in percent are listed in Table 17. These results indicate that the reduced form equations of all models track the jump in the prices of grains in 1973 and 1974, as well as the sharp decrease which followed in 1975. The success of the models in tracking the price movements up and down suggests that the structure of this market was the same over the entire period of the study.

The out-of-sample predictions of the price of grains have the largest percentage deviation from the actual prices in 1973 and 1974, while the best predictions are for 1975.

TABLE 17: COMPARISON OF THE ESTIMATED PRICES PREDICTED BY THE MODELS FOR 1973, 1974, AND 1975, AND THE OBSERVED PRICES IN INTERNATIONAL MARKETS

YEAR	GRAIN	ESTIMATED PRICE	OBSERVED PRICE	DEVIATION %
Selected Countries' Models:				
1973	All	99.93	140.49	28.87
1974	All	129.48	200.96	35.57
1975	All	128.90	161.70	20.28
1973	Fine	128.31	202.88	36.76
1974	Fine	166.43	307.23	45.83
1975	Fine	164.03	225.96	27.41
1973	Coarse	76.44	86.73	11.86
1974	Coarse	99.88	111.30	10.26
1975	Coarse	99.32	105.81	6.13
1973	Rice	170.22	310.84	45.24
1974	Rice	244.14	488.75	50.05
1975	Rice	241.04	332.47	27.50
1973	Wheat	98.24	135.50	27.50
1974	Wheat	127.97	175.60	27.12
1975	Wheat	120.31	146.03	17.61
World Models				
1973	Rice	264.02	310.84	15.06
1974	Rice	323.62	488.75	33.78
1975	Rice	296.58	332.47	10.79
1973	Coarse	264.02	86.73	13.93
1974	Coarse	101.35	111.30	8.94
1975	Coarse	98.22	105.81	7.17

One exception to this pattern is the case of the world rice model. The out-of-sample prediction for the price of rice in 1973 is $264.02, off the actual observed value of $310.84 by only 15.06%. The equivalent deviation of the world rice model for 1975 prices is off by 10.79% and for 1974, 33.78%. In the rice model for the selected countries, the closest out-of-sample predicted value for the price is rice is off by 27.50% in 1975.

Equivalent deviations in the corase grain models are only 6.13% in 1975 for the selected countries model, and 7.17% in the world model. Based on the percentage deviation criterion the wheat model performs better than does the fine grain model, followed by fine grain and rice in the selected countries models. The predictions of the world models are much closer to the observed prices. The average percentage deviation of all seven models for 1973 is 25.60%, for 1974 30.22%, and for 1975 only 16.70%. No perfect tracking of the movements in the grain prices is expected in the out of sample forecast due mainly to two reasons:

<u>First</u>: The bad weather conditions that cause a shortfall in world grain production in 1972 left their mark on the prices of grains during 1973. This study, because of the diversity of the countries covered, has not attempted to include a weather variable in the model, so this effect is part of the error term.

<u>Second</u>: Currency speculation in 1973 and 1974 may have contributed to high grain prices. Following the announcement

of the United States of the suspension of dollar convertability into gold and the abandonment of the Bretton Woods agreement, the dominance of the dollar as the most important international reserve asset started to wane. Speculation against the dollar intensified, as holders of dollars and other assets attempted to reduce the weight of dollar-denominated assets in their portfolios. The active movement of private capital from one country to another caused sharp fluctuations in exchange rates. Holding currencies became risky and uncertain. To hedge against the uncertainty, and to avoid the unpredictability of the movement into flexible rates, investors shift toward holding commodities. Houthakker (32) and Johnson (36) attributed the boom in commodity prices that happened in 1972-75 partially to currency speculation. Cooper and Lawrence (14), however, indicated that movements in the exchange rates of 1973-74 had not so much a direct effect as a psychological one. Nevertheless it is interesting that Johnson (36) estimated that the effects of the overvaluation of the dollar in international monetary markets added up to 15% to grain prices. Taking these two considerations into account one can conclude that the out-of-sample success of the reduced-form equations in tracking the prices of grains in international markets to their peak in 1974 and then down in 1975, is good.

CHAPTER VIII

WORLD FERTILIZER SITUATION AND PRICE FLUCTUATIONS

The important role of fertilizers in influencing movements in international prices of rice and grains, as demonstrated in the model of this study, necessitates a brief discussion about the nature of fertilizers, their world consumption and price fluctuations in international markets.

Importance of Fertilizers

Agriculture development plans have been mainly directed toward large scale schemes such as irrigation, land reclamation, and settlement, as well as simple technical improvements such as row planting, improved tillage practices and others. These measures could not be very effective unless key inputs such as fertilizers, high yielding seed varieties and adequate plant protection against pests and diseases were employed. According to United Nations reports (49) the use of fertilizers alone by small scale farmers in Asia (especially Far Asia), in conjunction with farming methods, could increase crop yields by 50%. Mellor (42) investigated the contribution of different factor inputs to grain production in India during the period 1949 to 1973. He found that the contribution of fertilizers increased from about 11% in the 1950s to approximately 57% in the late

1960s and early 1970s. Parker and Christensen (47) presented data which indicated the importance of fertilizer expenditures as a percentage of total operating costs of farms in some elected developed countries. The data showed that, if purchased livestock feed (a minor cost in developing countries) is excluded, fertilizer accounted for from as low as 26% in France, 29% in Italy, 30% in Denmark, 38% in the Netherlands, 42% in Yugoslavia, 45% in Greece, and up to 49% in Spain. If the cost of the purchased livestock feed is included, fertilizer costs run down slightly to 24% in France, 30% in Japan, 42% in Greece, 40% in Yugoslavia and 48% in Spain. In the United States, according to Mullins et al. (45), fertilizer costs accounted for 28% to 32% of the total pre-harvest costs in most rice growing areas in1975. An extra 10% was added to that for the aerial application of fertilizers and pesticides.

Recently, Pinstrup - Anderson (48) estimated the increase in yields due to fertilizer to be from 36.4% in Africa to 69.9% in Latin America, with an overall average of 57% for the developing countries. The importance of fertilizers and the spectacular results that could be achieved by their application (compared to other factor inputs) led the Food and Agriculture Organization of the United Nations to call fertilizers the "spearhead" of agricultural development (62).

Fertilizers can be classified into two major groups, according to the elements that supply the plants:

First: Micro-elements are those which are needed in small amounts of a few pounds per acre, like iron, copper, zinc, boron, manganese, and cobalt.

Second: Macro-elements are those which are needed in large amounts of several hundred pounds per acre. These are nitrogen, phosphorous and potassium. They are known as the three major elements, and are the most important commercially for crop production.

Nitrogen fertilizers are the only fertilizers which can be synthetically produced. The process of ammonia synthesis, developed by Haber-bosch at the beginning of this century in Germany, benefited the nitrogen industry significantly. The chief result was to break the global monopoly status of Chile, which possesses the largest natural deposit of sodium nitrate used as nitrogen fertilizers.

The situation of the phosphate and potassium fertilizer industries still depends on existing known deposits in some countries. The world leading rock phosphate producers are the United States, the Soviet Union and Morocco. Morocco, however, is the leading exporter in the world markets. The largest exporter of potassium in the form of muriate of potash is Canada (44).

World Supply of and Demand for Fertilizers

World fertilizer production and consumption has increased rapidly over the past twenty years. Consumption of the three major fertilizers -- nitrogen, phosphate and potassium -- has increased more than four-fold from 28.5 million tons in 1960 to 116.1 million tons in 1980 (see Table 18). While consumption of both phosphate and potassium has increased by three times, consumption of nitrogen has increase by about six times. Nitrogen is considered to be the most important element in the fertilizer industry.

Because of expectations associated with the green revolution in the mid-1960s, the fertilizer industry anticipated a large demand for fertilizers. World fertilizer capacities increased by over 20 million tons from 1962-72, an average rate of 10.8% annually. Fertilizer demand in the last part of the 1960s was not as great as expected, however, because the free revolution did not spread widely or as rapidly as expected. Overcapacity and overproduction caused the price of nitrogenous fertilizer, urea, to drop from $95.75 per ton in 1965 to $46.00 in 1971. According to the USDA, Economic Research Report #98 (69), about 20% of the existing fertilizer industrial capacity was closed, especially the old, inefficient plants. The depressed conditions in the fertilizer market persisted until 1971 when the market showed signs of firming up (64). Low process and ample supplies of fertilizers in the U.S. and other developed countries facilitated a large increase in fertilizer aid shipments to developing countries. Nearly half of the fertilizer purchased by developing countries was financed on aid terms in the late 1960s (64).

TABLE 18: WORLD CONSUMPTION OF N, P_2O_5, and K_2O

IN 1000 METRIC TONS 1960-1980

YEAR	NITROGEN N	PHOSPHATE P_2O_5	POTASH K_2O	TOTAL $N+P_2O_5+K_2O$	%RATE OF CHANGE
1960	10,325	9,780	8,465	28,480	5.7
1961	10,910	10,225	8,585	29,720	4.4
1962	12,430	11,105	9,290	32,825	10.4
1963	13,980	12,225	10,100	36,305	10.6
1964	16,375	13,955	11,036	41,366	13.9
1965	18,828	14,948	12,284	46,060	11.3
1966	21,777	16,112	13,092	50,981	10.7
1967	23,942	16,957	14,074	54,973	7.8
1968	26,625	18,174	14,696	59,495	8.2
1969	28,691	18,818	15,469	62,978	5.9
1970	31,767	19,843	16,670	68,280	8.4
1971	33,348	21,098	17,625	72,071	5.6
1972	35,711	22,477	18,802	76,990	6.8
1973	38,697	32,157	20,733	83,587	8.6
1974	38,577	22,690	19,824	81,091	-3.0
1975	43,238	24,129	21,538	88,905	9.6
1976	46,384	26,389	22,951	96,174	8.2
1977	49,784	28,529	22,904	101,217	5.2
1978	53,749	30,626	24,457	108,832	7.5
1979	57,285	31,150	23,968	112,403	3.3
1980	60,336	31,489	24,264	116,089	3.3

Source: Annual Fertilizer Review, Food and Agriculture Organization of the United Nations, Rome 1981 (6)

Such shipments contributed significantly to the rapid adoption of the green revolution technology in Asia during 1967-71, and helped to increase production of grains and rice in that area. However, lower prices in international markets as well as the ready availability of fertilizers at even lower prices under aid agreements, have probably also contributed to some relaxation of the sense of urgency about the need to build new plants in developing countries. Besides, the already existing fertilizer plants in the developing countries were operating at a low measured capacity utilization of 50-60% (69), partly because of low demand and partly for the reasons already noted.

Demand for fertilizers began to grow relative to capacity in the late 1960s and early 1970s. But this change was not reflected in increasing world prices of fertilizers until 1972. For example, the price of bagged urea reached the bottom and was traded at $46.00 per ton in 1971; it increased to $59.25 in 1972, an increase of 29%. Likewise, the price of superphosphate increased from $43.00 per ton to $67.50 per ton in 1972, an increase of 57% in just one year. These increases in the prices of fertilizer as of 1972 affected grain prices unevenly.

During 1972, many random events contributed to an unexpected crisis in world grain production which was to last for several years. What occurred was a drop in world total grain production due to bad weather conditions to 2.7% below the 1971 level, and a depletion of grain stocks, which decreased the ratio of stocks to utilization to its lowest level since 1960. In addition, unexpectedly Russian grain purchases and sharp drops in oilseed and fishmeal production occurred in the same year. All these events increased world anxiety over food supplies, causing an expansion of crop area in North America and increased needs for fertilizers in developing countries. Demand for fertilizers began to overtake supply and fertilizer prices started to increase sharply. At the time, the fertilizer industry's capacity was too low for this high demand for fertilizers. To handle the unanticipated rise in demand, fertilizer manufacturers in developed countries used the available capacities to their maximum, and those of developing countries increased the operating capacities of existing plants. These actions were considered to be the only solution to cope with the fertilizer supply shortages, since increasing industrial capacities by building new plants requires two to three years (4, 70). Short supplies and high prices of fertilizers placed an added burden on efforts to increase food production in those developing countries where fertilizer is crucial, especially the relatively land-scarce countries of Asia and Southeast Asia, which constitute the major producing regions of rice.

In addition to the above-mentioned circumstances affecting the fertilizer industry, a new unanticipated event, the world oil crisis, was taking place. The relationship between oil and the fertilizer industry in a technical one and will be discussed in the following section.

Impact of the World Oil Crisis and the Prices of Fertilizers

Nitrogen fertilizers, the only fertilizers which can be synthetically produced, are mainly made from oil by-products. The basic intermediate material for their production is ammonia, which is a combination of a hydrogen source and the nitrogen in the air. Hydrogen sources are available practically all over the world, either because they are found locally as natural gas, or they are produced as a by-product from processing fuels like naptha, or refinery gases at refinery sites. During the 1950s and 1960s the oil refineries supplied required feedstocks, or raw materials needed for their manufacture, at relatively low prices, thus providing the petrochemical industries with tremendous savings from economies of scale. This contributed to a steady decline of nitrogen prices up to 1971, when oil prices started to increase steadily in international markets. The price of a barrel of oil (Saudi Arabia origin) was \$1.30 in 1970, increased to \$1.65 in 1971, \$1.90 in 1972, \$2.40 in 1973 and more than tripled its level in 1974 to \$9.76. The petrochemical plants found themselves obliged to compete with oil refineries which were producing gasoline.

The idea here is that the costs of chemical production are necessarily arbitrary, because chemicals are produced jointly in more or less fixed proportions during the oil refining process, while other chemicals have alternative uses as gasoline components. High prices of gasoline have encouraged oil refineries to produce more gasoline at the expense of the alternative production of feedstocks. As a result, feedstock prices increased and elevated the prices of chemical products, especially nitrogen fertilizers, through 1973 and 1974 (30). For example, the price of urea, an intensive nitrogen fertilizer which was traded at $95.75 per metric ton f.o.b. at any origin in Europe in 1965, decreased to $46.00 in 1971, but increase to $59.25 and $94.75 per metric ton in 1972 and 1973, respectively. In 1974 it reached the highest level ever at $313.75 per ton, or more than three times its price level of 1973 and more than five times the 1972 level.

The success of OPEC in increasing the price of crude oil encouraged other producers of exhaustible raw materials to follow a similar path. Thus Morocco, the leading exporter of the world (44), decided to increase the price of rock phosphate in early 1974 from $13.75 per ton in 1973 to $54.52 per ton. This was another surge in the price of raw materials in fertilizer manufacture (33). As a result, the price of superphosphate jumped from $100.00 per ton in 1973 to $308.00 in 1974.

The price of muriate of potash followed the trend and increased from $42.50 per ton (f.o.b. Vancouver, Canada) to $60.50 from 1973 to 1974.

TABLE 19: PRICES OF UREA, SUPERPHOSPHATE AND POTASH IN INTERNATIONAL MARKET IN DOLLARS PER METRIC TON

YEAR	UREA ANY ORIGIN EUROPE	SUPER PHOSPHATE U.S. GOLF PORTS	POTASH VANCOUVER
1960	93.26	40.00	28.50
1961	90.51	42.25	30.00
1962	94.13	94.75	30.00
1963	72.25	43.00	30.00
1964	90.50	43.00	32.50
1965	95.75	47.25	29.50
1966	89.25	47.25	27.50
1967	79.25	47.00	25.50
1968	65.50	37.50	24.00
1969	56.00	39.00	22.00
1970	48.25	42.50	31.50
1971	46.00	43.00	32.50
1972	59.25	67.50	33.50
1973	94.75	100.00	42.50
1974	315.75	308.00	60.50
1975	197.67	205.00	81.33
1976	111.67	91.50	55.50
1977	127.42	97.92	51.17
1978	144.80	98.04	56.38
1979	172.88	143.34	76.05
1980	236.78	178.04	115.71

Source: International Financial Statistics published by International Monetary Fund, Washington, D.C., 1981, (33) To recapitulate, rising prices of energy, chemical feedstocks and raw materials required for nitrogen and phosphate fertilizer manufacturing have raised the cost of their production. This situation was coupled with a very limited capability of the fertilizer industry to increase the existing production capacity in the short run. The result was the record high fertilizer prices of 1973, and especially, 1974. In affirming this analysis, the Economic Research Report of USDA (69, page 62) added "increased energy costs account for only a part of the tripled prices of fertilizer products. Compared with increased demand an limited capacity the effects of higher energy costs and higher plant construction costs are relatively minor." The FAO Assessment of the world food situation indicated the start of a fertilizer crisis in 1973. It added "A cyclical production shortfall has been characterizing the fertilizer market since the end of the 1971 and led to not only high prices but even physical shortages in 1973" (68, page 3). Also Don Paarlburg, former Director of the Agricultural Economics Division, USDA, described the situation as "Fertilizer Crunch" which according to him was building up since mid-1971, due to the over-capacity of the late 1960s that discouraged new investment in the fertilizer industry (46).

Decreases in World Consumption of Fertilizers

The tight world supply/demand situation in the chemical fertilizers industry in 1974 caused world consumption to decrease from 83.6 million tons in 1973 to 81.1 million tons in 1974, or about 3%. It was the first time world fertilizer consumption showed such a decrease (6). The decrease in the consumption rate was higher in phosphate and potassium fertilizers, amounting to 6.1% and 4.4%, respectively, than for nitrogen fertilizer, which decreased by only 0.3%. Shortages of fertilizers in 1973 and 1974 were easy to trace. Some of the developed countries reported marginal declines in fertilizer consumption. Among developing countries Bangladesh also decreased its consumption, and other countries did not increase their consumption as they had over the previous five years. For example, India increased its consumption only 3%, compared with an average of 13.5% since 1967. Thus, it could be concluded that limited supplies of fertilizers and the high prices were undoubtedly important factors in slowing projected food production goals in these countries in 1973 and in 1974 and had increased further the already existing pressure on grain prices in the international markets.

International fertilizer prices began to drop rapidly after January 1974. Consequently, consumption started rising again in 1975-76 to a new record level of about 89 million tons, or up by 9.6% in just one year. This was caused by significant increases in fertilizer consumption was back in line again during 1976-77. This was associated with lower international price of fertilizers and with better crop/fertilizer price relationships. In 1977, the recovery of demand fertilizers led to a strengthening of international prices of nitrogen, phosphate and, to a lesser degree, of potash.

Prices of all fertilizers continued to increase to the end of the decade. From 1977 to 1980 the price of superphosphate rose 82% and that of potash 126%. Increases in fertilizer prices this time may have resulted from a general increase in the cost of production caused by high interest rates, the escalation of investment costs and the doubling the oil prices during 1979-80. Consequently, the rate of increase of total consumption of fertilizers in the world declined to only 3.4% in 1979-80, compared to 7.5% the year before.

Government Intervention in Local Markets for Fertilizers

While international prices for fertilizers were highly fluctuating, price paid by local farmers in individual countries showed an even wider range of fluctuation. Fertilizer prices paid by local farmers in individual countries are influenced by many factors. These factors include local government agricultural policies and specifically fertilizer policy, local production of fertilizers or their importation, availability of foreign exchange, the official exchange rate, the actual shadow price of foreign exchange, the existence of control of grains prices within the country, the amount of grains produced locally, the amounts of grain imports needed to cover local consumption, and self-sufficiency policy in grain production. The involvement of government in local prices of fertilizers among others depends mainly on whether the country is a net exporter, or a partial or total importer of fertilizers.

Some countries control all production, importation and distribution of fertilizers; some interfere just by dictating guidelines in one or more segments of the fertilizer industry, either exports or imports. In socialistic countries and many of the developing countries fertilizers prices are state-determined. An agency is set to oversee imports and maintain a price equalization scheme that imposes a tax or pays a subsidy accordingly as foreign price fall short of or exceed price levels predetermined by governmental officials. These levels are related to prices for domestically produced fertilizers which in turn are set according to the cost of production.

The extent of government intervention on local markets and its effects on prices on input fertilizers will be quantitatively illustrated by cross-section data for 1974 (when price of fertilizers reached the peak in international markets), and a time series example for one country to show a trend in retail prices of major fertilizers over a period of time. As indicated above in 1974 the price of urea increased from $94.75 per metric ton to $315.75, or 233%. Data on farm prices collected in 1974 by the Food and Agricultural Organization of the United Nations recorded the following increases: 259.7% in Sri Lanka, 268.8% in Upper Volta and 318.4% in Guatemala. The price of superphosphate increase by 208% in the international market and reached a steep level of 379.9% in Upper Volta. On the other hand, where governments interfered by subsidizing, local prices were much lower than international markets. For example, in Bangladesh, the price of urea went up by only 42.8%m if superphosphate by 59.9% and the price of potash by 60%. In Chile the price of urea and superphosphate increased by 128.8% and 89.6%, respectively. In industrial countries, price increases were generally lower. Japan's price for urea rose by only 29.1%. In the Federal Republic of Germany, superphosphate rose by only 43.2%, in the U.S. potash rose by 25.5% and in Canada prices rose slightly by 18.3%.

While 1974 was marked generally by the unusually steep increases of fertilizer prices, there were several countries in which the 1973 price level was maintained. These countries were Ghana, Kuwait, Nepal, Niger, Togo, Czechoslovakia, Hungary and Poland (6).

Governmental agricultural policies can totally isolate local prices of fertilization from price movements in the international market. Table 20 shows the trend in farm gate price of four major fertilizers in Egypt from 1965 to 1976.

TABLE 20: RETAIL PRICES OF FERTILIZERS IN EGYPT
FARM-GATE PRICES IN EGYPTIAN POUNDS PER TON

YEAR	UREA 46%	SUPER PHOSPHATE 15%	AMMONIUM[1)] SULPHATE 20.5%	POTASSIUM[2)] SULPHATE 20.5%
1965	64.000	12.500	29.000	27.368
1966	64.000	12.500	29.000	27.368
1967	64.000	12.500	29.000	27.368
1968	64.000	12.500	29.000	27.368
1969	64.000	12.500	29.000	27.368
1970	64.000	12.500	29.000	27.368
1971	64.000	14.650	29.000	27.368
1972	64.000	15.650	29.000	27.368
1973	64.000	15.650	29.000	27.368
1974	64.000	15.895	29.000	27.368
1975	64.000	15.895	29.000	27.368
1976	64.000	15.895	29.000	27.368

These prices do not include the 5% discount to cooperatives.

Source: Choksi, A. Meeraus, and A. Stiutjesdijk, 1977 "A Planning Study of the Fertilizer Sector in Egypt" World Bank Staff Working Paper No. 269, Washington D.C., 1980 (12)

Notes:
1) Ammonium sulphate is close substitute for urea
2) Potassium sulphate is a close substitute for muriate of potash

All prices have remained constant except for that of superphosphate which has increased slightly reflecting quality improvements. Over the same period, however, world prices of urea, for example, declined from $95.75 per metric ton in 1965 to their lowest level of $46.00 in 1971, then began to rise very sharply to $315.75 in 1974 and fell back again to $111.67 in 1976.

CHAPTER IX

MARKET INTERVENTIONS AND THEIR EFFECTS ON GRAIN PRICES

The assumption that free market forces are dominant in the rice market and that the statistics on which the models are based reflect these forces fairly are simplifying assumption intended to ease the job of constructing the models and particularly to facilitate their use as a part of the system. Realistically, however, governments to a considerable extent interfere in local markets by differents means which include subsidies, taxes and various agricultural trade policies. Government actions have caused distortions or separation of price movements in international markets from being reflected in local domestic markets and led to segmentation of the international markets with the impact that higher prices of world markets are modified, dampened or totally nullified in domestic markets. Accordingly, the increase in prices of international markets has caused rice consumption in these countries to fluctuate within a narrow range or not at all. A closer look at demand data for grain and rice shows that total grains demanded in the world amounted to 1,202.6 million metric tons in 1972, and increased to 1,260.9 in 1973 despite an increase of 92% in the composite of price of grains from 1972 to 1973. In 1974, when prices peaked, the demand for total grains in the world decreased to 1,227.4 million metric tons, or by 2.6%, despite increases in the composite price of all grains by 174% from 1972 to 1974.

The situation in world demand for rice was even more astonishing. Demand for rice continued to steadily increase from 212.1 million tons in 1972 to 220.7 in 1973 and 228.9 million in 1974, despite a 243% increase in price from 1972 to 1974. Intervention in domestic farm prices of local markets is not a characteristic of developing and planned economies only, but of developed countries as well. Domestic farm prices of many developed countries are generally above the international price level. For example, in 1960, the Japanese price of rice amounted to $193 per ton, compared to $125 in the world market (28).

During 1968-71, the average price of $390 per ton, was nearly two and half times the world price of $165.75. In 1972 the domestic price was $400 per ton, about three times the international price and in 1973 was $636 per ton, still above and unprecedented level that the world prices reached in late 1973 and early 1974.

The European community countries evolved an import levy system that would raise import prices to the level existing in their countries, in order to curtail imports and to maintain a higher level of domestic prices. As world prices of grains surged in 1973 and 1974, the EC countries imposed export taxes and license requirements to restrict exports of grains. This policy was successful and resulted in grain-price stability within the community. Except for Italy, prices of grains in local currencies increased by only 10% between 1971 and 1974 (69).

Governments of centrally planned economies follow a policy of providing low priced bread for all consumers, subsidizing grains to keep consumer prices stable while at the same time attempting to increase local production. As a result, consumers and producers in these countries experienced little of the price impacts felt elsewhere around the world during the surge in grains prices of 1972-74. In developing countries, of policies depend on whether the country is a net exporter or importer of rice or other grains. The net effect of these policies is large, since they determine how much food is produced, how much is consumed and how much is exported or imported. The main objectives of these policies are to control and maintain low and stable prices for basic food items, which in most cases consist of a cereal. Policies differ from one country to another. Policies include price controls, procuring rice or grains from farmers at a price significantly below international markets, taxes, subsidies, etc. In pursuing these policies governments often serve special interest groups, rather than rely on economic analysis.

A regime is politically dependent on the support of particular groups. Accordingly, there exists a political market that differs from an open, competitive economic market (28, 56). In developing countries even though the rural population is larger, the political markets look usually to the satisfaction of the urban population at the expense of the rural. If the international price of staple food, like rice, increased by 50% the decrease in consumption associated with a free market would be politically unacceptable. To prevent prices from fluctuating, governments try to close the gap and bear the costs to keep consumption near the previous levels and to achieve a greater degree of price stability. The extent and the magnitude of these subsidies are often large. For example, budget subsidies to consumers during the 1972-74 grains price era rose to nearly one fourth of total governmental expenditures in countries like Egypt and Pakistan, and amounted to as much as 5% of the gross domestic product (10). In 1976, the consumer subsidy program in Egypt absorbed 30% of Government expenditure and accounted for 10% of Gross Domestic Product (12).

The magnitude of price distortion as a result of market segmentation in developing countries are further demonstrated by the following example. Using prices of the United States to reflect international market prices, as they did reasonably well according to D.G. Johnson (39), Table 21 indicates the wholesale price of rice in Calcutta, India and the U.S., in U.S. cents per kilogram, from 1970 to 1975.

From 1970 to 1972, the Calcutta wholesale price averaged about 74% of the U.S. price. But through subsidies during the high price period of 1973-74, the government

TABLE 21: WHOLESALE PRICES OF RICE, IN CALCUTTA, INDIA, AND THE UNITED STATES, IN U.S. CENTS PER KILOGRAM, 1970-1975

YEAR AND MONTH	CALCUTTA, INDIA	UNITED STATES	INDIA/U.S. PERCENT
1970	14.5	18.8	77.13
1971	14.5	19.2	75.52
1972	14.3	19.6	72.96
1973	14.1	53.2	26.50
1974	17.9	44.4	40.32
1974			
VI	18.5	55.1	33.58
VII	18.4	50.7	36.29
VIII	18.1	48.5	37.32
IX	17.9	43.7	40.96
X	17.9	41.7	42.93
XI	17.8	44.1	40.36
XIII	17.8	45.9	38.78
1975			
I	19.0	45.9	41.39
II	19.1	45.9	41.61
III	19.3	45.2	42.70
IV	19.0	45.2	42.04
V	18.5	41.9	44.15
VI	17.9	42.5	42.12
VII	17.5	43.0	40.70
VIII	17.1	41.6	41.10
IX	16.7	37.3	44.77
X	17.0	36.9	46.07
XI	16.6	37.5	44.27
XII	16.7	37.4	44.66

Source: Adapted from, "International Prices and Trade in Reducing the Distortions of Incentives," by D. G. Johnson (37, 57) held the price of rice in 1973 to only 26.5% of the U.S. price. In June 1974, the Calcutta price was only 33.58% of the U.S. price. During 1975, the former averaged about 43% of the latter.

In India as a whole, the price of rice in relation to world prices from 1961 to 1972 indicated that rice was seriously underpriced. Sukhatme (61), after adjusting these prices for the open market exchange rate for the Rupee, found that rice was undervalued by 50% or more except for 1963, when prices were undervalued by only 31%..

In Thailand, the Bangkok domestic prices of corn and rice have been approximately equal per ton, although in the open world market the price of rice tends to be more than twice that of corn (28).

Another form of governmental intervention in agriculture trade policies is provided in countries where rice exports are one of the few government sources of revenue and foreign exchange. Domestic prices are totally controlled and regulated by government, is such a way that prices received by farmers are below world prices. Among the lowest rice prices in the world are those received by farmers in Thailand, Burma and Egypt. Thailand and Burma regulate domestic prices by holding down the price their farmers receive for rice by export controls and export taxes. For example in Thailand, except for the periods 1971-73 and 1975, the rice premium has constituted 21 to 35% of the export price of rice and provided an important source of government revenue (28). The situation in Egypt is probably more severe, since governmental control extends to limiting the total acreage allowed for rice production. Since rice requires special provision of water on a four-day cycle, governments could manage to limit yearly acreage of rice production through water allocation to delineated areas. Rice and cotton are summer crops and grow in the same region. However, cotton is a cash and important export crop. Therefore cotton is considered to be a more important sources of foreign exchange in Egypt. If cotton prices are high in the international market, governments in order to maximize foreign exchange earnings expand the area allocation for cotton production at the expense of the area of rice production. If the international price of rice is high, government policy for the same reason will allow farmers to produce more rice.

Rice farmers are required to deliver a fixed proportion of their production to governmental cooperative stores. They are paid a fixed price of this quota or they are charged large fines for default. Any quantities over this amount could be sold either to the same cooperative stores. They are paid a fixed price for this quota or they are charged large fines for default. Any quantities over this amount could be sold either to the same cooperative stores at a marginally higher price or sold to private merchants at substantially higher prices. For example, in 1977, the delivery quota was equivalent to 32% of each farmer's crop with a 15% bonus for any quantity purchased over the quota. No governmental data were available for the price of rice sold in the free market to private merchants, but it was estimated that this amounted to 100% over governmental co-operative prices (2).

Government considerations in formulation agricultural policies,* especially in developing countries, are affected by two basic economic factors:

first: since consumers have low incomes, spend much of it on food and much of their food expenditures on cereals, the cost of basic cereals is therefore important to the welfare of consumers;

second: since food prices are an important part of the cost of labor, rises in the cost of food lead to demands to increase wages which can be disruptive to economic development plans.

While these policy goals are understandable with regard to consumers and wage workers in industry, their impact on the agricultural sector, the largest generally, is widespread and could affect the country's capacity for food production. As revealed above in the case of Egypt, which is probably not too different from many other countries, government policy has forced rice growers to finance the subsidy program and to contribute substantially higher pro-

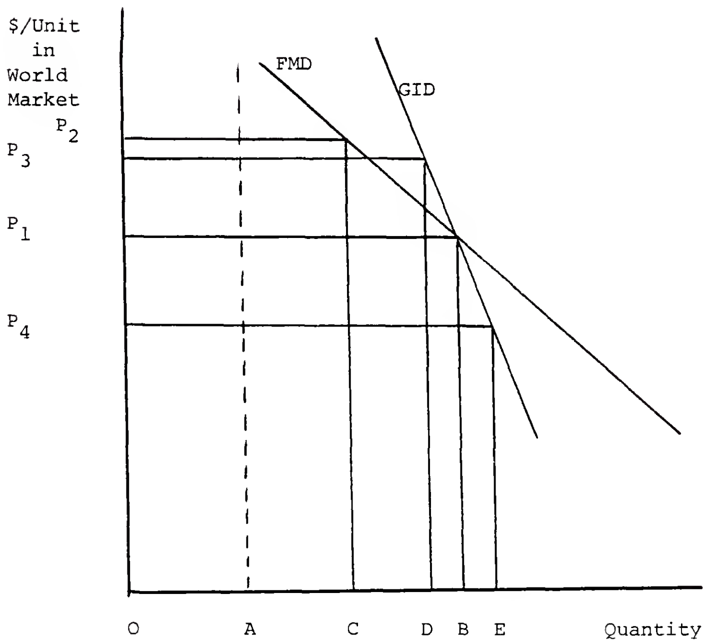
*For more details see also J.W. Mellor (43).

portions of their income to the treasury. The production policy rewards those who sell in the black market, promotes farmers' resentment and is inconsistent with the government's production targets. According to World Bank staff working paper No. 388, unless a radical restructuring of the system of intervention in Egypt occurs, the country might eventually become a rice importer (3).

The extent of the impact of government policies of food production capacity, consumption, exports, and imports needs to be evaluated on a country by country basis. Generally, however, government action in subsidizing higher prices imported rice or grains in local markets renders the price elasticity of demand lower in absolute value. This can be shown in Figure 1.

Under free trade, domestic production is OA. The country imports AB, and total domestic consumption is OB at the world price of P_1. Assuming that the price of rice has increased in he world market to P_2 imports will be reduced to AC and total consumption to OC. If the government intervenes by importing rice (or grains) at the high world prices and subsidizes the local market however, it will impose a new demand schedule, GID. At the new schedule GID, the government imports will amount to AD or AE, according to whether the subsidy is $OP_2 - OP_3$ or $OP_2 - OP_4$ respectively. In both cases the quantity demand at the world price P_2 is increased compared with the case of a free market.

FIGURE 1: Government Intervention's Effect of Subsidizing Higher prices Imported Rice in Local Markets



The new demand schedule GID is more inelastic than the free market demand (FMD) schedule. In the latter case, the quantity demanded will be smaller if world price increases and the consumer will have to pay the higher price for rice. In this case

$$|\eta^{*} Q, P_W| < |\eta\ Q,\ P_W|$$

where η^{*} is the elasticity of the optimal subsidy.

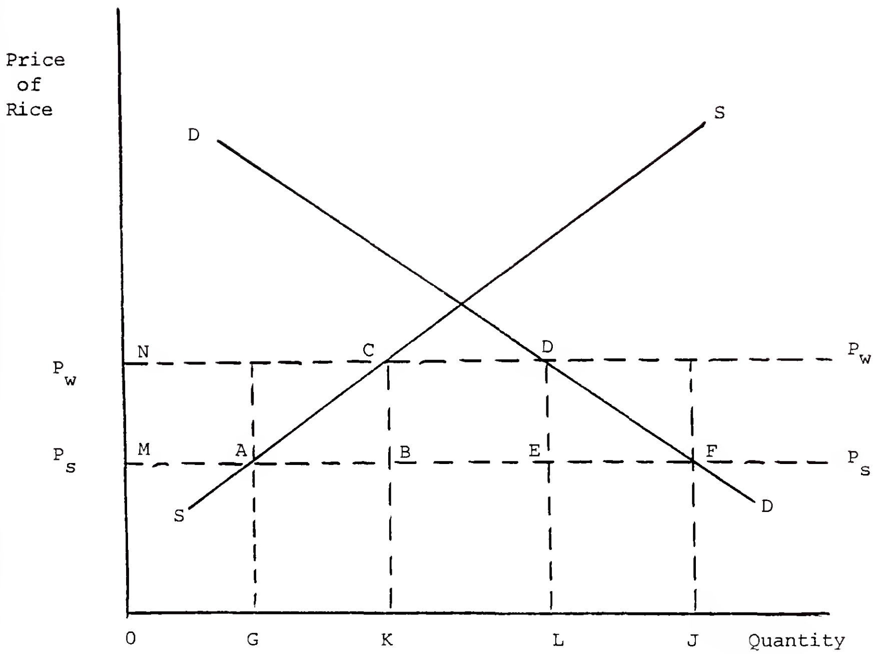
Now suppose α_i is the share in world imports of country i. Then the summation of all countries at the "optimal subsidy" level is

$$\sum_{i=0}^{n} \alpha_i\ \eta^{*} Q, P_W > \sum_{i=0}^{n} \alpha_i\ \eta\ Q, P_W$$

This represents the governments tendency to "perversely" intervene when the price is high in world market. If all governments' react the same, the world demand for imports will increase, escalating prices.

Government intervention in local markets by subsidizing imported rice can also be illustrated in the case of a small country by Figure 2. The domestic demand and supply curves are shown as DD and SS respectively. The line $P_W P_W$ represents the world supply of rice. In the case of free trade or no government intervention, domestic production is represented by OK, imports are KL and total consumption is OL. If government decided to subsidize the price of rice by the equivalent amount of OP_W - OP_S, however, domestic production will decrease to OG, imports will increase to GJ and total domestic consumption to OJ.

FIGURE 2: Subsidy of Imported Rice



Government action affects domestic producers, consumers and the welfare of the society. The increase in the amount imported constitutes a loss to domestic producers represented by MACN, the gain to consumers is MFDN and the new loss to society consist of the deadweight loss of producers and consumers' surplus equal to ABC plus DEG. Since a sharp fluctuation in staple food prices could seriously erode the welfare of a developing country, where people devote a large proportion of their income for food consumption, government actions to alleviate the effects of price fluctuations on its citizens could be justifiable. If foreign exchange funds are limited, however, a country will have little choice but to reallocate some funds from its planned economic development projected for that year.

Two obvious ways of decreasing imports and increasing the independence of a country from international market price fluctuations are to provide incentives for local production and to keep stockpiles in the country itself. These will be discussed in more detail in the next chapter.

While the purpose of this chapter is to illustrate the extent and consequences of government intervention in the local market, it is not intended to analyze the welfare effects of that intervention in a given country. It seems worthwhile to point out that any planned solution to food shortage problems which relies on the help of government agencies would result in a considerable waste of government funds unless this intervention is based on the grounds of equity.

Whether government subsidies for grain consumption and/or production are a positive or a negative argument in the utility function of a particular country depends upon the values of the society. All economics is concerned with choice. Since choice necessitates an objective intervention fashioned to deal with a particular situation cannot always be applied in other countries. What is best for one country may be inappropriate for another. Accordingly, it is appropriate to conclude this chapter with a few words about what seems to be relevant procedure for the selection of policy. The tools of cost-benefit analysis appear to provide the proper perspective. In a given situation, the policy maker should consider the problem and imagine the application of each of the alternative approaches to it. The principle of selection is simple, though not the practice. Each measure of policy (including that of doing nothing) will have costs and benefits associated with it. The policymaker should select that measure for implementation which produces the greatest net benefits for the country.

CHAPTER X

STOCKS AND PRICE STABILITY OF GRAINS IN INTERNATIONAL MARKETS

The inverse relationship between the amount of stock available and the price of rice or grains proved to be statistically significant. Thus, it seems evident that the amount of stock plays an important role in the structure and stability of grain price in international markets. Keeping enough stocks to stabilize prices has been suggested by many authors (7, 8, 29, 36, 37, 46, 54, 60), but none of those cited has provided a quantitative approach in a simultaneous equation model which includes variables such as supply, demand, prices, and income, as in this study. While the objective of keeping stocks on a world wide basis seems logical, it is not simple to attain. A number of complex issues, like total size of stocks, payments of costs, and operating rules, have to be solved on regional or international levels. In this chapter, these issues will be discussed briefly.

Historical Trends of Holding Stocks

Traditionally, stockpiles were held in grain exporting countries. Over the years these countries have constructed storage facilities and have developed a system to handle all aspects of large shipments. These operations have been carried out either by governments or the private sector which includes farmers, grain traders, processors and rice milling houses.

The initial motivation in carrying over large amounts of stock in grain producing countries was, in general, the result of governmental policies. Under the International Wheat Agreements of 1947, world grain prices were under government control. Participating governments were obliged to buy up grain surpluses to make sure that prices would not exceed the ceiling parity. Agricultural policies in both the United States and Canada, the principle world exporters of grains, were consistent with the overall goals of the agreement in stabilizing grain prices. Both governments conducted a policy of buying up grains from farmers a prices above the cost of production in order to slow down the movement of population off farms (9). While these surpluses were a burden on taxpayers, the domestic price-support program and acreage production control in the United States provided a large amount of grain stocks which permitted relative stability in world grain prices. However, after the breakdown of the Wheat Agreement in 1968, government efforts were concentrated on reducing the stocks in their storages. In order to reduce the costs of price support and stock programs, the policy maker sought to move American food supply from high price supports and towards a market economy (11). Also farmers felt that keeping a large amount of grain stocks would influence the markets and possibly depress prices (63). As a direct outcome of these policies in the United States and in other grain producing nations, world stocks of wheat decreased by 35% between 1968-69 and 1970-71 (see Table 9).

The inelastic demand and supply characteristic of grains indicate that grain markets are inherently more sensitive to supply and demand changes than many other markets. The availability of grain stocks in the 1960s resulted in relative price stability and permitted the importing countries to augment their domestic supplies in time of serious shortfalls by relying on the exporting countries. Besides, the Russian grain production policies were fluctuating seriously from one year to another, contributing to more instability. For example, "the deviation of Russian production from the trend has ranged from a surplus of 24 million tons in 1967 to a shortfall of 82 million in 1980." For the rest of the world, the "range of variation was from a positive 37 million tons in 1964 to a negative 51 million" in 1975 (9). According to the same reference, except for a few years in the late 1960s, the Soviet Union has not used grain stocks as a policy variable to meet current demand in case of production shortfalls. They carried out a policy of reducing consumption during years of low crop yields or relied on grain purchases from world markets in time of local shortages. All these factors added a sense of abundance of food and a sense of disincentives to food production in many developing countries, thus relied on food imports. This trend can be seen in the increasing share of developed countries in world grain exports. The developed countries exported 61% of the world's total grain exports in 1956-60 and 83% in 1972. The proportion from developing countries decreased from 22.8% to 11.3% during the same period and that of the centrally planned countries from 16% to only 6% (69).

The point to emphasize here is that despite the reliance of many developing countries on grain imports and the sporadic purchases of the Soviet Union, a large degree of world price stability was achieved during the 1960s and early 1970s. Stocks had succeeded in stabilizing grain prices following crop shortfalls that occurred in 1965 to 1967, but failed to do so in 1972. That failure probably involved changes in policies of grain exporting countries to reduce their grain stocks. Grain stocks were slowly liquidated starting in 1968. No country in the world, except India (65), made an effort to increase stocks to offset this decline in world stocks. The ratio of stocks total utilization of world grain was steadily declining and reached its lowest level in 1974 (see Table 9). The steady decline in the amount of stocks caused a steady increase in the world prices of all grains as it reached a peak and caused the crisis of 1974, as mentioned before. Bosworth and Lawrence (9, page 106) indicated that the crisis was a direct outcome of mistaken government policies that allowed the reserve grain stocks to fall to critical levels. They further indicated that price effects on world markets were then greatly magnified by the insulating policies of many countries, which discouraged any efforts toward conservation by their own consumers.

Grain stocks started to increase after the 1977 Farm Act passed and the United States government returned to subsidizing price supports, surplus storage and acrage control programs (26). However, in 1979 and 1980 stocks decreased and contributed again to the increases in the grain prices of 1979 and 1980.

Total Size and Estimated Costs of Holding Stocks

World grain stocks needed to cover most of the contingencies in the world were estimated by the Economic Research Service of the USDA. Assuming perfect substitution between all grains including rice, 56 million tons of grains are needed to cover 95% of the world production shortfalls from the trend for any single year. This level of stocks constitutes the amount needed over and above the working stock levels. By assuming no substitution between grains, world stocks requirements were estimated at 80 million metric tons. These amounts of stocks are based on a protection level of 95% (a guarantee of 19 out of 20 years). If the level of protection is decreased to 68%, however, the amounts will accordingly decrease between 25 million and 40 million tons of grain depending on the degree of substitution assumed.

As mentioned previously, the largest deviation in world grain production (especially wheat) from the trend was in the Soviet Union. If the Russians would hold enough wheat stocks to cover their own contingencies, the rest of the world would need about 30% less reserves than estimated above (69).

Total cost of holding stocks is a function of how long stocks are held, the quantities held, storage and interest rate charges, wastages and losses during the storage period as a result of rodents, insects, etc., as well as other maintenance and management costs. While costs of acquiring the grains could be recovered when grains are released or sold, other costs still have to be covered. Statistical data on the costs of holding grains are not easy to find for many countries.

Generally, the costs are likely to be very much higher in humid and tropical areas than in temperate zones. In the United States, the costs of the annual interest rate and storage charges were estimated to amount to $10 per ton before 1972. Following the increase in the grain prices and interest rates, costs increased to $15-20 in December 1974 (70). At present the estimated costs will likely fall in the range of $25 per metric ton annually. Accordingly, the total cost to the world of holding reserve stocks to meet 95% of the world's shortfalls in grain production will amount to approximately $1.4 to 2.0 billion a year.

Who Would Hold Stocks?

Stocks could be held by either the private or public sectors or both. The private sector operates in a quite different way in order to maximize their profits. Therefore, they repeatedly have to adjust their stock-holding positions to their calculated expectations to keep the balance between the total costs and expected profits. Stock accumulation by the private sector usually starts at harvesting time and is disposed of before the next harvest. Stocks holding against crop failures for longer periods seem to be beyond the capacity of the private sector. Such holding require large capital inputs over several years. Theoretically, however, the private sector could do the job. But prices are expected to rise in a speculative manner if crop failure occurs, and this would lead to undesirable price instability, precisely the problem addressed here.

The alternative is to rely on government supported agencies to hold stocks. Thus the question arises of who would hold them. Traditionally grain exporting countries or the importing countries, where shortfalls are more likely to take place, hold stocks. Most importing countries have no storage capacities and presumably no administrative or organizational capability to handle stocks. According to the International Food Policy Research Institute's report No. 2 (51, page 31), any attempt by developing countries to be completely self-sufficient in terms of stocks is costly and would use their scarce resources needed for other economic development plans.

No doubt grain exporting countries could establish new storage capacities to be financed by their taxpayers. But this would not constitute the best guarantee for importing countries that if a serious need arose, exporting countries would not behave like the private sector in asking for higher prices and thus contributing to the instability of grain prices in the international markets. A combination of both ways suggests that stocks would be held in one country but owned by another, as long as there is assurance that stocks would be available to the owning country on its demand. But, who could prevent a hungry mob from taking grain in storage in a country suffering from a famine?

A World Food Conference was held in November, 1974 to deal with the deterioration of the world food situation (33, 64, 66, 68). During that meeting, the Food and Agricultural Organization of the United Nations proposed an International Stocks Agreement based on a system of nationally held stocks with an exchange of information and international consultation. In this proposal both exporting and importing countries would share the responsibility of maintaining reserves. Through frequent communication and exchange of information both could achieve better prediction of the short run movement trends in the supply and demand of grains. Thus, a better information system could help to deal more effectively with problems as they develop and also contribute to a reduction in factor uncertainty in world markets, which would lead to a reduction of the amounts of stocks worldwide.

While this suggestion has been discussed for some time in international forums, it has not yet achieved global agreement. The International Food Policy Research Institute (51), made various proposals which would reduce the cost of holding stocks by pooling aggregate risks at the world level. These proposals were based on the assumption that some degree of independence exists in production fluctuations in different countries. Therefore, the larger the area that pools its risk together, the smaller the average proportional deviation, and the smaller the amount of stocks relative to consumption required. Three solutions have been proposed:

1- stock may be held internationally or in cooperation with exporting and importing countries.

2- insurance programs may be established to guarantee minimum levels of supplies and stable prices to needy countries in times of crop failure, and

3- international financial arrangements may be established to provide balance of payments assistance to countries in case of crisis.

While the first proposal is complicated to implement, as previously discussed, the second is promising and was studied in some detail by Konandreas _et al_. (41). The third proposal will certainly enable grain importing countries, especially those with limited foreign exchange funds, to purchase needed grain in time of serious shortfall, without putting stress on their balance of payments. During the period of high grain prices in 1973-74, countries with limited amounts of foreign exchange funds were obliged to convert funds from some other project, or even cancel some economic development projects, to save and arrange enough funds to purchase grains. That situation was very detrimental to their overall economic development progress.

The Long Run Solution

Carryover stocks represent a solution of price stability in the short run. In the long run, grain importing countries should pursue a domestic agricultural strategy to meet an increased demand for food by increasing food production in their own countries, which would minimize both imports and/or stocks carryover. Agricultural policies in the long run should aim towards raising the productivity of the agricultural sector through improved technology and/or expansion of the areas under crop production. These policies should be especially aimed at the small farmer and landless agricultural workers.

The desirability of providing low grain prices to consumers and the need to maintain incentive prices for producers combine to form a difficult dilemma. The effect of these policies, practiced mainly in developing and socialistic countries, was a dampening of farmers' incentives to produce food grain, thus making it necessary for some countries to import grains. These countries should share the responsibility of dealing directly with their domestic problems, by maintaining incentive prices for grain production.

On this aspect, D.G. Johnson wrote, "Prices do matter. Farmers, like the rest of us, respond to economic incentives" (38 , page 213). In another article he also wrote, "with national agricultural policies as they are in countries that consume one-half of the world's grain, the cost of achieving a substantial degree of price stability in international markets will be large" (38, page 828). World grain production can be changed if governments see the need for change and are willing to modify their local agricultural policies. According to G.T. Brown (10), higher prices could stimulate agricultural production by:

1- causing the producers to move closer to their production possibility frontier by better use of resources,

2- encouraging the use of more labor and other variable resource inputs to reach higher output levels,

3- attracting investment and the discovery and adoption of new agricultural technologies which would contribute or lead to lower cost production functions.

Ezner *et al*. (18) indicated that food conditions will worsen for many poor developing countries unless they readjust their policies to increase domestic production. Grain imports of the developing countries in 1985 are projected to increase much faster than imports in the rest of the world (5).

In conclusion one could say that the stock equation of the model of this study recommends an important policy instrument which would minimize price fluctuation and lead to stability in world rice and grain prices. In practice, however, the achievement of worldwide workable buffer stocks seems difficult to realize. Economic analyses are required to compare the costs and benefits of these approaches with other alternatives to determine national food policies of individual countries. As briefly discussed above, the issues involved are numerous; however, the role of stocks constitutes one of the most critical issues now facing world communities in order to avoid another surge in international grain prices similar to 1973-74.

CHAPTER XI

SUMMARY AND CONCLUSIONS

This chapter includes a brief review of major points addressed in this study, concluding remarks associated with its goals and objectives, and suggestions with respect to improving future studies.

Summary

The purpose of this study was to analyze the movement in the international price of rice during the 1970s, with a view to explaining the unprecedented price increase of 1973 and 1974, which was followed by a decrease during 1975.

A structural model of the world grain market was specified which puts together equations for the supply of grain, the demand for grain, the price of fertilizer, and the stocks of grains. While explaining movements in the price of rice constituted the goal of this study, all major grains were considered in the formulation of the model. The performances of three variants of the model were presented. The first aggregates the supply and demand of all grains and assumes perfect substitution among them. The second aggregates wheat and rice, and the third looks at rice alone without considering substitutes. Following these approaches, seven models were tested for 25 selected countries and extended to include a world model for rice and a world model for coarse grains. These models attempt to capture the movements in the international prices of grains as transmitted from the local markets of the individual countries. The methodology used in the formulation of the model is simple and robust. A basic foundation for the structural equations and a reduced form derived from them is the assumption of free competition in the international market. No single government is large enough to have a substantial effect on the price of any grain. Grain prices are endogenously determined and are expressed in the reduced form in terms of only predetermined variables and an error. Empirical results obtained in this study are discussed in the following section.

Major Conclusions

All seven models performed well, not only tracking grain prices up in 1973 and 1974, but also following them down in 1975. The models estimated from data exclusively from other years explained the volatility of grain prices of the early 1970s. The model succeeded in predicting well the actual values of the endogenous variable - the international prices of rice, wheat, and coarse grain. While perfect out-of-sample tracking of the prices was not expected, the average percentage deviation of all seven models amounted to only 16.70% in 1975.

Results of the reduced form equation of each model indicate that the most important variable affecting the international prices of rice, wheat and coarse grains is the price of fertilizer containing nitrogen, phosphate, and potassium. The fertilizer equations of all models indicated that the price of fertilizers is determined by the price of oil, multipled by the ratio of nitrogen to total world consumption of nitrogen, phosphate, and potassium and by the industrial capacity utilization ratio of the anhydrous ammonia industry. Both variables have positive coefficients which are significant at the 1% or 5% level. Ammonia is chosen because of its crucial place in the manufacture of nitrogenous fertilizers. It is the principal form in which fixed nitrogen is available, and therefore it is the basis for almost all nitrogenous fertilizers--ammonium sulfate, nitric acid, urea, ammonium sulfate, calcium nitrate, and ammoniating materials containing nitrogen as a nutrient.

Ammonia, the basic intermediate material for their production, is produced from a hydrogen source and the nitrogen in the air. Hydrogen sources are readily available either because they are found locally as natural gas, or they are produced as a by-product from processing fuels like naphtha, or refinery gases. During the 1950s and 1960s the oil refineries supplied the feedstocks, or raw materials needed for their manufacture, at relatively low prices, thus providing the petrochemical industries with tremendous savings. This contributed to a steady decline of nitrogen fertilizer prices up to 1971, when oil prices started to increase in international markets. The price of a barrel of crude oil (Saudi Arabian origin) increased from $1.30 in 1970, to $9.76 in 1974. As a result feedstock prices increased and elevated the prices of chemicals, especially nitrogen fertilizer. For example, the price of urea, an intensive nitrogen fertilizer which was traded at $46.00 per metric ton f.o.b. at any origin in Europe 1971, increased to $94.75 in 1973 and reached the highest level ever at $315.75 per ton in 1974. That price is more than three times the level of 1973 and about seven times the 1971 level.

The success of OPEC in increasing the price of crude oil encouraged producers of exhaustible raw materials to follow a similar path. Thus Morocco, the leading exporter of rock phosphate (raw material for phosphate fertilizer) in the world decided to increase its price from $13.75 per metric ton in 1973 to $54.42 in early 1974. As a result, the price of superphosphate jumped from $100.00 per ton in 1973 to $308.00 in 1974. The price of muriate of potash followed this trend and increased from $42.50 per ton to $60.50 from 1973 to 1974.

Rising prices of energy, chemical feedstocks, and raw material required for nitrogen and phosphate fertilizer manufacturing raised the cost of their production. Parallel to this situation, a "fertilizer crunch" had been building up in the industry since 1971 with its roots expanded from events of the late 1960s. Because of expectations associated with the green revolution in the mid-1960s, the fertilizer industry had anticipated a large growth in demand. World fertilizer capacities increased rapidly, but demand did not grow as expected because the green revolution did not spread as foreseen. Overcapacity and overproduction caused prices to fall, and about 20% of the existing capacity was closed. The depressed conditions in the fertilizer market persisted into the new decade. It was not until 1971 that the market showed signs of firming up. At the end of this year a cyclical production shortfall has been characterizing the fertilizer market and led not only to high prices but even physical shortages in 1973. This situation was coupled with very limited capability of the fertilizer industry to increase existing production capacity in the short run. The result was the record high fertilizer prices of 1973 and 1974.

The positive link between the price of fertilizers and the price of grains in the international markets provides a strong policy implication in the medium or long term. Developing countries endowed with raw material for nitrogen phosphate fertilizers can establish the basis for significant expansion in production capacity. Increasing the capacity utilization of existing plants will augment world fertilizer production. The availability of fertilizers of suitable prices will improve the prospective of exploiting the agricultural potentials of many developing countries and increase their grain production. The fact that total cost per unit of crop decreases as yields increase from the use of fertilizer is a tremendously important economic consideration. It could be used in the cost-benefit analysis when countries have to decide whether to import food grain or subsidize imported fertilizers in local market. Decision makers, especially where foreign exchange constraints exist, could make large savings and invest them in other sectors of the economy.

Another factors affecting the price of grain is the amount of stocks available. This study shows an inverse relationship between the amount of stocks and the price of grains. Therefore, stocks, if they were managed properly, could maintain price stability or at least decrease fluctuations in the price of grains. The existence of more adequate national stocks would itself be a contribution. An international agreement on grains stockholding should be considered by major importers and exporters of grains.

While the objective of keeping stocks on a worldwide basis seems logical, it is not simple to attain. A number of complex issues, like the total size of stocks, payments of costs, operating rules, etc., have to be solved at regional and international levels to make stockholding workable. The issues involved are numerous. However, stocks are considered an important policy instrument to avoid another surge in international grain prices like 1973-74.

The variable income as a determining factor for demand for rice or grains is positive and statistically significant at the 1% level in all models. All demand equations of the seven models indicate that increases in per capita income were associated with increases in the consumption of grains and rice--i.e., a positive income elasticity of demand for grains. The estimated income elasticities of demand for grains in the selected countries models fluctuate between 0.286 in the rice model up to 0.434 in the wheat model and are similar to those published in the literature. One should note that the income variable used in these models is also a proxy for time, which could not be included as a separate regressor in the demand equation because of collinearity. Besides, the income variable represents per capita income and does not reflect the effect of population growth on demand. That effect is incorporated into the coefficient of the income variable. That is, the estimated coefficients do not represent income elasticities only, but include the impact of population growth and other changes correlated with time.

Government policies keep the price movements in international markets from being reflected in local domestic markets. Such policies lead to segmentation of the international markets with the impact that higher prices in the international markets are modified, dampened or totally nullified in domestic markets. Accordingly, the increase in prices in international markets caused consumption in some countries to fluctuate within a narrow range or not at all. Such behavior was reflected in the regression analysis of the model. The estimated price elasticities of demand in the structural equations were very small in absolute value. These estimated elasticities do not reflecting the actual degree of substitution, especially in developing and socialistic countries, where governments subsidize food prices. For example, during 1973 and 1974 total rice consumption in the 25 countries of the model increased by 5.3% and 5.6% respectively. Interference in the local market did not allow the dynamic forces of the price mechanism to play its normal role in adjusting supply and demand.

Price instability is considered to be a major inhibitor to the expansion of grain production. Producers prefer to have a relatively stable price while consumers want low prices. But the different policies by which governments seek to realize these goals often insulate the domestic grain markets from the international markets. By placing a certain value on the price of grain in the local market, governments often cause distortions in the cost-price relationship and put it artificially in imbalance. Farmers divert their production efforts from grain to more profitable crops. Government policies should concentrate on providing incentives for the private sector to spur more local grain production. Its role of intervention should rest on a perception of equity, especially in poor nations.

The estimated coefficients of the nominal interest rate are statistically insignificant except in the rice models. No general conclusion can be reached regarding the importance of the nominal interest rate to the prices of grains in international markets.

The last variable in the reduced form equations is the time trend. The estimated coefficients are positive and statistically significant only in the rice model for the selected countries.

In summary one may state that the model takes into account the various factors affecting the international price of rice, wheat, and coarse grains. It provides for some insights into the stabilization of the world prices to prevent unusually large price fluctuation. These insights include keeping adequate stockpiles, increasing the industrial capacity of fertilizer production, improving the capacity utilization of existing plants, and increasing local grain production in developing countries as well as in the Soviet Union in order to ease the pressure on international markets.

Suggestion for future studies

The model could be expanded in future studies to include more variables. A possibility is to distinguish between demand for grains for human consumption and for and livestock. The lack of statistical data might constitute a difficulty especially in developing countries, but it is possible to obtain data for some countries like the United States and Western European countries.

More effort is required to develop the capacity utilization measure prior to 1973 which would add more strength to the model. A closer study of world industrial capacity of fertilizer production as well as capacity utilization in the developing and the developed countries is needed. Perhaps the capacity utilization variable should be endogenously specified.

The out-of-sample success of the reduced-form equation in tracking the price of grains in international markets to their peak in 1974 and then down in 1975 was good. The incorporation of a variable that could account for the currency speculation of 1973-1974 might improve and lead to more perfect price tracking especially for 1973 and 1974. The inclusion of such a variable could possibly enhance the out-of-sample predictions of the model and is suggested in future studies.

Finally, the results obtained by this model are attributed basically to market fundamentals and are explained by the traditional theory of supply and demand. But the possibility that the grain markets were pushed into a "price bubble" in the sense of Flood and Garber (21) during the 1973-75 period is not ruled out. This issue could be clarified using a rational expectations model.

APPENDIX

STATISTICAL DATA ON SUPPLY, QUANTITY DEMANDED, STOCKS AND RICE IMPORTS OF THE SELECTED COUNTRIES

TABLE 22: MILLED RICE PRODUCTION IN THE SELECTED COUNTRIES IN 1000 MT (1960-1980)

YEAR	6 OPEC	NON-OPEC	MAJOR EXPORTERS	TOTAL	WORLD TOTAL	PERCENT OF TOTAL
1960	10,960	7,607	75,371	93,928	158,650	59.21
1961	10,259	8,435	78,426	97,120	162,887	59.62
1962	11,149	8,288	81,152	100,589	164,992	60.97
1963	10,035	9,070	83,384	102,389	172,651	59.30
1964	10,605	9,462	90,256	110,323	184,155	59.91
1965	11,281	8,992	89,660	109,993	173,414	63.39
1966	11,828	9,755	95,011	115,594	179,341	65.01
1967	11,595	10,080	102,117	123,792	193,793	63.88
1968	12,934	9,963	97,521	120,418	195,072	61.73
1969	13,400	11,510	100,416	125,326	203,412	61.61
1970	14,286	11,737	106,522	132,545	211,006	62.82
1971	14,917	11,704	109,848	132,469	214,939	63.49
1972	14,333	11,212	105,807	131,352	206,665	63.56
1973	15,721	12,367	113,008	141,096	222,610	63.38
1974	16,388	13,311	120,187	148,887	227,195	65.97
1975	16,418	13,443	121,875	151,736	242,843	62.48
1976	17,212	14,241	121,579	153,032	236,067	64.83
1977	17,141	15,590	122,762	155,493	250,155	62.16
1978	19,040	15,119	131,191	165,350	259,812	63.64
1979	19,443	16,073	131,500	167,015	248,578	67.91
1980	21,153	14,429	127,490	173,072	263,999	65.56

Source: Compiled from Foreign Agriculture Circular FG-38-80 U.S.D.A. Foreign Agricultural Service, Washington, D.C., December 1980, (23)

TABLE 23: DEMAND FOR MILLED RICE IN THE SELECTED COUNTRIES IN 1000 MT (1960-1980)

YEAR	6-OPEC	NON-OPEC	MAJOR EX-PORTERS	TOTAL	WORLD TOTAL	PERCENT OF TOTAL
1960	12,095	9,382	70,778	92,255	157,944	58.41
1961	11,240	10,240	74,436	96,196	163,459	58.85
1962	12,324	10,124	76,343	98,791	164,138	60.19
1963	11,322	11,108	78,066	100,496	172,244	58.35
1964	11,731	11,779	85,468	108,978	183,936	59.25
1965	11,738	11,423	85,122	108,283	173,414	62.44
1966	12,230	12,124	89,866	114,220	180,764	63.19
1967	12,145	12,002	92,513	116,660	190,091	61.37
1968	13,288	12,564	89,857	115,709	191,665	60.37
1969	14,373	13,368	93,228	120,969	200,645	60.29
1970	15,219	14,370	101,115	130,704	211,008	61.94
1971	15,762	14,132	106,312	136,206	217,482	62.63
1972	15,731	14,041	101,199	130,971	210,568	62.19
1973	17,453	14,675	105,713	137,851	220,814	62.43
1974	18,254	14,554	112,660	145,564	228,638	63.67
1975	18,877	15,615	112,669	147,263	223,851	62.97
1976	19,355	15,883	113,833	149,185	235,516	63.34
1977	20,784	17,208	113,279	151,397	245,657	61.63
1978	21,768	18,146	120,739	160,798	253,417	63.45
1979	23,398	18,363	122,985	164,921	251,900	65.47
1980	23,619	18,516	121,933	164,268	258,955	63.43

Source: Compiled from Foreign Agriculture Circular FG-38-80 U.S.D.A. Foreign Agricultural Service, Washington D.C., December 1980 (23)

TABLE 24: STOCKS OF MILLED RICE IN THE SELECTED COUNTRIES IN 1000 MT (1960-1980)

YEAR	6-OPEC	NON-OPEC	MAJOR EX-PORTERS	TOTAL	WORLD TOTAL	PERCENT OF TOTAL
1960	850	860	2,968	4,678	8.7	53.78
1961	818	689	2,839	4,346	7.8	55.72
1962	801	815	2,247	3,863	7.7	50.17
1963	829	694	2,170	3,693	9.4	39.29
1964	863	873	2,246	3,982	12.5	31.86
1965	902	1,211	2,403	4,516	12.8	35.28
1966	850	1,197	2,730	4,777	11.4	41.90
1967	981	1,206	3,194	5,381	14.5	37.11
1968	931	1,163	5,386	7,480	17.7	42.26
1969	1,371	828	8,117	10,316	19.6	52.63
1970	1,184	1,259	9,755	12,198	19.1	63.86
1971	1,535	1,704	8,491	11,730	16.3	71.96
1972	1,581	1,948	5,485	9,014	10.9	82.70
1973	1,277	1,354	2,964	5,595	12.9	43.37
1974	1,836	1,164	3,689	6,689	11.3	59.19
1975	1,846	2,200	4,243	8,289	18.9	43.86
1976	837	1,999	6,325	9,161	17.6	52.05
1977	1,226	2,540	6,068	9,834	23.8	42.94
1978	934	3,256	7,918	12,108	28.2	42.94
1979	1,775	2,757	9,483	14,015	23.6	59.39
1980	1,529	3,075	8.745	13,349	26.3	50.76

Source: Compiled from Foreign Agriculture Circular FG-38-80, U.S.D.A. Foreign Agricultural Service, Washington D.C., December 1980 (23)

TABLE 25: RICE IMPORTS OF THE NON-OPEC SELECTED COUNTRIES IN 100 MT (1960-1980)

YEAR	SRI LANKA	SOUTH KOREA	MALAY-SIA	SING-APORE	HONG KONG	PHILIP-PINES	IVORY COAST	SENE-GAL	MADAGA-SCAR	SYRIA	USSR	TOTAL
1960	528	-	380	335	364	9	34	110	-	28	20	1,808
1961	469	-	341	335	394	9	34	118	-	26	228	2,078
1962	411	-	317	350	427	31	43	101	2	35	194	1,911
1963	403	117	399	440	412	256	26	184	5	21	363	2,626
1964	658	-	414	270	410	300	51	179	78	35	238	2,633
1965	642	-	305	291	270	570	78	159	13	29	275	2,732
1966	693	32	253	262	367	108	83	153	-	32	397	2,390
1967	355	139	291	256	421	290	24	185	-	26	260	2,257
1968	370	267	247	288	314	-	47	146	43	39	327	2,068
1969	309	631	245	237	347	-	56	119	20	30	323	2,317
1970	543	720	306	281	332	437	79	188	61	40	332	3,319
1971	339	1,007	164	277	355	375	97	200	49	49	280	3,192
1972	266	624	128	358	457	482	88	170	71	56	154	2,854
1973	340	337	185	235	426	311	148	192	99	51	153	2,477
1974	330	165	334	163	315	157	73	207	65	88	194	2,291
1975	450	483	146	143	344	135	2	102	100	72	279	2,256
1976	425	177	210	226	362	55	5	236	100	83	460	2,339
1977	543	61	300	200	341	26	148	229	100	73	414	2,435
1977	543	61	300	200	341	26	148	229	100	73	414	2,435
1978	187	-	415	150	345	-	142	228	136	86	631	2,320
1979	212	355	240	175	341	-	230	261	175	96	500	2,585
1980	260	1,000	273	186	360	-	250	300	150	110	500	3,389

Source: Compiled from Foreign Agriculture Circular FG-38-80, U.S.D.A. Foreign Agricultural Service, Washington, D.C., December 1980 (23)

TABLE 26: RICE IMPORTS OF THE SIX OPEC SELECTED COUNTRIES IN 1000 MT (1960-1980)

YEAR	INDONESIA	IRAN	IRAQ	SAUDI ARABIA	KUWAIT	NIGERIA	TOTAL	WORLD IMPORTS	PERCENTAGE OF WORLD IMPORT
1960	891	19	70	104	18	1	1,103	5,459	19.88
1961	1,064	7	69	85	18	1	1,244	6,323	19.39
1962	1,025	3	14	142	18	1	1,203	5,971	19.85
1963	1,043	41	95	120	20	2	1,301	7,485	17.38
1964	1,010	29	1	99	25	1	1,165	7,968	14.30
1965	203	10	-	141	50	1	405	7,416	4.79
1966	308	24	11	142	47	1	533	7,165	6.78
1967	354	2	-	125	19	1	501	6,362	7.58
1968	628	1	-	124	42	1	796	6,857	10.99
1969	604	1	2	151	27	1	786	6,744	11.25
1970	956	60	97	151	38	2	1,304	7,949	15.93
1971	503	92	33	203	55	5	891	7,956	10.51
1972	748	145	16	125	54	6	1,094	7,171	14.50
1973	1,660	268	210	131	16	6	2,291	8.282	27.59
1974	1,070	367	218	137	75	8	1,875	8,008	23.69
1975	673	276	198	220	41	42	1,450	7,417	20.37
1976	1,293	578	237	257	64	103	2,532	8,288	31.16
1977	1,989	2,300	290	255	84	413	3,351	9,434	35.97
1978	1,845	371	300	404	85	564	3,569	10,326	35.14
1979	1,953	500	350	496	90	320	3,709	11,031	34.39
1980	1,000	500	375	475	100	400	3,850	12,360	31.15

Source: Compiled from Foreign Agriculture Circular FG 38-80, U.S.D.A. Foreign Agricultural Service, Washington, D.C., December 1980 (23)

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