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# Factors Affecting Grains Prices, 1970-84

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SUMMARY

Grain prices went through a boom-to-bust cycle from the early 1970s to the mid-1980s. This period was also one of dramatic change in the structure and pattern of agricultural trade. What were the factors which caused these changes? This is an especially important and topical question. With agricultural protection the subject of negotiations under the Uruguay Round of the GATT, correct interpretations of recent major events in these markets are vital.

This paper uses an econometric simulation model of the world grain markets to quantify the contribution of various economic and policy development to price movements during the 1970-84 period. The results show that the fertilizer price increases of 1972-74 and 1978-81 was the key factor causing grain prices to increase during this time. Fertilizer price changes accounted for nearly one-third of the movements in grain prices. The second most important factor was the two agricultural policy shocks--the large increase in USSR wheat imports in 1972 and the US Government's payment-in-kind (PIK) program of 1983. These two events accounted for approximately 25% of the movement in grain prices during 1970-84. The third most important contributor to grain price movements was the differential growth rates of income over the period. Incomes grew faster during 1973-80 than over the 1980-84 period, causing grain prices to rise in the earlier period and fall in the latter period. This pattern of income growth accounted for approximately 9% of wheat and rice price movements and 17% of maize price movements. The final factor considered was exchange rate movements, measured as the difference between actual nominal exchange rates for each country during the period compared to

constant 1971 levels. The simulation results show that exchange rates accounted for between 2.5% and 6% of the price movements, depending upon the grain.

The paper concludes by considering the prospects for future grain price movements in light of this perspective of the historical price movements. The short-term prospects do not suggest much chance that prices will rise significantly. However, the longer-term price prospects include a significant chance of substantially higher prices. The likely causes of such a price increase include: (i) sharply higher fertilizer prices due to inadequate investment in the industry in recent years; (ii) a government policy-induced grain shortage such as occurred in the early 1970s; or (iii) a substantial increase in developing country imports due to the maturing of the Green Revolution.

## I. INTRODUCTION\*

1. The structure and patterns of international grain trade have changed greatly in the past 10-15 years and this has been accompanied by large variations in prices. The changes began with the very large increase in prices during the 1973-74 period. This increase was seen, by some, as a manifestation of the growing inability of the world's resources to keep up with the increases in population. Lester Brown, for example, expected a period of chronic scarcity and rising food prices because he believed that population and income growth had begun to exceed the food production capacity of the world (Brown and Eckholm, 1974). This view was widely shared by the popular press. Others viewed the situation as transitory. Paarlberg expressed this view:

"...for the next decade or so the probability is good that (world) food production, in total, will keep a half step ahead of population growth, but that there will be times and places of critical shortages..."

(Paarlberg 1974)

After more than a decade it is now evident that Paarlberg was nearly prophetic in his view. But perhaps he did not fully expect the boom-to-bust cycle which followed.

2. The purpose of this paper is to quantify the importance of the various factors influencing grains price movements during the 1970s and 1980s, and by doing this to better understand the current situation. This is done by means of simulation exercises using the World Bank's global econometric model of the grains markets. The paper concludes with the outlook for the grain market from the perspective of the events of the past 15 years.

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\* Acknowledgement with gratitude is extended to Moshe Buchinsky for assistance in the model simulations and for his acting as a sounding board for the ideas developed here. Gratitude is also expressed to Ronald Duncan for his review and comments on the paper.

## II. FUNDAMENTAL CHANGES IN THE GRAINS MARKETS DURING THE 1970S

3. World grain prices have reached the lowest levels in real terms in at least 50 years. By 1986 the real prices of wheat, maize and rice had declined 21%, 26% and 50% respectively, relative to the highs reached in 1981 (World Bank, 1986 (b)). World stocks of grain are estimated to be about 24% of utilization, the highest level since before 1960 (USDA, 1987). The share of world stocks held by the United States was estimated to have reached 56% at the end of the 1986/87 crop year. Grain trade levels have declined 12% from their record highs in. In response to these events, key changes were made to the agricultural policy of the world's largest grain exporter--the United States--as manifested in the Food Security Act of 1985 (see Glaser, 1986 for a description of this Act).

4. The new US legislation included measures to reduce US government support levels for wheat and coarse grains prices and curtail US crop production. The intent of the legislation was to restructure US agriculture to accommodate the reduced export levels. This policy was in contrast to that of the 1970s when production was subsidized to meet the rapidly-growing export market. To understand how the markets have changed so dramatically since the 1970s and to gain a perspective on the current situation, it is helpful to review the events of the last 15 years.

5. Prior to the early 1970s, the level of grain trade was fairly small and trade was largely from industrial countries such as the United States, Canada, and Australia to other industrial countries such as the EEC and Japan. Demand from developing countries was mainly from countries such as India and Pakistan and their import needs were met through food aid. For many of these countries, this was the only source of imports since they lacked the incomes to purchase grain at commercial rates. On balance, the USSR and Eastern Europe

were small net importers of grain during the 1960s. The USSR exported grain to Eastern Europe during most of the period, but the levels of trade were relatively low.

6. In 1970 the industrial countries took 53% of the world's grain imports, the centrally planned economies of Eastern Europe imported 10% and the developing countries (including China) imported 37%. By 1984, the share of world grain imports of the industrial countries had declined by more than one-half, from 53% to 26%, while the shares of the centrally planned economies and developing countries had risen from 10% to 26% and from 37% to 48% respectively (based on USDA data).

7. The shift in imports away from the industrial countries was accompanied by a substantial increase in trade volume. Between the periods 1965-70 and 1975-80, the average volume of world grain trade increased by 76% while production grew only 32%. In 1960 world grain trade was 8.4% of production and by 1980 it had grown to 15.2% of production. For the United States, grain exports grew from 21% of production during the 1965-70 period to 35% during the 1975-80 period. As the volume of exports grew, so did the importance of the export market to exporting countries.

8. The number of countries which were important grain traders also increased. In 1984, the five largest grain importers accounted for only 42% of the world total; the 10 largest accounted for 59% and the 20 largest accounted for 76%. Among grain exporters, market share is much more concentrated. The five largest grain-exporting countries accounted for 80% of world exports in 1984.

9. Exports of grain have been supplied primarily by the industrial countries and their share has increased during the last two decades. In 1960, the industrial countries exported 72% of the world's grain trade. The centrally planned economies of Eastern Europe exported 11% and the developing

countries (including China) supplied 16% of world grain exports. Industrial country exports peaked at 86% in 1979 and have averaged 82% since 1980. The centrally planned economies' share of world exports has averaged only 2% since 1980 and the developing countries' share has averaged 16%.

10. Several fundamental economic and policy changes underlay the dramatic changes in grain trade in the 1970s. The most important of these was probably the sharp increase in crude oil prices of OPEC which began a large redistribution of wealth. Oil-exporting countries, including a number of non-OPEC countries such as Mexico and the USSR, became substantially wealthier. This increased wealth provided the wherewithal to change their consumption patterns and to increase their grain imports. Countries which were previously insignificant participants in the grain markets became major importers. These countries include China, the USSR, Mexico, Indonesia and Nigeria, to name a few. Also important was the rapid income growth of a number of oil-importing middle-income developing countries such as Brazil, the Republic of Korea, Hong Kong and Singapore. Economic growth in these countries was tied to manufacturing rather than petroleum, but the consequences were the same--the demand for imported grain increased sharply.

11. During the 1970s rapid income growth occurred in the developing countries while growth slowed in the industrial countries and centrally planned economies (see Table 1). Over the 1973-80 period, real GDP grew at 5% p.a. in the developing countries but at only 2.8% p.a. in the industrial countries, and approximately 3% in the centrally planned economies. This was in sharp contrast to the 1960s when GDP growth in all regions was high--6% p.a. in the developing countries, 5% p.a. in the industrial countries and 4-5% in the centrally planned economies.

TABLE 1: REAL GROWTH OF GDP, 1960-86 (ANNUAL PERCENTAGE CHANGE)

COUNTRY GROUP	AVERAGE		
	1960-73	1973-80	1980-86
DEVELOPING COUNTRIES	6.0	5.0	3.3
LOW-INCOME COUNTRIES	4.5	4.7	6.9
MIDDLE-INCOME OIL EXPORTERS	7.0	5.8	2.5
MIDDLE-INCOME OIL IMPORTERS	6.3	5.5	1.2
INDUSTRIAL MARKET ECONOMIES	5.0	2.8	2.3
E. EUROPEAN NON-MARKET ECONOMIES			
USSR	5.2	3.4	2.6
OTHER	4.3	2.9	1.8

SOURCE: WORLD BANK, WORLD DEVELOPMENT REPORT, 1983 AND 1986; INTERNATIONAL ECONOMICS DEPARTMENT

12. The shift of import demand from industrial countries to developing and centrally planned economies meant that income growth gained greater importance in explaining agricultural trade. Prior to the 1970s, the main grain-importing countries were the industrial countries which generally had low income elasticities for agricultural imports. As grain trade shifted to the developing and centrally planned economies the importance of income growth to trade increased because of the higher income elasticities for grains in these countries. This change dramatically increased the strength of the linkages between general economic activity and agricultural trade. Previously, faster or slower income growth had little effect on the demand for grains; suddenly it had large and immediate effects on demand and trade. Another implication of these changes is that the demand for grains is now much more affected by policies which affect income. Consequently, in analyzing the

outlook for the grains market, emphasis must be placed on macroeconomic activity and policy developments in both the industrial and developing countries.

13. Other important economic changes during the 1970s included the movement away from the fixed exchange rate system and the closer integration of the world's capital markets. These innovations drew the world's economies closer together and made possible much greater swings in economic growth. A recession was no longer confined to a country or region, but as we have seen in the last five years, it can now engulf the entire world.

III. FACTORS EXPLAINING GRAIN PRICE MOVEMENTS DURING 1970-84

14. Besides the fundamental economic changes identified in the previous section, other factors such as production shortfalls believed to be caused by poor weather conditions during the early-1970s were also credited with causing the initial price increases. It is extremely difficult to determine whether these shortfalls were caused by changes in economic variables such as fertilizer prices, by government policy changes or by weather-related shocks--all concurrent events. For example, the large wheat imports by the USSR in 1972 surprised the markets since neither a production shortfall nor previous market behavior justified such large imports. Other policy adjustments such as the US supply control programs also appeared to have substantial impacts on grain markets during this period.

15. In this section, an attempt is made to separate the contributions of the various factors to the movements in grain prices during 1970-84. A certain arbitrariness is evident by the choice of the factors considered and how they are defined. Given these choices, the relative importance of each of the factors is determined through simulation exercises with an econometric model of the world grains markets.

16. This report does not focus on the effect of agricultural policies of countries such as the United States, Japan or the EEC or the structure of these markets, even though these policies have undoubtedly been important in determining world grain prices. Rather, it examines the contributions of the fundamental economic changes identified in the previous section, given the existing global structure of agriculture. This approach is justified by arguing that a different global structure, for example a more liberal trading

system, would have led to a different base line of grain prices, but the events examined in this report would still have been important determinants of prices.

17. The model which is used to evaluate the contribution of the various factors to grain price movements is the World Bank Commodity Markets Division's World Grains and Soybeans Model (Mitchell, 1985). The model is a 24-region model of rice, wheat, coarse grains, soybean and soybean products markets. It is an annual econometric model estimated over the 1960-84 period and simultaneously for all commodities and regions. The model's primary endogenous variables are area harvested, yields, production, net trade, consumption and ending stocks for each commodity and region. A world market clearing price is also determined. Agricultural policies are assumed endogenous to the estimated responses with the exception of the United States where policy is modeled explicitly. Certain other policy events such as the large wheat imports of the USSR in 1972/73 and the US Payment-in-Kind (PIK) program in 1983 are also explicitly modeled. The primary exogenous variables are gross domestic product, population, exchange rates, consumer price indexes and fertilizer prices. A set of simulations was chosen to evaluate the importance of the following key factors contributing to the rapid rise in agricultural trade and prices in the 1970s: income growth, exchange rate changes, fertilizer price changes and policy changes. Results are presented only for the grains markets although the simulations also included soybeans.

18. Initial model runs were carried out to validate the model and to see how well it is able to track grain prices during the 1970-84 period. This set of results forms the basis for evaluating the impact of the various factors. Two types of model simulations were used for validation. First a "static"

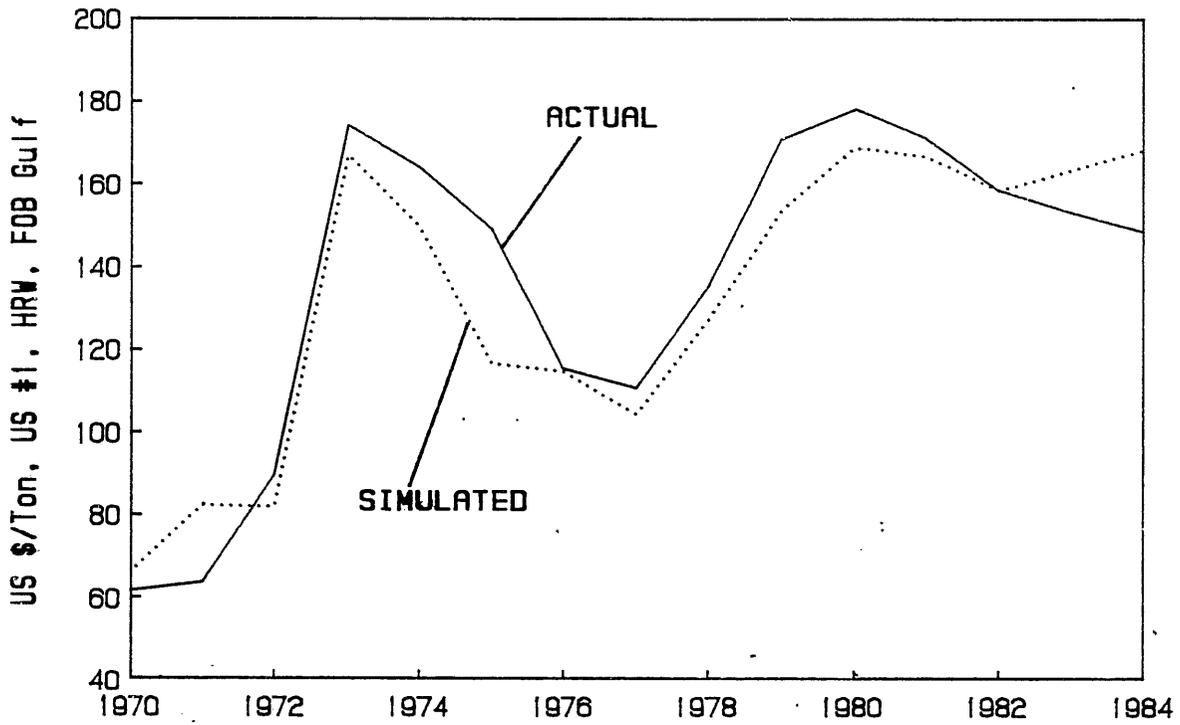
price simulation was run over the 1970-84 period and then two "dynamic" simulations were run over the same period. The static simulation is a series of one-year-ahead forecasts where all exogenous and predetermined variables are assumed known. The dynamic simulation assumes that only the exogenous variables such as income, population and certain shocks or policy changes are known. Endogenous variables are not corrected for forecast error when they are used as lagged variables in the dynamic simulation and therefore the forecast errors can accumulate. The dynamic simulation is a stricter test than the static simulation of a model's ability to track the historical data and of model stability.

19. The dynamic simulation was run under two sets of assumptions about changes in exogenous variables. In the first case, both the changes in the exogenous macroeconomic variables and the exogenous agricultural events, defined above took place. This means that the macroeconomic variables--income, exchange rates, fertilizer prices and inflation rates--were set to their actual values during the period. Exogenous agricultural events such as droughts, policy shifts, etc. were also assumed to have taken place. The second type of dynamic simulation assumed that only the changes in the macroeconomic exogenous variables took place and that the exogenous agricultural events did not. The purpose of the latter simulation was to check the relative contribution of agricultural events and macroeconomic changes. The more closely the model tracks actual price movements using only exogenous macroeconomic variables, the more important macroeconomic factors were to the grains markets. Population was assumed known in all the simulations.

20. The three simulation trackings are compared to the actual data for wheat, maize and rice prices in Figures 1-3. In Figure 1A, the static simulation demonstrates the one-year-ahead tracking ability of the model for the wheat price. The results show generally good tracking of the actual price movements. The model tends to underestimate the price peaks during 1973-75 and 1979-81 and overestimates in 1983-84. The simulated wheat price explains 88.3% of the variability of the actual price over the 1970-84 period using the static simulation and 78.2% using the dynamic simulation with all exogenous variables known. In Figure 1B, the two dynamic simulations of wheat prices are shown. The tracking results from the simulation where all exogenous variables are assumed known show that the model is stable and does not tend to accumulate errors, and that it can adjust to changes in macroeconomic and agricultural policy events. The results also show that the basic pattern of price movements, if not the precise level of prices, was essentially due to factors exogenous to agriculture. The second of the dynamic simulations shows that the model is able to duplicate the general movement of prices during the 1970s and early 1980s from changes in macroeconomic variables only. The major exception is the sharp increase in 1973. (This price increase was not caused by macroeconomic events but rather by the large USSR grains imports--a policy decision.) The price increases in the 1974-76 and 1978-81 periods can be explained by changes in the macroeconomic variables. This conclusion is very important as it contradicts the argument that the major changes in prices during the 1970s were primarily due to agricultural events.

21. The results for maize, Figures 2A and 2B, and rice, Figures 3A and 3B, support the results for wheat. The broad trends in prices over the 1970-84 period were due to changes in the macroeconomic variables while the short-term fluctuations in prices were largely the result of policies and events specific

**FIGURE 1A: WHEAT PRICE - STATIC SIMULATION**



**FIGURE 1B: WHEAT PRICE - DYNAMIC SIMULATION**

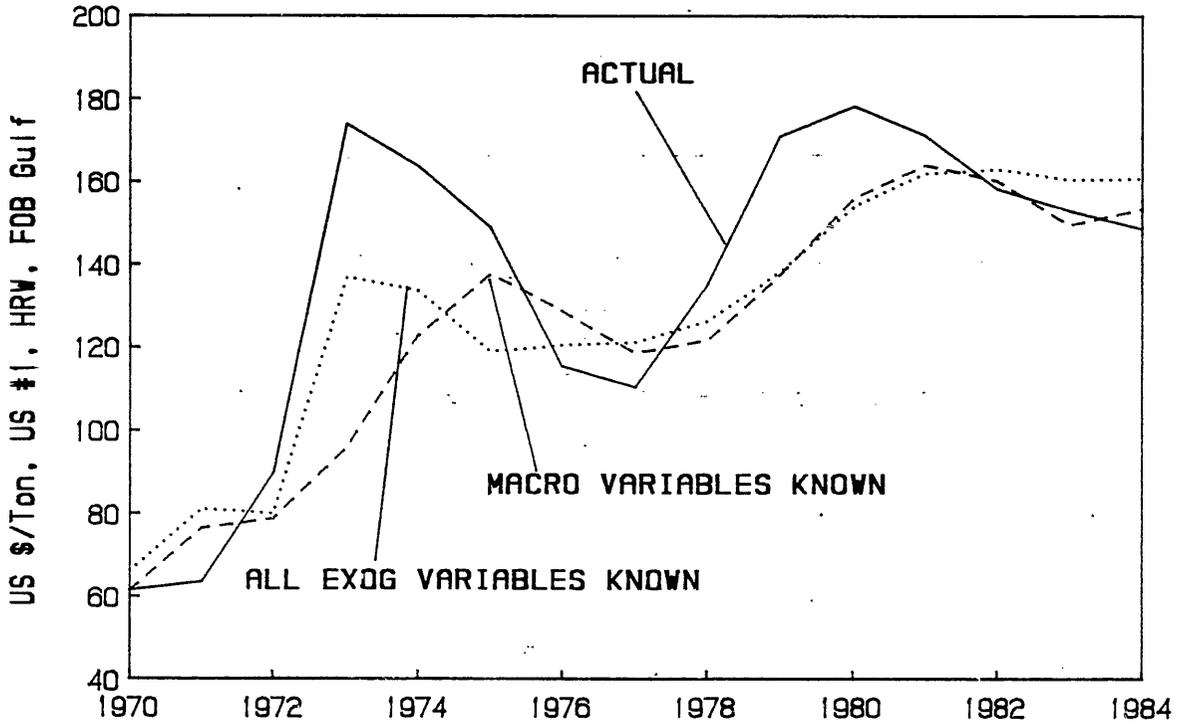


FIGURE 2A: MAIZE PRICE - STATIC SIMULATION

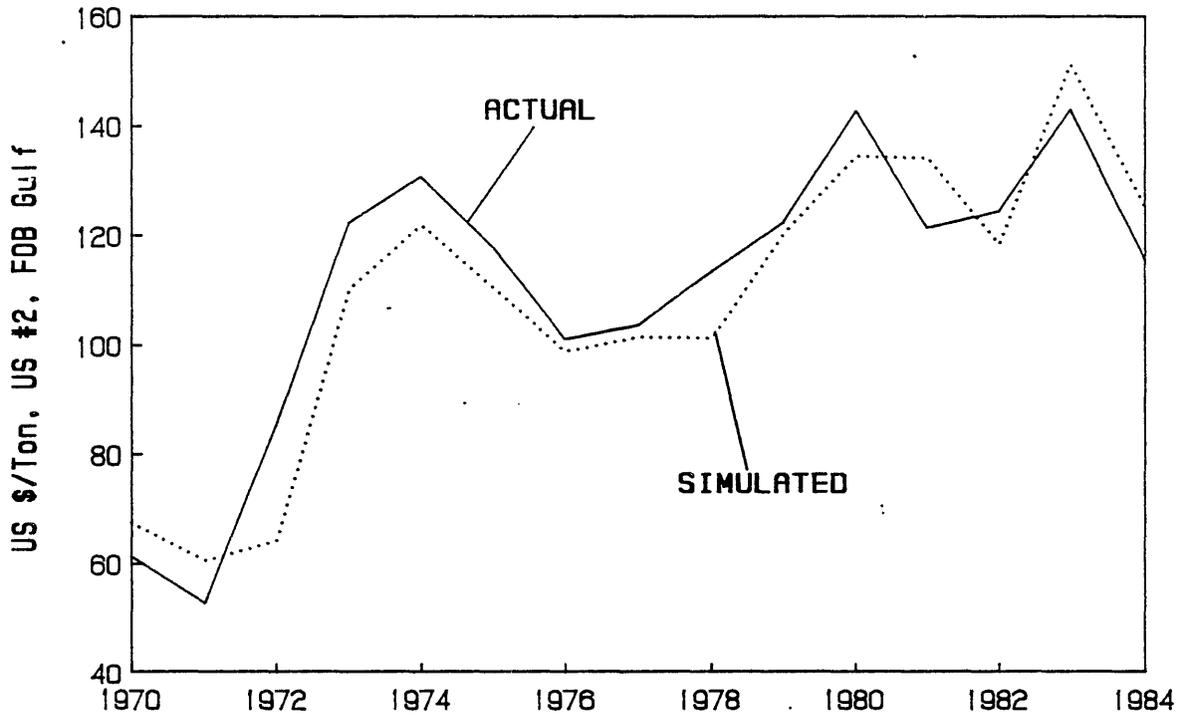


FIGURE 2B: MAIZE PRICE - DYNAMIC SIMULATION

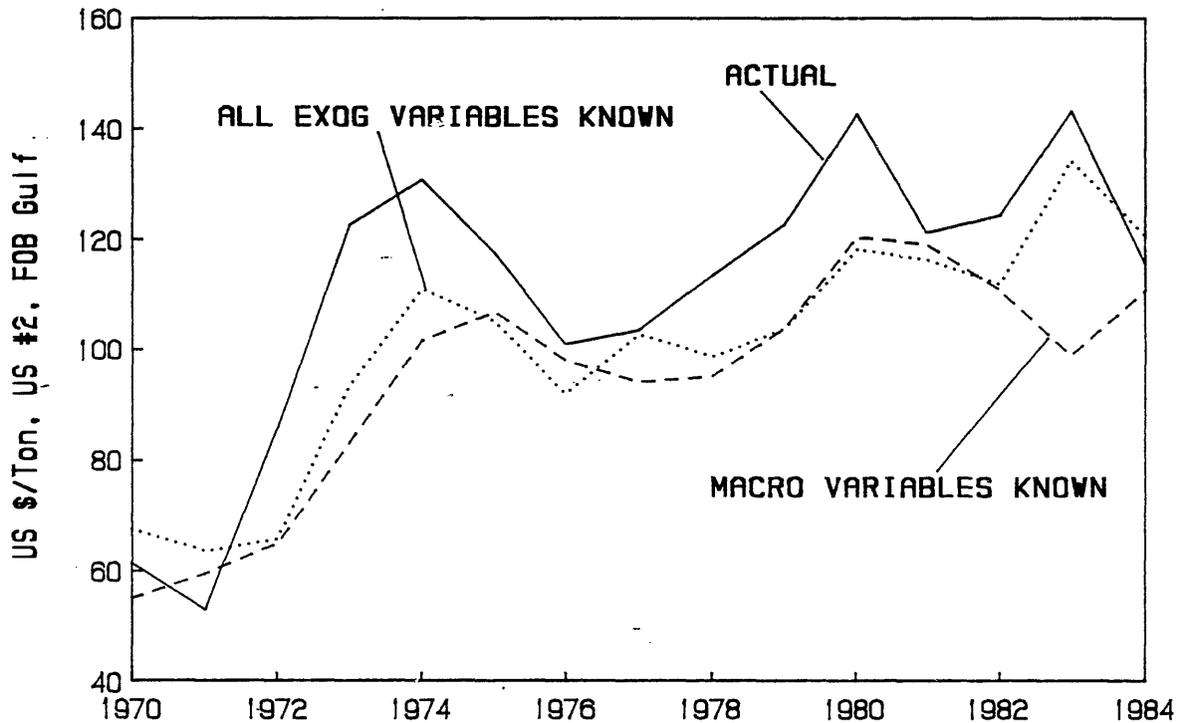


FIGURE 3A: RICE PRICE - STATIC SIMULATION

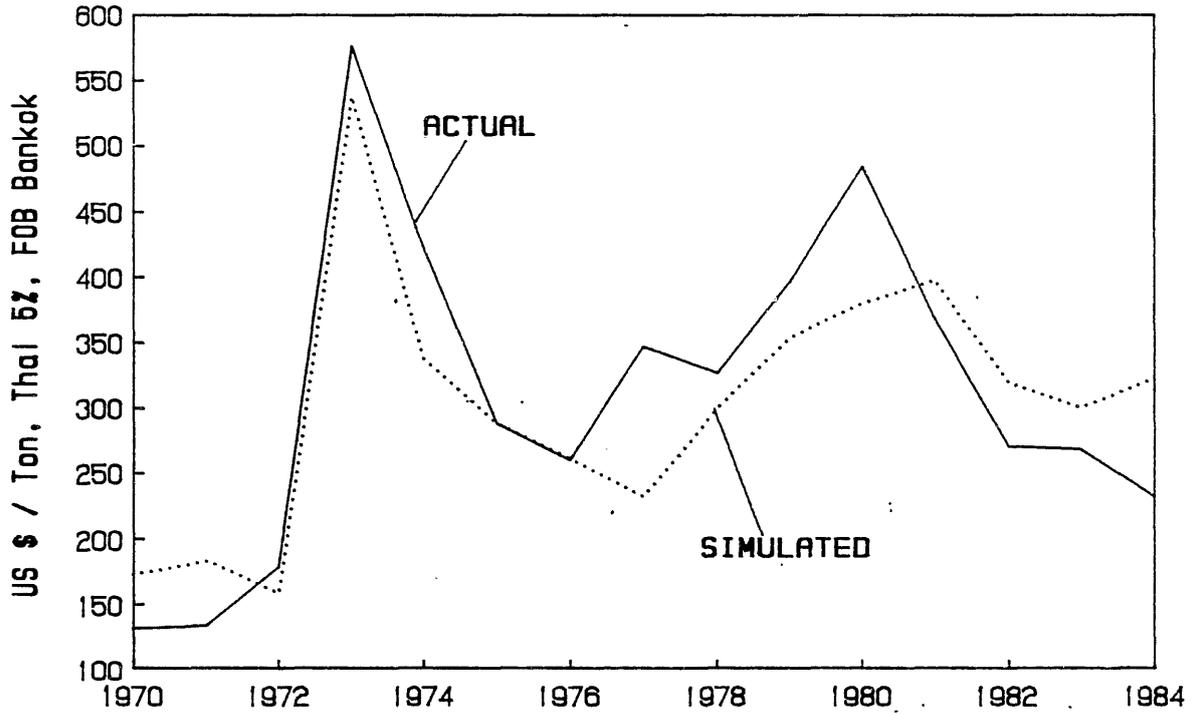
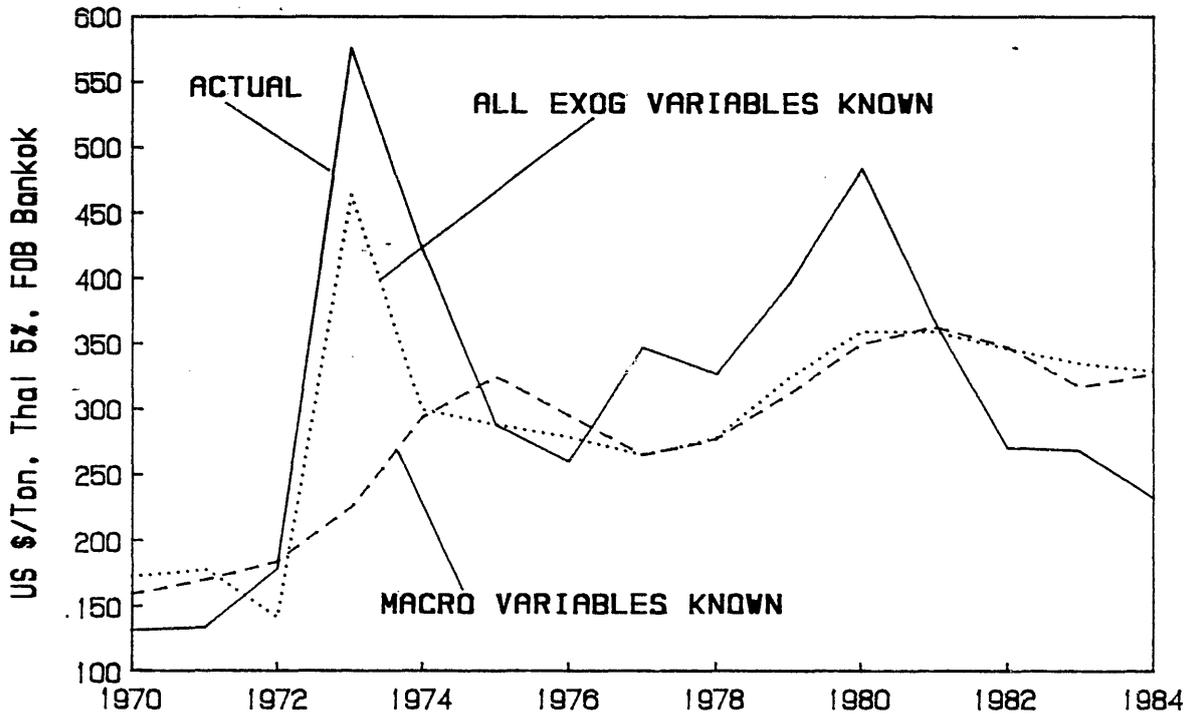


FIGURE 3B: RICE PRICE - DYNAMIC SIMULATION



to agriculture. The static simulation explains 87% of the variation of the maize price over the 1970-84 period, and the dynamic simulation explains 81.4%. The most important agricultural variable influencing the maize price was the 1983 US PIK program and drought. (This can be seen as the price difference between the two dynamic simulations.) These events raised prices at a time when a large part of the world was still in recessions.

22. Rice prices were more variable during the 1970-84 period than wheat or maize prices. The static simulation explains 77.7% of the variability of the rice price during this period while the dynamic simulation explains 66.8%. The rice price was strongly influenced by the increase in wheat prices in 1973. Perhaps because of the thinness of the market, rice prices increased more than wheat prices.

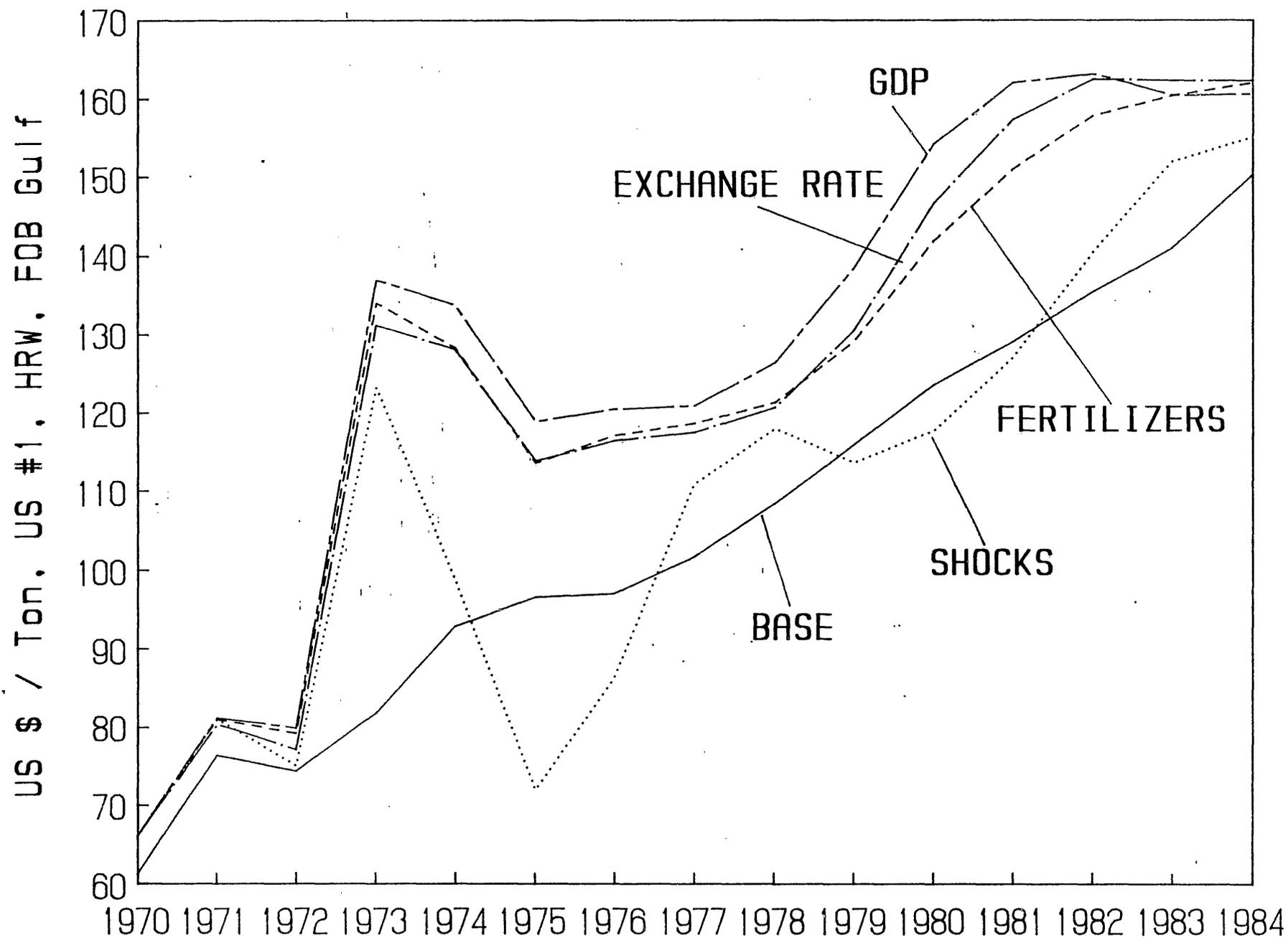
23. These simulation results reported above suggest several important characteristics of the world grain markets. First, macroeconomic events are more important in determining long-term price movements than are agricultural factors such as droughts. Specific agricultural factors can cause sharp price movements during a one- or perhaps two-year period, but do not appear to have long-run impacts. During the period under review the long-run level of prices has been largely determined by factors such as income growth rates and fertilizer prices. Therefore, even efforts of countries such as the United States to manage supply or stimulate demand through subsidized sales arrangements may not have lasting effects on the grains markets. Secondly, the linkages between the grain markets are very strong. A policy which affects wheat, for example, has implications for the rice market as well. These linkages have become stronger over time because of the types of economic change which have taken place.

24. The importance of these various exogenous factors to the movements in grain prices has been determined individually. First, we simulate the removal of the major shocks (both macroeconomic and agricultural) which occurred during the 1970s to establish a BASE case. We then add them back one at a time to allow the impact of each to be measured. Figures 4-6 show the simulated wheat, maize and rice prices during the period 1970-84 under the various assumptions. Dynamic simulation was used because many of the scenarios are likely to have had multi-year impacts which a static simulation would not capture. The simulations were carried out cumulatively so that the final simulation is identical to the dynamic simulation shown in Figures 1-3, with all exogenous variables known.

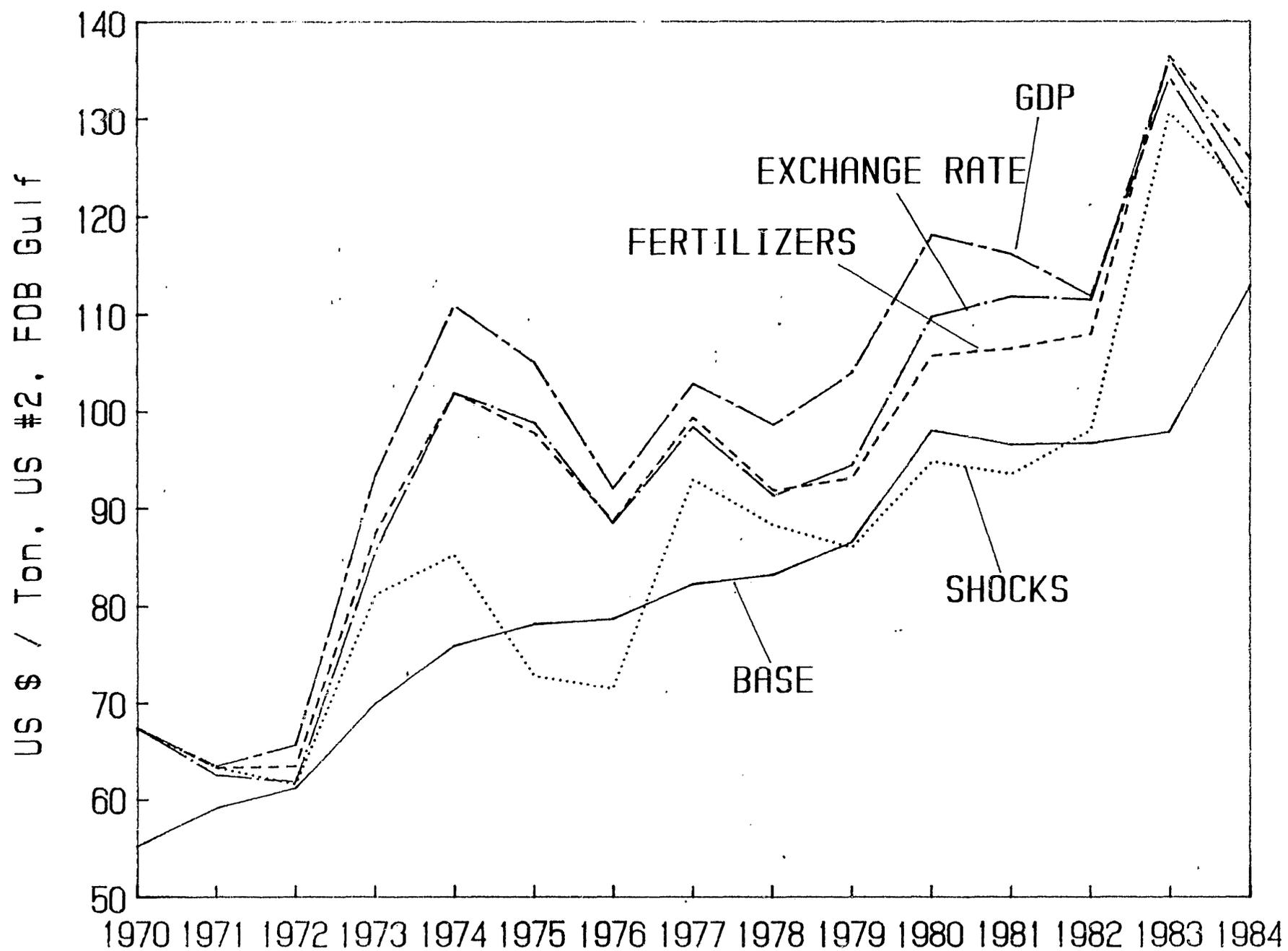
25. The BASE simulation assumes no droughts, no policy shocks, constant nominal exchange rates and smooth real income growth over the 1970-84 period. It also assumes constant real fertilizer prices at 1971 levels. This simulation shows a steady increase in nominal prices which corresponds to the general price trends over the 15-year period.

26. The first addition to the BASE simulation was the inclusion of the two major shocks--the large USSR imports of wheat in 1972 and the US PIK program and drought in 1983. Their impacts are shown in Figures 4-6 as SHOCKS and are measured as the differences in prices relative to the BASE. (The embargo on US grain sales to the USSR in 1980 was not included in the simulation because it does not appear to have had a significant impact on grain prices or trade levels.) The large USSR imports in 1973 caused simulated wheat prices to double and rice prices to nearly triple. Even though rice was not imported by the USSR, the rice price increases due to demand changes in the world wheat market. A review of the data for 1973 supports this result.

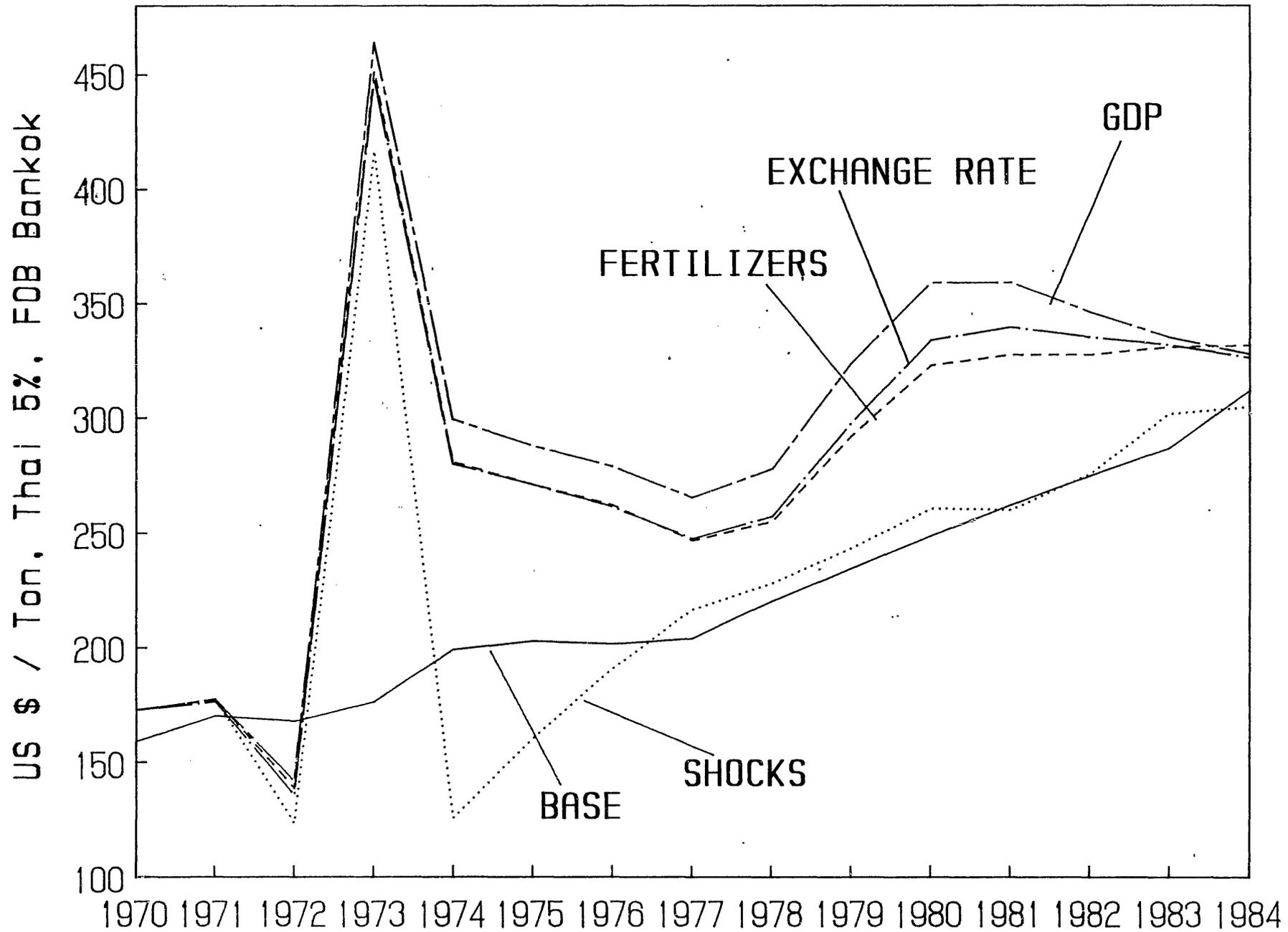
# FIGURE 4: WHEAT PRICE SIMULATIONS



# FIGURE 5: MAIZE PRICE SIMULATIONS



# FIGURE 6: RICE PRICE SIMULATIONS



World rice production increased 5.7% in 1973 to a record high and world ending stocks increased 20.9%. However, world consumption increased 8.8% which, was also a new record high, and trade in rice increased 13.7%--reflecting the flow-on from the increased demand in the wheat market. The simulated price increase lasts only one year if no other changes to the BASE simulation are made. In the next year production increases and prices decline. Prices eventually stabilize at levels near the BASE simulation. Maize was relatively unaffected by the price increases in wheat and rice because the USSR imports were confined largely to wheat and because the maize market is not as thinly traded as the rice market. Maize is also not as close a substitute for wheat as is rice.

27. The second shock was the 1983 US PIK program and subsequent drought. These events almost exclusively affected maize and other coarse grain production in the United States. (World wheat and rice production both increased in the 1983/84 crop year, while coarse grain production declined 6.7%.) According to the simulated results, these events caused maize prices to rise approximately \$20 per ton when otherwise they would have fallen \$15 per ton. The price impact lasted only one year. Wheat and rice prices were largely unaffected.

28. The second addition to the BASE case was the increase in fertilizer prices associated with the formation of OPEC in 1973. The increase in crude oil prices led to a tripling of nitrogen fertilizer prices between 1972 and 1974. Fertilizer consumption and grain yields declined and demand for grain imports increased to replace the drop in production, leading to an increase in grain prices in 1974. A second sharp increase in fertilizer prices occurred in 1979 when OPEC again raised petroleum prices. The model response is similar to

the earlier episode. The simulated results show that the higher energy and fertilizer prices were a major factor behind the increased grain prices in the 1973-76 and 1979-82 periods. A caution needs to be offered to the reader to the effect that these results are derived by including world fertilizer prices in the country yield equations. A distinction has not been made between energy prices, which also affect production costs, and fertilizer prices. Therefore, the simulation results reflect the combined effects of the higher energy prices and the higher fertilizer prices. The link between world grain yields and real fertilizer prices can be shown by regressing yields on a linear trend, current and lagged fertilizer prices and a dummy variable for the drought in the United States in 1983. 1/

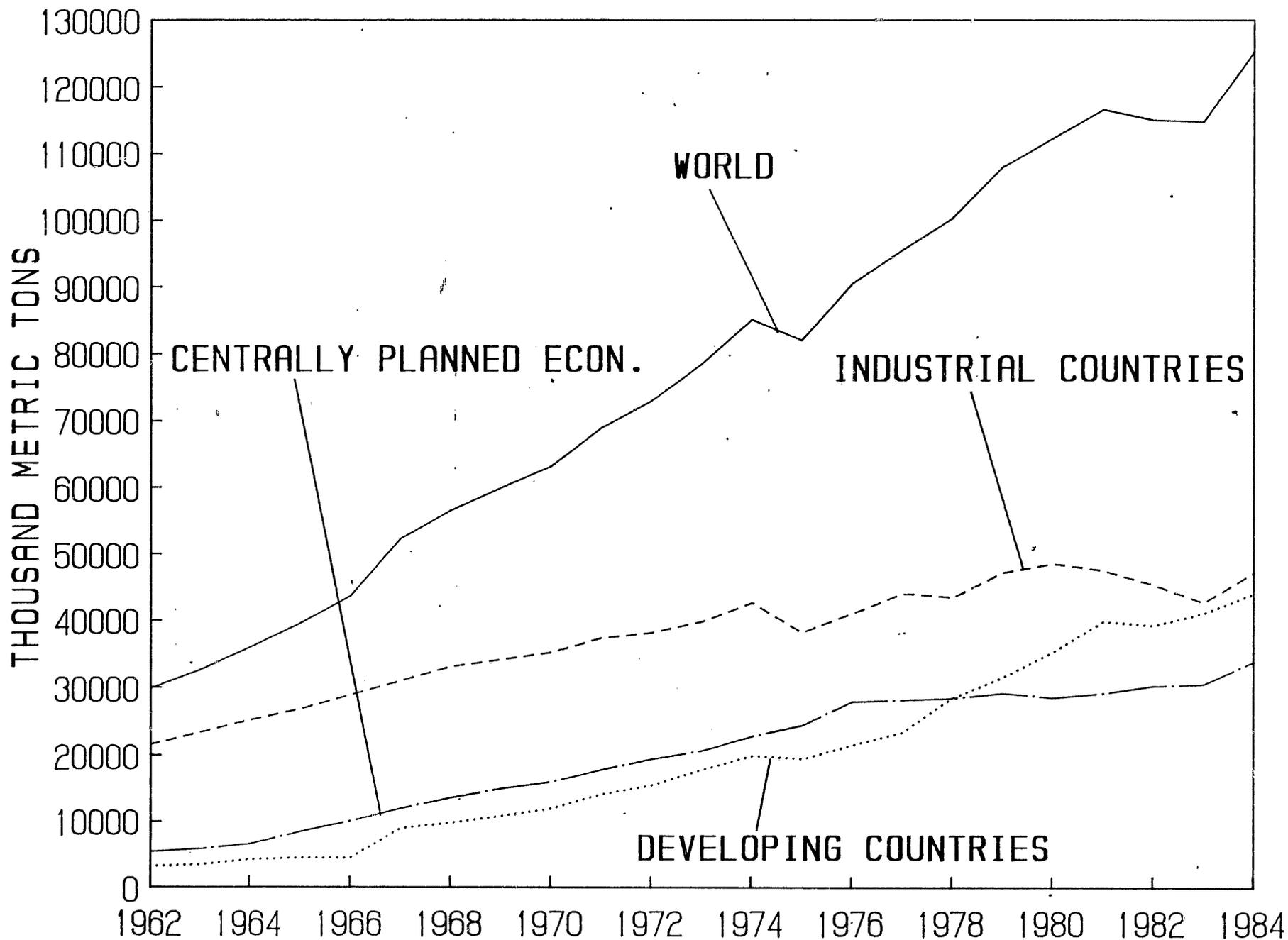
29. The quantities of total fertilizer nutrients consumed are shown for the world and major country groups for 1962-84 in Figure 7. World fertilizer use declined noticeably in 1975 following the sharp increases in fertilizer prices in the previous year. The decline in the industrial countries the largest consumers, was 10.7% on a volume basis. Consumption in the industrial countries has remained well below the 1962-74 trend since 1975. The developing countries did not reduce fertilizer consumption as much as the industrial countries, but they did reduce total fertilizer consumption in 1975 and slowed the growth of fertilizer use during 1976-78 relative to the decade prior to

---

$$\begin{aligned} \underline{1/} \quad Y_t &= 1.28 + .041 T_t - .021P_t - .020P_{t-1} - .081D83 \\ &\quad t=47.4 \quad t=2.20 \quad t=2.08 \quad t=1.93 \\ R^2 &= 0.99 \quad D.W. = 1.92 \quad \text{Period} = 1961-87 \end{aligned}$$

where  $Y_t$  = world grain yields in tons per hectare.  
 $T_t$  = linear trend with 1960=1, 1961=2, etc.  
 $P_t$  = urea price deflated by the US consumer price index.  
 $D83$  = a dummy variable for 1983.

**FIGURE 7: TOTAL FERTILIZER CONSUMPTION, 1962-84**



1974. The centrally planned economies did not reduce fertilizer consumption immediately in 1975, but held consumption nearly constant from 1976 to 1983. The second increase in fertilizer prices in 1980 and 1981 again led to declining world fertilizer consumption in 1982 and 1983, with most of the decline concentrated in the industrial countries. (However, much of the decline in consumption in 1983 was due to the large reduction in US area planted because of the PIK program.)

30. The third significant event during the 1970s to be evaluated was the floating of the exchange rates of the major industrial countries. Schuh has stressed its importance in many articles (see, for example, Schuh (1984)). The effects of exchange rate floating were removed in the BASE simulation by holding nominal exchange rates at their 1971 levels, i.e., prior to the change in exchange rate policy. Under floating exchange rates the dollar generally weakened during the 1970s and strengthened during the 1980s, which had the effect of lowering grain prices for non-US countries during the 1970s and stimulating import demand and reducing export supplies; the opposite effects occurred during the 1980s as the dollar strengthened and the prices to non-US importers and exporters increased. The results of the simulation show that the exchange rate changes contributed to the increase in grain prices during the 1970s and depressed prices during 1982-84. However, the price impact is relatively small, especially compared to the effects of the fertilizer price increase. The reasons for this relate to from the generally offsetting results between countries.

31. For some countries, such as Japan, currency exchange rates have strengthened significantly since 1971 relative to the US dollar. Consequently, the simulation comparing actual exchange rates since 1971 with fixed nominal

exchange rates at the 1971 level, results in lower grain import prices and higher imports. For the 1972-84 period, due to the lower price simulated wheat imports by Japan were 6.5% higher than they otherwise would have been. A similar situation existed for Thailand, resulting in an increase of 2.4% in wheat imports during 1972-84.

32. A second group of countries had currencies which strengthened relative to the dollar during the 1970s and then weakened during the 1980s. For example, the currencies of Western European countries generally strengthened relative to the dollar until about 1980 and then weakened significantly. This caused imports to first rise and then fall, relative to the fixed exchange rate simulation. Among developing countries, India, Indonesia and Nigeria were in this group. Several exporting countries including Canada and Australia were also in this group.

33. A third group of countries, primarily developing countries, had rapidly depreciating currencies throughout the 1972-84 period relative to the US dollar. These countries include many Latin American countries--Argentina, Brazil, Mexico--and many African countries. For these countries, the simulation using actual exchange rates results in higher import prices and lower imports than the simulation with fixed nominal exchange rates at 1971 levels. For example, the North African region imported 7.6% less wheat, the Central African region 1.1% less, Brazil 1% less and Nigeria 3.4% less.

34. The remaining group of countries consist of the USSR and Eastern European centrally planned countries which have currencies which do not trade in world markets. These countries were only affected through changes in grain prices caused by changes in imports and exports by other grain trading countries. These effects were relatively small with total trade declining by 0.3% during the entire 1972-84 period.

35. The net effect of the exchange rate simulation is that neither the level of the world price nor the total level of trade in grains changes significantly. Within total trade however, several countries experienced substantial changes in their trade levels. The details of these changes are beyond the scope of this paper.

36. The final simulation attempts to capture the impact of the changes in income growth during the period. This was done by comparing actual income growth with the smoothed income growth path assumed in the BASE simulation-- which was obtained from an end-points comparison. As discussed earlier (see also Table 1) the notable income changes during the period included the more rapid income growth in the developing countries during the 1970s compared to the 1980s and the slowdown of income growth in the industrial and centrally planned economies during the 1970s. These differential growth rates were associated with the formation of OPEC and the subsequent increase in petroleum prices, but many other factors such as the emergence of newly industrializing countries were also important. Regardless of the causes, the developing countries had relatively greater income growth during the 1970s than either the industrial or centrally planned economies and this stimulated grain import demand and prices. The negative impact on grain consumption and imports due to the lower income growth in the industrial countries was less important than the positive effects from the faster developing country growth because of the differences in income elasticities. The effects of the increased developing country income growth show up as a sustained price increase in all grain prices from 1973 to 1981. The income effect (shown as GDP in Figures 4-6) is largest for maize because of the higher income elasticity for feed grains compared to food grains. Beyond 1981, the price effects are reversed as the world recession severely slowed income growth in the developing countries.

37. Other events of the period which were not evaluated or which could not be separately identified and which may have been important contributors to the price movements during the period including one factor which has received much attention in recent years--the large foreign debt of certain developing and centrally planned economies. In a few countries, such as Mexico and Poland, agricultural imports appear to have been adversely affected. However, the debt problem is largely confined to Latin American countries which historically have not been large grain importers. Moreover it was probably not a major factor during the period prior to the early 1980s.

38. The contribution of each of the above sets of events to grain price movements during the 1970-84 period have been quantified relative to the BASE simulation. This was done by measuring the total absolute price differential associated with each simulation relative to the total for all simulations. The portion of the price variability not explained by the four scenarios was obtained by regressing the actual price on the simulated price from the dynamic solution with all exogenous variables known. The unexplained movements in grain prices range from 18.4% for maize to 33.2% for rice. This is high, but is not unexpected for a dynamic simulation. The simulation results are summarized in Table 2.

39. The simulation results show that the fertilizer price changes were the dominant factor explaining the grain price movements during 1970-84. This single event directly explained nearly one-third of the movements in grain prices during the period. The second most important factor in explaining grain price movements were the two so-called agricultural policy shocks. The first was the very large wheat imports by the USSR which caused wheat and rice prices to surge in 1973. The second policy shock was the 1983 US PIK program

TABLE 2: IMPORTANCE OF FACTORS IN EXPLAINING GRAIN PRICE MOVEMENTS, 1970-84

	WHEAT	MAIZE	RICE
	-----(% OF PRICE VARIATION)-----		
AGRICULTURAL POLICY SHOCKS	24.6	27.9	22.4
FERTILIZER/ENERGY PRICE INCREASES	38.9	30.7	32.8
EXCHANGE RATE MOVEMENTS	4.8	6.0	2.5
INCOME GROWTH DIFFERENTIALS	9.9	17.0	9.1
NOT EXPLAINED	21.8	18.4	33.2

and subsequent drought. The impact of these events was largest in the maize market but also impacted wheat and rice. In 1983, maize prices were an estimated US\$33 per ton higher than would have occurred without the PIK program. Wheat and rice prices were \$11 and \$15 per ton higher, respectively. In 1984 maize prices remained \$9 higher and wheat and rice \$5 and \$7 higher, respectively.

40. Exchange rate movements relative to the US dollar were found not to be very important in explaining changes in grain prices or in total trade during 1970-84. During the 1970s, the value of the dollar weakened, leading to lower grain import prices for many countries and stimulating demand and raising world grain prices. The price increases were greatest in the period 1980-82, and were relatively small prior to 1980. The strengthening of the dollar after 1981 depressed prices in 1983 and 1984. However, these effects are much smaller than expected.

#### IV. FUTURE PROSPECTS

41. Given the perspective of the simulation results, what are the future prospects for grain prices and trade. In general, they are not good for producers in the near term. World income growth appears unlikely to increase substantially, energy and fertilizer prices have fallen in recent years and short-term prospects argue for little change, and world grain stocks are at record levels. However, as seen in the simulation results, adjustments can be expected in response to recent price changes, and these changes are becoming evident. The intermediate-term prospects for price increases appear quite good given that these adjustments are allowed to occur.

42. Much of this adjustment will come about through slower production growth. A factor not previously discussed in this paper has been the spectacular increase in production in many developing countries during the last two decades. China, Indonesia, Pakistan, India--and many other countries--have increased production beyond their current requirements. It is important to recognize that these gains were to a large extent based on switching cropland from traditional wheat and rice varieties to the high-yielding varieties (the "Green Revolution"). This variety change often led to a doubling of yields when the new varieties were irrigated and heavily fertilized. These gains are largely realized by now and future yield growth may not be as rapid. Moreover, the varieties and technology are not yet available for the next "Green Revolution."

43. Low fertilizer prices have also contributed to the rapid growth in production in the last few years--perhaps leading to a false sense of accomplishment. India, for example, increased total fertilizer consumption 93%

from 1980 to 1986. Indonesia increased total fertilizer use by 105% from 1980 to 1986. These increases were possible partly because real fertilizer prices declined more than 50% during this time. (For example, urea prices decreased 58% over this period.) It seems unlikely that fertilizer prices will remain at current low levels for a sustained period of time. Recent low prices have led to plant closings and severe curtailment of investment programs. This is a repeat of past patterns with sharp fluctuations in investments causing wide fluctuations in prices.

44. The supply control measures introduced by the United States in the 1985 Food Security Act will also contribute to the reduction in production. The conservation reserve portion of the US farm bill is intended to remove 16-18 million hectares from crop production. This is about 15-20% of the total grain and soybean area in the United States. Additional land will be temporarily diverted from production in a further effort to reduce stocks. As much as 35% of the rice area, 30% of the wheat area and 25% of the coarse grain area will be diverted in each of the next several years. Supply reductions will also come from other countries as current low prices discourage investment in agriculture. The result will likely be a period of real price increases in the late 1980s and early 1990s as supply increases lag the growth of demand. This type of behavior has occurred before.

45. During the late 1960s when prices were low, stocks were reduced in the United States, Canada and Australia through special government programs. In Canada, for example, the harvested area of wheat was reduced by nearly one-half in 1970 compared to 1969 through a program called LIFT (lower inventories for tomorrow). In Australia, the 1970 wheat area harvested was 32% lower than in 1969, and in the United States the 1970 wheat area harvested was 25% below

the level three years earlier. These actions contributed to the large price increases of the 1972-74 period and to the subsequent great concern about the ability of the world to feed itself. Supply adjustments are beginning to be seen in a number of major grain exporting countries beyond the large cutbacks seen in the United States--although the magnitude of the reductions are not yet as large as occurred during the 1969-72 period.

46. A final factor which must be considered is the prospect of global agricultural trade liberalization. The United States has made agricultural trade reform a major priority in discussions at the 94-nation General Agreement on Tariffs and Trade (GATT). The US proposal is to move toward a world where production and trade decisions will not be distorted by government intervention. The changes would occur over a period of perhaps 10 years and would involve all the countries involved in GATT. The huge system of government subsidies and protection to farmers in the United States, Japan and the EC would be dismantled. The results would be far reaching and would totally restructure the patterns of agricultural trade.

47. The decade of the 1970s was probably unique because of the number of changes which occurred early in the 1970s--such as the rapid rise in energy and fertilizer prices, the large wheat imports by the USSR in 1972 (30% of world wheat trade of the previous year) and the floating of exchange rates among the major industrial countries. These factors, combined with the intentional decline in grain stock levels by the major grain-exporting countries from 1968-72, led to the sequence of events which dominated agriculture for the next decade. History will not likely repeat these events but neither will agriculture retreat into quiet repose. The next shock to agriculture seems likely to come from one of three sources. First, the current

low fertilizer prices are leading to substantial reductions in fertilizer production capacity which could lead to sharply higher fertilizer prices at some future period. If this coincided with a rise in energy prices, the effects on agricultural production would be significant. Secondly, a policy-induced shortage is possible in the major exporting countries. The US supply control programs have a 10-year horizon and could hold land out of production even as prices rose. Other major exporting countries have not yet entered into such large supply control programs, but they did in the late 1960s and may again. Thirdly, the maturing of the Green Revolution is an important factor in many developing countries. The growth of production of 4-6% per year which many developing countries have had during the last two decades seems certain to slow. If this is accompanied by rapid income growth, import demand could grow as rapidly as during the 1970s.

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