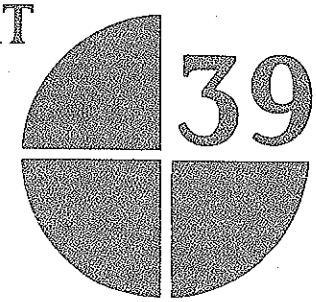
RESEARCH REPORT



THE WORLD RICE MARKET: STRUCTURE, CONDUCT, AND PERFORMANCE

Ammar Siamwalla
Stephen Haykin

June 1983

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FOREWORD

Because rice is the staple food of the majority of the world's population, particularly of the poorer people of developing countries, the International Rice Research Institute (IRRI) was founded to generate new technology to rapidly expand the supply of rice. IRRI has achieved extraordinary success, not only through the development of specific varieties of rice such as IR8, but by demonstrating approaches to rice cultivation that have had profound influences on human welfare and on the environment within which rice research and production take place.

The International Food Policy Research Institute (IFPRI), as the policy-oriented center in the Consultative Group on International Agricultural Research (CGIAR) system, has maintained a long-term collaborative research relationship with IRRI on rice policy in Southeast Asia. As some of the countries in that region expand their rice production, their behavior in the world rice market becomes more important.

IFPRI itself has had a long-standing interest in food security issues and the role of international trade in helping countries attain food security. IFPRI Research Report 4, *Food Security: An Insurance Approach,* by Panos Konandreas et al., examined how international markets can be used to stabilize national supplies. *Developed-Country Agricultural Policies and Developing-Country Supplies: The Case of Wheat,* Research Report 14, by Timothy Josling, *Economics of the International Stockholding of Wheat,* Research Report 18, by Daniel Morrow, and *Estimates of Soviet Grain Imports in 1980-85: Alternative Approaches,* Research Report 22, by Padma Desai, look at various aspects of the workings of the world wheat market. In collaboration with the International Maize and Wheat Improvement Center (CIMMYT), IFPRI held a conference in Mexico, the proceedings of which were published in *Food Security for Developing Countries,* edited by Alberto Valdés (Boulder, Colo.: Westview Press, 1981).

Two of the four authors of a forthcoming volume entitled "International Finance for Food Security," to be published by the Johns Hopkins University Press for the World Bank, are members of IFPRI's staff. Much of this past work has concentrated on the world wheat market. The present study on rice broadens our perspective on an equally important commodity. This is particularly important because within the world markets, rice displays characteristics that are quite different from those of wheat.

Ammar Siamwalla's and Stephen Haykin's report examines the impact of the dramatic yield-increasing research results of the past two decades on the world rice market. The uneven benefits among countries of this research have shifted international trading patterns, with important consequences for the world rice market. In particular, an unintended by-product of the very success of the research has been to keep the world market quite thin, making it an unsatisfactory recourse for national market stabilization. The implications for national rice policies in such areas as self-sufficiency, irrigation investment, and storage policy are obvious, as are the implications for research policy on the improvement of yield stability.

Ammar Siamwalla has been studying the large data set on rice analyzed in this research report for many years. Before joining IFPRI in 1978, he was a faculty member at Thammasat University in Bangkok, where his research on a wide range of topics provided the insights for this broad analysis of rice markets. His frequent collaborations with IRRI and other institutions in the region provided the intimate knowledge of the rice economy essential to this work.

IFPRI, building on this research, is proceeding with in-depth studies of irrigation economics, also in collaboration with IRRI and the Asian Development Bank. These studies will emphasize investment needs and their relation to technology and overall rice supply-demand balances.

John W. Mellor

Washington, D.C.
June 1983

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We would like to thank John Mellor and Alberto Valdés for their encouragement, helpful advice, and above all for their patience with this project during its long gestation period.

Thomas Slayton and Robert Tetro at the U.S. Department of Agriculture were extremely helpful with the data. Tom Slayton also reviewed the manuscript and helped us with good advice and solid information. Ron Duncan of the World Bank provided useful data for our price analysis. Our colleague, Bruce Stone, was an invaluable resource concerning Chinese matters.

A highly imperfect first draft was reviewed by John Mellor, Mark Rosegrant, Robert Thompson, Hiroshi Tsujii, and Alberto Valdés. They treated that manuscript with greater kindness than it deserved but also provided us with insights and advice that contributed greatly to our revision work. Mark Rosegrant commented on the revisions as they unfolded. Randy Barker examined the penultimate version. His judgments on various points have been invaluable.

Ammar Siamwalla
Stephen Haykin

1

SUMMARY

This research report examines the workings of the world rice market, employing a structure-conduct-performance framework but focusing on sovereign governments, instead of firms, as the principal actors. Data on trade, prices, and production and consumption are examined and an econometric model is formulated and applied to the data.

In the examination of the structure of the rice market, the report describes the operation of the world rice market, examines data on production and consumption growth, and compares wheat and rice prices and world and domestic rice prices for various countries.

Structurally, the market is essentially a thin residual market. In Asia, which is the main consuming and producing region for rice, the thinning process has been further accentuated by technological change, because new technology has been more readily adopted by importing countries than by exporting countries. This bias arises from the greater suitability of the technology to the importing countries' environment. The comparative advantage of the traditional exporting countries has rested on the large, flat river deltas that simplify planting but make water control difficult and expensive. Good water control is a major requirement for modern technology. Thus, Asia's role in world trade has been declining on both the import and the export sides.

Just as important as the small proportion of rice that is traded are the fluctuations of the participants' shares of the market. The import volume of a major importer can dwindle to almost zero in a few years, and the same holds true on the exporting side. This absence of fixed trade channels makes for high search and transaction costs.

On an aggregate basis, the real price of rice has increased relative to that of wheat. Among the causes that can be identified are the faster population growth among rice consumers, the stronger income effect (because the income elasticities of demand are higher for rice on a worldwide basis), and the more rapid growth in the supply of wheat. These three causes have contributed about equally to the shift in relative prices.

An examination of the long- and short-run conduct of countries participating in the rice market shows how policies affect the traded volume. An econometric model is used to explain the short-run responses of governments to fluctuations in world prices and domestic production.

If basic structural changes are making the Asian portion of the market thinner, the policy conduct of individual governments has made this change even more pronounced. Importing countries tend to pursue productivity-enhancing policies somewhat more aggressively than exporters—both sides arguing that they cannot trust the thin world market as a reliable source for imports or as an outlet for exports. This expectation is self-fulfilling, as the consequence of such conduct is to make the market even thinner.

The way governments conduct rice trade also tends to increase instability. Rice imports and exports of most countries do not respond strongly to world prices. The trade of a few responsive countries in East Asia, most notably the People's Republic of China, and of the United States (with a lag) provides one of the few elements of stabilization that exist. Unfortunately, the smaller volume of exportable surplus relative to world production produced by these countries precludes them from playing the role of a supplier of last resort, as the United States does for wheat and maize. The absence of a central market for rice (similar to Chicago for wheat and maize) is partly connected to this lack of a supplier of last resort. The unreliability of the market has induced many governments to depend primarily on their own stockpiles, so that a relatively small portion of the supply shocks enters the world market. Without the cushion from the domestic stocks, it is unlikely that the world rice market can handle the full brunt of an aggregate supply failure.

Finally, the performance of the world rice market for stability, efficiency, and income distribution is examined.

The world rice market has failed in the reallocation of production from countries where costs are high to countries where costs are low. In addition, countries that independently pursue their own rice supply security incur a small additional cost for storage that would not be necessary if the world market were efficient. Although the inefficiencies of the market may be credited for boosting efforts to increase production through technical innovation in importing countries, they must also be held responsible for the corresponding reluctance among exporters to increase production. By far the most serious consequence of the market's poor performance lies in the perceived instability where, as pointed out earlier, expectations have led to long-term policies that are self-confirming. Participants then have to bear large search and transaction costs, which are a much larger proportion of the rice price than similar costs for wheat or yellow maize. Because rice has no central market, these high search and transaction costs cannot be reduced through competition. These frictions also increase the risk for storers, making it difficult to induce enough private storage of rice to lubricate the world market.

However, because policies to foster independence from the world market are inherently rational for individual countries, it is unlikely that governments will change their policies to achieve a more efficient world market in rice. This would require them to make their import or export volumes more responsive to world prices—a rather demanding condition politically. The only ground for optimism is the entry into the market of countries that are potentially more responsive because they do not look to rice as a residual source or outlet or as a food staple. This development may make for greater stability.

2

STRUCTURE

Rice is the staple food of the majority of the world's population, but as an item of international commerce it is of only secondary importance, ranking fourteenth among the commodities covered in the World Bank's *Commodity Trade and Price Trends.*[1] Why this should be so is, in a sense, the underlying theme of this research report.

The starting point and the focus of this analysis are the main actors in the world rice market—the governments of sovereign states interacting in what may be regarded as an unregulated market. The actions of farmers and households are examined only insofar as they influence government behavior. The main rationale for this approach is that the world market is effectively curtained off from the domestic rice markets of most of the economies under consideration. If there is any linkage, it is mediated by government actions.

Other than focusing on the role of governments rather than firms, the report follows a conventional structure-conduct-performance framework. This chapter examines the structure of the world rice trade.

The world rice market is thin because it has always been a residual market, and in the past two decades the introduction of high-yielding varieties (HYVs) in the major rice-growing parts of Asia has made it even more of a residual market. This makes for unstable trading patterns because participants vary the volume of trade considerably. This lack of a regular channel of trade makes for relatively high search costs and hence a thin market.

The sections below document these points. The first section provides data demonstrating the relatively low volume of production that is traded. The next shows the pattern of world trade and explains the shifts arising from the growth experiences in Monsoon Asian countries. This is followed by a digression on the interaction between the wheat and rice markets. In the final section we attempt to analyze the concept of the "thin market."

The Traded Ratio of Rice

The proportion of rice production that is traded internationally is small and until 1975 was declining (see Table 1). The ratio of trade to production is small because the bulk of rice production occurs in the monsoon lands of Asia, which stretch from Pakistan to Japan, and these countries are also major rice consumers. The coincidence of rice production and rice consumption is high relative to wheat. This is demonstrated by comparing frequency distributions of the ratios of consumption to production by country. A frequency distribution that is dispersed, as in the case of wheat (Figure 1), implies that the locations of consumption and production probably do not coincide. In contrast, the frequency distribution for rice is more concentrated around 1, which implies that consumption occurs in the countries where rice is produced (see Figure 2). A low proportion of traded rice is particularly characteristic of Asia, as can be seen in the comparison of frequency distributions for Monsoon Asia and the rest of the world in Figures 3 and 4.

The general overlapping of production and consumption areas holds true not only internationally, but within each country as well. The proportion of rice produced that enters domestic markets is generally quite low. Table 2 gives some scattered evidence of the ratio of marketed surplus to production as gleaned from various sources. Even in a major exporting country such as Thailand, the ratio of rice marketed to total production

[1] International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, 1981). Rice, however, ranks first among agricultural commodities as an item of trade between developing countries, according to a study now under way by Alberto Valdés of the International Food Policy Research Institute.

is barely one half. Where the data allow comparisons over time, for example in Indonesia, a general increase in the ratio can be discerned.

Although the traded ratio of rice has been declining until recently, a distinction should be drawn between countries in Monsoon Asia and those outside it. In Monsoon Asia the decline in the traded ratio has continued uninterrupted (see Table 3), while in other countries trade has generally grown relative to production. This development may make for a more elastic response to world market conditions, but as the analysis in Chapter 3 indicates, past behavior argues against such a conclusion.

These characteristics of the rice trade indicate several things about the structure of the international rice market. First, that so little of the rice produced enters the world market implies that fluctuations in production have magnified effects on volumes traded in the world market, making it highly unstable. This instability is offset to some degree by the fact that the primary fluctuation in production does not lead to an equal fluctuation in the volume of rice marketed. Although rice producers do absorb some of these fluctuations by adjusting on-farm consumption, existing data suggest a lower degree of absorption than is implied by the share of marketed surplus that is shown in Table 2. About one third or less of the production variation is absorbed by the farmers' own consumption, whereas the other two thirds or more is passed on to the marketed surplus, which can be expected to be more variable relative to its size than is production.[2]

Although the traded ratio of rice may be small, the relationship of the rice trade to the marketed surplus is significant for this study. Fluctuations in the volume of marketed surplus of an individual country are usually countered by changes in the volume of rice imported or exported and/or by changes in stock levels. As the marketed surplus is consumed largely in the urban areas, which are considered to be more politically important, the strategic role of international trade in rice is grasped by most governments. Thus, rice trade is typically conducted directly by governments or rigidly controlled by them.[3] Even Hong Kong, otherwise a model of laissez-faire economy, closely regulates imports of rice by means of quotas. Naturally, this pervasive government influence has had a strong impact on the structure of the market.

World Rice-Trading Patterns

There have been some major changes in the trading patterns in rice since World War II. Most importantly, the three major rice exporters before the war—Burma, Thailand, and Vietnam—no longer dominate the trade. Vietnam has been importing rice consistently for almost two decades. Burma's exports plunged abruptly in 1966 and have stayed below 1 million tons ever since, although in the past few years there have been clear signs of a revival.[4] Of the three countries, only Thailand has retained a significant share of the world market. Furthermore, Korea and Taiwan, former Japanese colonies, used to export large quantities of rice (annual averages of 1.09 and 0.62 million tons respectively during the period 1936-38), mostly to Japan.[5] Taiwan now exports much smaller volumes, while the Republic of Korea has become a highly erratic importer, whose import volumes generally exceed the

[2] Raisuddin Ahmed estimates the elasticity of marketed surplus with respect to production in Bangladesh in the mid-1970s to be 3.3 (Raisuddin Ahmed, *Agricultural Price Policies under Complex Socioeconomic and Natural Constraints: The Case of Bangladesh*, Research Report 27 [Washington, D.C.: International Food Policy Research Institute, 1981], p. 40). The average ratio of marketed surplus to production in those years is about 0.2. This implies a marginal propensity to consume rice with respect to production of about 0.34 [=1 – (3.3)(0.2)]. Toquero et al. estimate that the same propensity for the Philippines is slightly below the Bangladesh level at about 0.28 [=1 – (0.717)]. See Zenaida Toquero, Bart Duff, Teresa Anden-Lacsina, and Yujiro Hayami, "Marketable Surplus Functions for a Subsistence Crop: Rice in the Philippines," *American Journal of Agricultural Economics* 57 (November 1975): 705-709, Table 1, Equation (6.4).

[3] See Walter P. Falcon and Eric A. Monke, "International Trade in Rice," *Food Research Institute Studies* 17 (No. 3, 1979/80): Table 4, for an extensive list of instruments used by Asian governments to control rice trade.

[4] "Tons" denotes metric tons for the purpose of this report.

[5] V. D. Wickizer and M. K. Bennett, *The Rice Economy of Monsoon Asia* (Stanford, Cal.: Food Research Institute, Stanford University Press, 1941), p. 28.

Table 1—World rice production and world rice trade, selected periods

Period	Production	Total Exports	Percent of Production Exported
		(million metric tons)	
1936-40	109.3[a]	5.7[b]	5.2
1950-54	122.0	4.7	3.9
1955-59	147.3	6.1	4.1
1960-64	163.5	6.8	4.2
1965-69	184.2	6.7	3.7
1970-74	208.6	7.3	3.5
1975-79	247.8	10.3	4.2

Sources: 1936-40: V. D. Wickizer and M. K. Bennett, *The Rice Economy of Monsoon Asia* (Stanford, Cal.: Food Research Institute, Stanford University Press, 1941), for production in all countries except China. For China, the estimate of 80 million tons of paddy for 1933 was taken (see Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-1959* [Princeton: Princeton University Press, 1965]). This is probably on the high side.

1950-74: Adelita C. Palacpac, *World Rice Statistics* (Los Baños: International Rice Research Institute, 1978). 1975-79: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, FG-22-82 (Washington, D.C.: USDA, September 1982). Conversion from a paddy to a milled rice basis is based on a world milling rate of 0.66, for 1936-74. See also Alberto Valdés, ed., *Food Security for Developing Countries* (Boulder, Colo.: Westview Press, 1981), p. 81.

Note: Rice in this table is milled rice.

[a] This includes 12 countries in Asia only (Burma, French Indochina, Thailand, Korea, Taiwan, Japan, India, Malaya, Ceylon, Java-Madura, the Philippines, and China). These countries produced about 91 percent of world production in 1950.

[b] This includes three countries only (Burma, French Indochina, and Thailand). Trade between Japan and its former colonies, Korea and Taiwan, is specifically excluded, because it does not cross political boundaries.

Table 2—Marketed surplus of rice as a share of total production, selected countries, selected periods

Country	Period	Marketed Surplus as Share of Total Production
		(percent)
Bangladesh	1953-68	12.2-14.2
India	1971/72-1974/75	21.6-23.9
Indonesia	late 1950s	17.5
	late 1970s	30.0-40.0
Philippines	1959-60	51.1
Taiwan	1970s	68.0
Thailand	1971	56.9

Sources: Bangladesh: Raisuddin Ahmed, *Foodgrain Supply, Distribution, and Consumption Policies within a Dual Pricing Mechanism: A Case Study of Bangladesh*, Research Report 8 (Washington, D.C.: International Food Policy Research Institute, 1979).

India: P. S. George, "Government Interventions in Foodgrain Markets" (unpublished paper, International Food Policy Research Institute, Washington, D.C., n.d.), p. 22. The data are for market arrivals as percent of production.

Indonesia: Leon Mears, *The New Rice Economy of Indonesia* (Yogyakarta: Gadjah Mada University Press, 1981), p. 100.

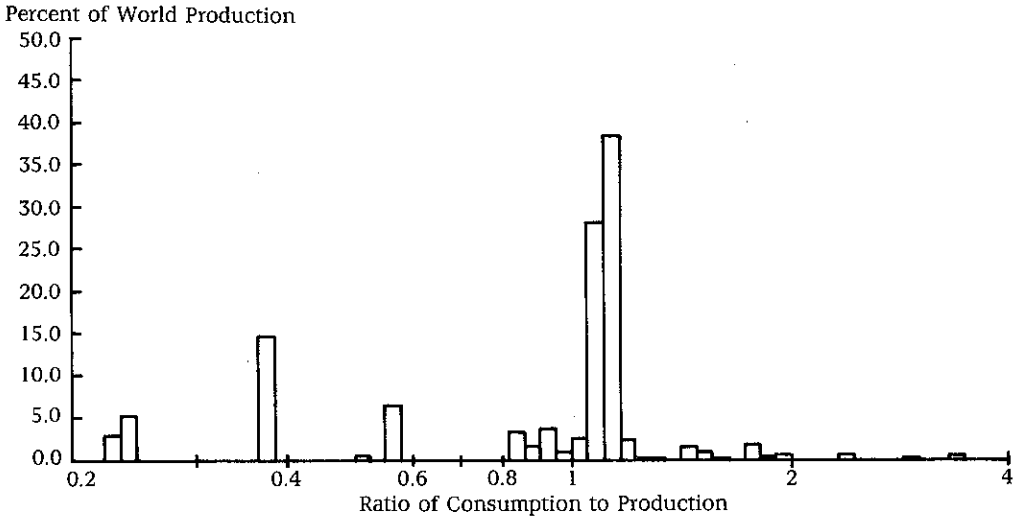
Philippines: M. Mangahas, A. E. Recto, and V. W. Ruttan, *Production and Market Relationships for Rice and Corn in the Philippines*, Technical Bulletin 9 (Los Baños: International Rice Research Institute, n.d.). The data refer to the estimated average marketed proportion of production.

Taiwan: Randolph Barker, "Rice Marketing in Asia: Implications for Research in Rice-Based Cropping Systems," in *Rice Research Strategies for the Future* (Los Baños: International Rice Research Institute, 1982), pp. 437-459.

Thailand: Ammar Siamwalla, *Rice in the Thai Economy* (Bangkok: Thammasat University, 1979), p. 88. (In Thai.)

Note: Bangladesh was East Pakistan prior to 1971.

Figure 1—Distribution of the ratios of consumption to production in wheat, 1976-78

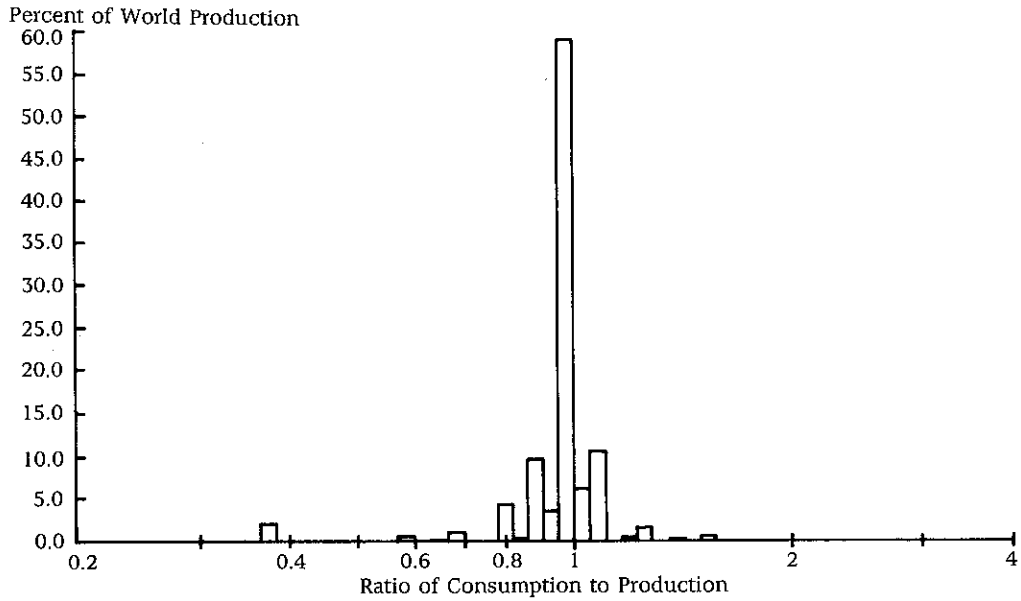


Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Notes: Countries where wheat production is negligible are excluded.

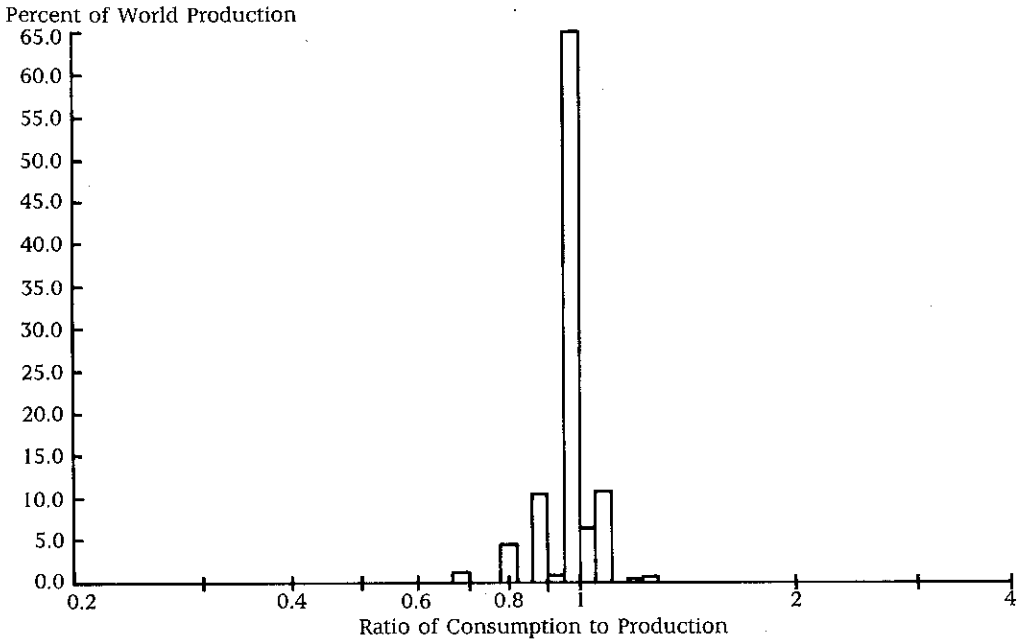
Countries with consumption to production ratios exceeding 4.0 that are not included and their ratios are: Bangladesh (5), Japan (25), Democratic People's Republic of Korea (6), Republic of Korea (24), Taiwan (6), Angola (8), Colombia (11), Costa Rica (6), Denmark (8), Ecuador (6), Honduras (57), Jordan (5), Lebanon (7), Libya (6), Mozambique (34), Nigeria (105.59), Norway (6), Paraguay (16), Peru (7), Venezuela (760), Yemen Arab Republic (9), People's Democratic Republic of Yemen (6), Zaire (54), and Zambia (35).

Figure 2—Distribution of the ratios of consumption to production in rice, 1976-78



Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains,* FG-38-80 (Washington, D.C.: USDA, December 1980).

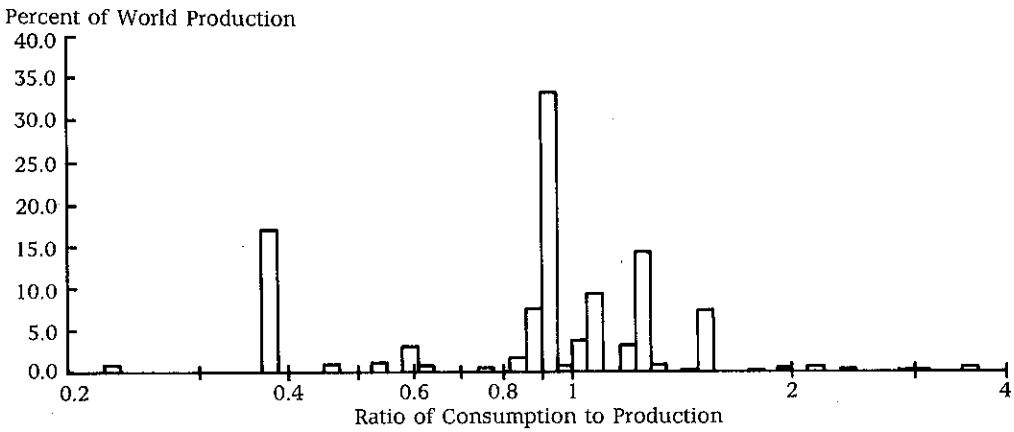
Figure 3—Distribution of the ratios of consumption to production in rice, Monsoon Asia, 1976-78



Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-38-80 (Washington, D.C.: USDA, December 1980).

Notes: Papua New Guinea and Singapore are not included because their rice production is negligible. Hong Kong is excluded because its ratio of consumption to production is 117.

Figure 4—Distribution of the ratios of consumption to production in rice, outside Monsoon Asia, 1976-78



Source: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-38-80 (Washington, D.C.: USDA, December 1980).

Notes: Countries with consumption to production ratios below 0.2 or above 4.0 that are not included and their ratios are: Australia (0.16), Algeria (7), France (11), Jamaica (42), Mauritania (11), Saudi Arabia (154), Senegal (5), Somalia (8), and Syria (125).

Table 3—Ratio of trade to production by region, 1950-79

Ratio	1950-54	1955-59	1960-64	1965-69	1970-74	1975-79
			(percent)			
Monsoon Asia						
Exporting countries	5.7	6.0	6.0	4.2	4.6	4.8
Importing countries	7.3	7.1	6.2	4.7	4.7	3.8
Outside Monsoon Asia						
Exporting countries	24.5	27.7	23.6	28.5	25.3	27.0
Importing countries	47.5	71.5	55.8	64.6	69.0	85.7

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: December 1979); U.S. Department of Agriculture, Economic Research Service, *Twenty-six Years of World Cereal Statistics, 1950-75* (Washington, D.C.: USDA, July 1976); and U.S. Department of Agriculture, *Agricultural Statistics* (Washington, D.C.: USDA, 1960 and 1966).

Notes: All percentages are for gross imports or exports. Data for the 1950s may understate ratios for Monsoon Asia and overstate ratios for outside Monsoon Asia due to lack of explicit trade data for Korea and Vietnam.

exports of the Democratic People's Republic of Korea. Making up for the general decline of these traditional prewar exporters are some new entrants, most notably Pakistan, the People's Republic of China, and Japan.

On the importing side, there has been a steady and substantial decline in the role of Asian importers, the only exceptions being Indonesia, and as already mentioned, the Republic of Korea. Japan and the People's Republic of China have become exporters. A number of raw-material exporting and rice-importing countries, such as the Philippines, Malaysia, and Sri Lanka, have either switched to exporting small quantities of rice or have reduced their imports substantially. India has virtually left the rice market, only occasionally making barter-type rice borrowing deals with its neighbors, the U.S.S.R. and Vietnam.

Tables 4 and 5 illustrate developments since 1960, during which time the market share of Monsoon Asia, particularly for imports, has declined rapidly. The concomitant rise of the United States among the exporters and of the Middle East and Sub-Saharan Africa among the importers may also be noted.

Next, the concentration of trade in a few major countries is examined. To do this, the Hirschman-Herfindahl measure or index is employed. This is simply the sum of the squares of the shares of each actor in total trade. If the entire trade is in the hands of one seller, the index will be 1. This is the maximum value of the index. If the trade is divided equally among n actors, then the value of the index is 1/n. If it is divided unequally among these n firms, then the index will take a value between 1/n and 1, depending on how dominant the largest participant is. Thus the larger the number of participants and the less concentrated the trade among the participants, the smaller the value of the index will be.

In Table 6 we report the Hirschman-Herfindahl index as calculated for rice and wheat exporting and importing countries. It is clear that there is more concentration among the exporting countries in the wheat market than in the rice market. Rice production can be carried out profitably over a wide range of factor proportions (particularly the land/man ratio) and is produced in countries with widely varying factor endowments.[6] Wheat production, on the other hand, appears to allow a much narrower range of substitutability between land and other inputs, and hence its production and exports are more concentrated in the "new" lands of North America, Australia, and Argentina.

The wider dispersion of wheat among importers, in comparison with rice, may seem surprising at first. Because of the much smaller total volume of rice traded,

[6] This point is argued (in a time-series context) for Indonesia by Clifford Geertz, *Agricultural Involution: The Processes of Ecological Change in Indonesia* (Berkeley, Cal.: University of California Press, 1963).

Table 4—Rice trade of rice-exporting countries and their share of the world market, selected periods

Region/Country	Average Annual Net Exports				Net Exports as a Share of Gross World Exports			
	1961-63	1969-71	1976-78	1978-80	1961-63	1969-71	1976-78	1978-80
	(1,000 metric tons)				(percent)			
Asia	4,177.7	4,789.4	4,492.3	5,978.3	64.0	61.6	47.9	57.3
Burma	1,682.3	694.3	474.0	546.7	25.8	8.9	5.1	5.2
China, People's Republic of[a]	554.0	1,414.7	1,260.3	1,150.7	8.5	18.2	13.4	11.0
Japan	-178.7	593.0	-5.0	395.3	-2.7	7.6	-0.1	3.8
Kampuchea	249.3	90.0	13.0	-127.0	3.8	1.2	0.1	-1.2
Korea, Democratic People's Republic of	7.3	81.7	256.7	310.0	0.1	1.1	2.7	3.0
Nepal	173.3	245.0	113.3	65.0	2.7	3.2	1.2	0.6
Pakistan	216.8	426.0	808.0	1,012.3	3.3	5.5	8.6	9.7
Taiwan	51.7	23.7	123.7	302.3	0.8	0.3	1.3	2.9
Thailand	1,421.7	1,221.0	1,558.3	2,323.0	21.8	15.7	16.6	22.3
Central and South America	228.7	379.3	717.7	128.5	3.5	4.9	7.7	1.2
Argentina and Uruguay	41.2	149.7	243.0	233.4	0.6	1.9	2.6	2.2
Bolivia, Costa Rica, Nicaragua, and Panama	-18.7	8.9	42.6	46.6	-1.0	0.1	0.5	0.5
Brazil	65.0	104.7	206.7	-299.3	1.0	1.3	2.2	-2.9
Colombia	-11.7	7.3	52.0	24.7	-0.2	0.1	0.6	0.2
Ecuador and Venezuela	16.7	24.7	7.0	-16.3	0.2	0.3	0.1	0.1
Guyana and Surinam	105.7	91.0	144.4	173.7	1.6	1.1	1.6	1.5
Mexico	31.3	-7.3	20.0	-34.3	0.5	-0.1	0.2	-0.3
European exporters	212.0	495.0	297.7	384.7	3.2	6.4	3.2	3.7
Italy	154.7	443.7	251.0	331.7	2.4	5.7	2.7	3.2
Spain	57.3	51.3	46.7	53.0	0.9	0.7	0.5	0.5
Other exporters								
Australia	52.0	132.3	270.7	352.0	0.8	1.7	2.9	3.4
Egypt	242.3	647.0	156.7	138.7	3.7	8.3	1.7	1.3
United States	1,022.0	1,633.7	2,184.7	2,499.7	15.7	21.0	23.3	24.0
Total of major exporters	5,934.7	8,076.7	8,119.8	9,481.9	91.0	103.9	86.6	90.9
Minor exporters	590.0	-301.2	1,258.2	947.1	9.0	-3.9	13.4	9.1
Adjusted gross exports	6,524.7	7,775.5	9,378.0	10,429.0	100.0	100.0	100.0	100.0
Imports of 27 major exporters	245.3	103.2	217.0	807.3	...	...	...	...
World gross exports	6,770.0	7,878.7	9,595.0	11,236.3	...	...	...	...

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-22-82 (Washington, D.C.: USDA, September 1982).

Notes: Pakistan excludes East Pakistan or Bangladesh. The figures for minor exporters include reporting errors. Adjusted gross exports are world gross exports less imports of 27 exporters.

[a] USDA figures for 1969 and 1970 world exports and exports of the People's Republic of China are adjusted upward to account for exports from the People's Republic of China to North Vietnam.

there is probably a floor to the extent of fragmentation that is economically possible. In other words, the rice market is forced to be more concentrated by the diseconomies of small-scale trade. The decline in the indexes for imports and exports may therefore be caused partly by the larger volume traded in the late 1970s, which permitted a higher degree of fragmentation.

The final characteristic of the rice trade is the extreme volatility in the volume traded by each individual country. Instability in the amount of the commodity traded is not unique to rice, but what makes rice

Table 5—Rice trade of rice-importing countries and their share of the world market, selected periods

Region/Country	Average Annual Net Imports				Net Imports as a Share of Gross World Imports			
	1961-63	1969-71	1976-78	1978-80	1961-63	1969-71	1976-78	1978-80
	(1,000 metric tons)				(percent)			
Monsoon Asia	3,304.9	4,501.0	3,720.9	3,300.5	60.3	64.2	42.2	33.1
Bangladesh	478.8	638.3	234.0	279.3	8.7	9.1	2.7	2.8
Hong Kong and Singapore	555.0	518.0	522.0	514.0	10.1	7.4	5.9	5.2
India	417.7	347.0	25.3	-347.0	7.6	4.9	0.3	-3.5
Indonesia	1,044.0	692.0	1,707.3	1,928.0	19.0	9.9	19.3	19.3
Korea, Republic of	15.3	591.7	46.0	366.3	0.3	8.4	0.5	3.7
Lao People's Democratic Republic	108.7	49.7	104.7	72.3	2.0	0.7	1.2	0.7
North Vietnam	-3.7	489.7	402.3	169.0	-0.1	7.0	4.6	1.7
South Vietnam	-172.3	355.0	n.a.	n.a.	-3.1	5.1	n.a.	n.a.
Sri Lanka, Malaysia, and the Philippines	861.4	819.6	679.3	318.6	15.7	11.7	7.7	3.2
Middle East	310.7	440.2	1,393.7	1,747.0	5.7	6.3	15.8	17.5
Sub-Saharan Africa	443.0	609.8	1,459.2	1,823.6	8.1	8.7	16.5	18.3
Western European importers	475.7	565.4	773.0	688.0	8.7	8.1	8.8	6.9
U.S.S.R. and Eastern Europe	383.0	558.0	644.0	836.2	7.0	8.0	7.3	8.4
Western hemisphere	297.2	394.1	405.7	530.9	5.4	5.6	4.6	5.3
Total of major importers	5,214.5	7,068.5	8,376.5	8,926.2	95.1	100.8	94.9	89.5
Minor importers	269.6	-56.8	449.6	1,042.2	4.9	-0.8	5.1	10.5
Adjusted gross imports	5,484.1	7,011.7	8,826.1	9,968.4	100.0	100.0	100.0	100.0
Exports of 81 importers	636.2	294.0	442.2	925.9	...	...	...	...
World gross imports	6,120.3	7,305.7	9,268.3	10,894.3	...	...	...	...

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-22-82 (Washington, D.C.: September 1982); and Food and Agriculture Organization of the United Nations, Committee on Commodity Problems, Intergovernmental Group on Rice, *Report*, various issues (Rome: FAO, various years).

Notes: Bangladesh was East Pakistan prior to 1971. Figures for North Vietnam include trade with the People's Republic of China. North Vietnamese figures for 1976-80 are for the Socialist Republic of (North and South) Vietnam. The Middle East includes Jordan, Kuwait, Lebanon, Syria, Yemen Arab Republic, People's Democratic Republic of Yemen, United Arab Emirates, Israel, Iraq, Iran, Saudi Arabia, Algeria, Libya, and Morocco. Sub-Saharan Africa includes Chad, Mali, Upper Volta, Nigeria, Somalia, Tanzania, Angola, Zaire, Madagascar, Mozambique, Mauritius, Reunion, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Senegal, Sierra Leone, and South Africa. Western European importers include Belgium-Luxembourg, France, Federal Republic of Germany, the Netherlands, Austria, Greece, Norway, Portugal, Sweden, Switzerland, United Kingdom, Denmark, Turkey, and Cyprus. Eastern European importers include Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and Yugoslavia. The Western hemisphere includes Cuba, the Dominican Republic, Haiti, Jamaica, Trinidad and Tobago, Canada, El Salvador, Guatemala, Honduras, Chile, and Peru. Minor importers include countries such as Papua New Guinea and reporting errors. Adjusted gross imports are world gross imports less exports of 81 importers. n.a. means not applicable.

unusual is the size of the coefficient of variation of the volume of individual countries' trade. To show this volatility, the coefficients of variation of the residuals from a linear trend of the rice and wheat trade for each of the 13 selected Asian countries were analyzed. The median values are 43.1 for rice and 27.4 for wheat, and for 11 out of the 13 countries examined, the coefficient of variation for rice is higher than for wheat. The full results are reported in Table 7.

Although the residual volume of internationally traded rice is clearly the cause of the instability, not many observers have realized the full implications of this fact. The final section of this chapter shows that it is this characteristic of the world rice market that makes it unusual.

Table 6—Hirschman-Herfindahl index of concentration for rice and wheat importers and exporters, 1961-63 and 1978-80

Commodity	1961-63	1978-80
Rice		
Imports	0.063	0.048
Exports	0.145	0.117
Wheat		
Imports	0.034	0.036
Exports	0.248	0.235

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, FG-22-82 (Washington, D.C.: USDA, September 1982); and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Note: The Hirschman-Herfindahl index is the sum of the squares of the shares of each actor in total trade.

Shifts in Production and Comparative Advantage in Asia

The changing trade patterns discussed above are, in part, a consequence of the technological shift resulting from the introduction of HYVs in South and Southeast Asia in the late 1960s. Rice production has always been strongly influenced by environmental factors. When the new varieties came out, they were adopted almost entirely in the irrigated areas. Comparison of data in the first and third columns of Table 8 brings out that association.

Table 8 also shows that the level of irrigation, and with it the level of HYV adoption, tends to be consistently lower among traditional exporters. This is because the major traditional exporters and Bangladesh cultivate their rice in the vast deltaic areas of mainland Monsoon Asia. These areas enjoyed a comparative advantage in rice production

Table 7—Coefficients of variation of rice and wheat trade for 13 Asian countries, 1961-80

Country	Rice			Wheat		
	Mean	Standard Error of Estimates	Coefficient of Variation	Mean	Standard Error of Estimates	Coefficient of Variation
	(metric tons)		(percent)	(metric tons)		(percent)
Bangladesh	-419.5	217.1	51.8	-1,005.8	455.2	45.3
Burma	805.9	343.8	42.7	-18.2	14.3	78.9
China, People's Republic of	1,257.0	502.9	40.0	-4,986.0	1,757.6	35.2
India	-241.9	185.2	76.6	-3,593.9	2,251.4	62.6
Indonesia	-1,046.0	450.4	43.1	-521.1	161.0	30.9
Japan	15.8	408.4	2,584.7	-4,470.2	340.1	7.6
Korea, Republic of	-247.3	268.9	104.5	-1,260.2	282.9	22.4
Malaysia	-302.3	79.2	26.2	-333.9	35.3	10.6
Nepal	190.5	80.2	42.1	-0.1	0.2	459.4
Philippines	-126.7	191.3	151.0	-570.3	77.9	13.7
Sri Lanka	-402.4	129.0	32.1	-540.4	109.7	20.3
Taiwan	95.2	120.8	127.0	-504.2	88.6	17.6
Thailand	1,623.6	571.2	35.2	-79.4	21.8	27.4

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables for Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables for Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-22-82 (Washington, D.C.: USDA, September 1982); U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Wheat, Corn and Total Coarse Grains Supply Distribution for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-13-82 (Washington, D.C.: USDA, April 1982); U.S. 1980 (computer printout); and Bangladesh, Bureau of Statistics, *Statistical Digest of Bangladesh* 9 (Dacca: Bangladesh Government Press, 1973).

Notes: The coefficients of variation are calculated as the absolute value of the ratio of the standard error estimate from a linear time-trend estimation to the mean of net exports. Bangladesh was East Pakistan prior to 1971.

Table 8—Share of total area of rice sown with high-yielding varieties (HYVs), irrigated and shallow rainfed, selected Asian countries, 1973-75

Country	Total Area Irrigated	Total Area Irrigated or Shallow Rainfed	Total Area Sown with HYVs
		(percent)	
Traditional importers			
Bangladesh	11	33	15
India	39	72	28
Indonesia	39	59	40
Malaysia	63	88	38
Philippines	40	96	62
Sri Lanka	50	83	67
Traditional exporters			
Burma	16	96	6
Nepal	17	92	18
Thailand	24	49	7
Vietnam	13	70	30[a]
Others			
China, People's Republic of	90	98	n.a.
Japan	96	96	n.a.
Korea, Republic of	92	100	26
Pakistan	100	100	39

Sources: Columns 1 and 2: Randolph Barker and R. W. Herdt, *Rainfed Lowland Rice as a Research Priority—An Economist's View*, Research Paper 26 (Los Baños: International Rice Research Institute, 1979), Appendix Table 1, p. 34. Column 3: Adelita C. Palacpac, *World Rice Statistics* (Los Baños: IRRI, 1978), Table 13, p. 40.

Notes: Shallow rainfed area is that having a maximum water depth of 5-15 centimeters. Percentages for total area sown with HYVs are for 1974/75. n.a. means not applicable.

[a] This figure is for South Vietnam only.

with the traditional low-input technology as a consequence of their favorable man/land ratios (except in Bangladesh).

With increasing population pressure in Asia in the postwar period both in the delta areas and elsewhere, it is clear that an increasing share of the output growth will have to come from increased output per hectare. In the first instance, this means better irrigation. Unfortunately, the topography of these delta areas, once considered so favorable to rice production, makes the task of irrigating them, particularly using conventional canal methods, considerably more expensive.[7] Furthermore, irrigation projects in these areas tend to have long gestation periods. To take one example, the Chao Phraya system in Central Thailand included the following major construction activities: construction of a diversion dam at Chainat, which was completed in 1950; construction of a storage dam (Bhumiphol), which was completed in 1957; construction of a second storage dam (Sirikit), which was completed in 1964; and initiation of a ditches and dikes project in 1964. It was not until 1969 that dry-season cropping began in earnest in the command area. Even now, the HYV technology is used there only during the dry season. Inadequate drainage makes it unprofitable to use HYVs during the wet season.

Thus, the main effect of the HYVs has been to lessen the advantage of the traditional exporting countries relative to the traditional importers in Asia, at least during the first decade after their introduction. These trends may not persist, however.

[7] Ngo Quoc Trung, "Economic Analysis of Irrigation Development in Deltaic Regions of Asia: The Case of Central Thailand," in *Irrigation Policy and Management in Southeast Asia* (Los Baños: International Rice Research Institute, 1978), pp. 155-164.

First, the area that researchers of the International Rice Research Institute (IRRI) have identified as amenable to the adoption of the semi-dwarf HYVs includes both the irrigated and the shallow rainfed areas.[8] The second column of Table 8 indicates the combined percentage of areas under these two categories. With the addition of the potentially HYV-amenable shallow rainfed area, the disadvantage of the traditional exporters is no longer so clear-cut. One traditional exporter that has begun to exploit this potential is Burma, which since 1975 has rapidly expanded its area sown with HYVs from about 7 percent in 1975 to 28 percent in 1980. This expansion took HYVs into nonirrigated areas as well as into irrigated areas, and it accounted for a dramatic growth in Burmese rice production without any substantial expansion in irrigation.[9]

Second, the alleged irrigation disadvantages in the major delta areas have arisen from the preoccupation with gravity systems that held until recently. The potential of tubewell irrigation has been demonstrated only during the late 1970s in one major delta area, Bangladesh; its use remains latent among the traditional exporters.[10] The possibilities should not be exaggerated, however, for the incremental growth in output in the delta areas will still largely come from expansion of the dry-season crop. The wet-season crop, which makes up the bulk of the output from these areas, will probably remain stagnant during the present decade, because of the difficulties with water control, particularly drainage.

Japan, Korea, and Taiwan, the three East Asian countries that constituted the Japanese Imperial free-trade area in prewar days, were actually the pioneers of the HYV revolution. These countries went through rapid technological changes in the 1920s and 1930s (in Japan's case, even earlier) in an attempt to meet Japan's needs.[11] They anticipated much of the strategy guiding the breeding work that ultimately led to the development of the celebrated IR8. They had the world's major—indeed the only effective—centers of scientific work on rice before IRRI was established. Since the Second World War, the technology lead that the East Asian countries held over their other Asian neighbors has been maintained, and if anything, increased, particularly during the 1960s when fertilizer prices in these semi-industrialized countries were declining rapidly.

However, in contrast to the absolute advantage that these countries have in rice production, it is likely that the productivity increases experienced by their nonagricultural sectors have been so massive as to make them experience a growing comparative disadvantage in rice production, even though the technological level of their rice production may be high and rising. Without a dramatic increase in rice productivity, we would expect these three countries to import huge quantities of rice. As it turned out, Taiwan and the Republic of Korea, which before the war supplied large quantities of rice to Japan, saw their exports rapidly dwindle and, in the case of the Republic of Korea, turn into imports. Japan, on the other hand, saw its normally large imports shrink and by the late 1960s turn into exports.

The usual explanation for this shift has been that Japan's policies are so powerful that they have actually reversed the trend set in motion by its growing comparative disadvantage in rice. Foremost among these policies is the extremely high protection for domestic rice production. Rice prices in the East Asian countries are usually multiples of the world rice prices.

Developments in Japan are summarized in Figure 5. This figure shows the movements of real prices of rice in constant yen for both

[8] The shallow rainfed area is defined as area having a maximum water depth of 5-15 centimeters. See Randolph Barker and Robert W. Herdt, *Rainfed Lowland Rice as a Research Priority—An Economist's View*, Research Paper 26 (Los Baños: International Rice Research Institute, 1979). The arguments and data used in the next few paragraphs rely a great deal on this paper.

[9] Food and Agriculture Organization of the United Nations, Committee on Commodity Problems, Intergovernmental Group on Rice, *Rice Production Policy of Burma* (CCP: RI 82/8), February 1982.

[10] For a fascinating account of earlier irrigation developments in another major delta area, see Robert Sansom, *The Economics of Insurgency in the Mekong Delta of Vietnam* (Cambridge, Mass.: Massachusetts Institute of Technology Press, 1970), particularly chapters 7 and 8.

[11] See Yujiro Hayami, Vernon W. Ruttan, and Herman M. Southworth, eds., *Agricultural Growth in Japan, Taiwan, Korea, and the Philippines* (Honolulu: University Press of Hawaii, 1979), Figures 2-8 (p. 47), pp. 70-71, and p. 93. See also Shigeru Ishikawa, *Economic Development in Asian Perspectives* (Tokyo: Kinokuniya, 1967), pp. 94-109.

producers and consumers. The real producer price clearly moved up following the enactment of the Agricultural Basic Law in 1961.[12] It rose about 45 percent during the six-year period, 1961-67. It then declined partially, but began to rise again in 1972. The consumer price changed less dramatically.

Superimposed on these changes, however, was the equally dramatic appreciation in the real value of the yen as the Japanese industrial export machine started rolling. The same diagram shows the corresponding decline of the real exchange rate (yen per dollar) since 1961.[13] The most dramatic decline was between 1961 and 1973, when it fell by more than a third (or the yen appreciated somewhat more than 50 percent). This decline, of course, reflects the rapid productivity gains made by Japanese industry at the time—gains that Japanese agriculture could not possibly match.

The policy of high prices for agriculture in the face of the real yen appreciation means that agriculture must be heavily protected. In sum, when the Japanese government has a target increase in the domestic price of rice in real (constant) yen, its relationship to implicit protection may be written:

$$p_d = p_w \cdot \pi + \theta_N,$$

where

p_d ≡ the nominal domestic price,
p_w ≡ the nominal world price in dollars,
π ≡ the exchange rate, and
θ_N ≡ the implied level of protection.

We may convert these into real variables by deflating them with a yen deflator, d_y, since they are expressed as yens.

$$p_d/d_y = p_w \pi/d_y + \theta_N/d_y,$$

or, using the dollar deflator $d_\$$:

$$p_d/d_y = p_w/d_\$ \cdot d_\$ \pi/d_y + \theta_N/d_y.$$

That is, real domestic price of rice = (real world price of rice) · (real exchange rate) + real protection.

Whereas the real world price of rice (in constant dollars) has been essentially trendless during the postwar period, the target domestic price of rice (in constant yen) has increased, particularly after 1961. That in itself would have caused an increase in the divergence of domestic and world prices, but with the substantial decline in the real exchange rate, the level of protection necessary had to become even larger.

In similar calculations for the Republic of Korea and Taiwan (Figures 6 and 7), the results are less dramatic, as are the policies themselves. The shift to a high price policy took place in 1968 in Korea and in 1973 in Taiwan.[14] The movements in the real exchange rates are not as striking for these two countries. They, however, may not faithfully reflect the underlying shifts as well as those for Japan because stringent foreign exchange controls were in force in both countries for much of the period under review, making evaluation of the real exchange rate a less meaningful exercise.

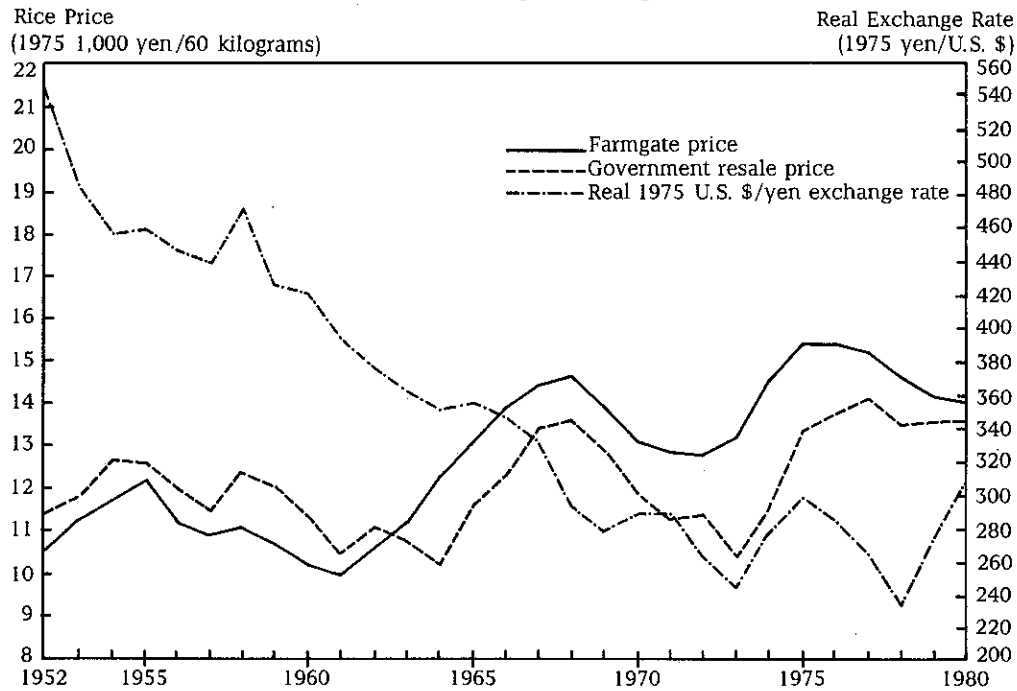
Table 9 provides a summary of the results in Monsoon Asia of the forces influencing production. We have fitted trend lines to the production data, after dividing the 1961-80 period into three subperiods: 1961-67, 1967-73, and 1973-80. The periods for Pakistan are somewhat different. These specifications are based on and adequately reflect the turning points in the production histories of

[12] The following account is based on Yujiro Hayami et al., *A Century of Agricultural Growth in Japan* (Tokyo: University of Tokyo Press, 1975), pp. 72 ff.

[13] The real exchange rate is defined as the nominal exchange rate (in yen per dollar) multiplied by the dollar deflator and divided by the yen deflator. The yen deflator was the GDP deflator for the International Monetary Fund, *International Financial Statistics: Supplement on Prices* (Washington, D.C.: IMF, 1981). The GDP deflator for the United States from the same source was compared with the c.i.f. manufacturing unit value index deflator taken from the International Bank for Reconstruction and Development, *Commodity Trade and Price Trends.* Although the two dollar deflators gave differing quantitative results, the qualitative implications were similar; the GDP deflator was used in order to be consistent with other parts of this report.

[14] See Pal Yong Moon, "The Evolution of Rice Policy in Korea," *Food Research Institute Studies* 14 (No. 4, 1975): 381-402; and H. Y. Chen, W. F. Hsu, and Y. K. Mao, "Rice Policies of Taiwan," *Food Research Institute Studies* 14 (No. 4, 1975): 403-417.

Figure 5—Real rice prices and the exchange rate, Japan, 1952-80



Sources: Price (government purchase price, brown rice, second grade, and government resale price to wholesalers in 1975 yen per 60 kilograms): Nosui Chosa Iinkai, *Kaitei Nihon Nogyo Kiso Tokei* [Revised Japanese Basic Agricultural Statistics] (Tokyo: Norin Tokei Kyokai, 1977), p. 376; Japan, Ministry of Agriculture, Forestry and Fishing, Bureau of Economics, Department of Statistical Information, *Pokketo Norin Suisai Tokei* [Pocket Statistics for Agriculture, Forestry, and Fishing] (Tokyo: Norin Tokei Kyokai, 1981), p. 195. Nominal exchange rate and Japanese GDP deflator: International Monetary Fund, *International Financial Statistics: Supplement on Exchange Rates* (Washington, D.C.: IMF, 1982); and International Monetary Fund, *International Financial Statistics: Supplement on Prices* (Washington, D.C.: IMF, 1982). U.S. dollar deflator: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, 1981).

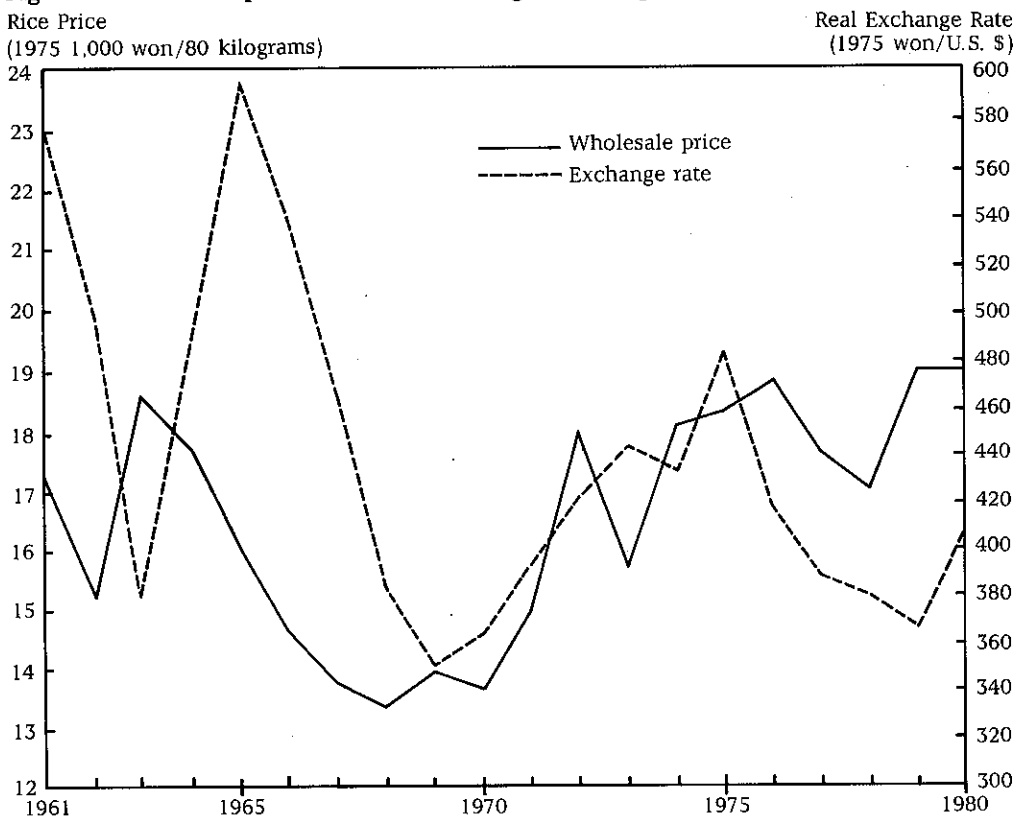
these countries.[15] Because a host of factors is reflected in these results, the contrasts cannot be expected to be as obvious as in Table 8, for example, where only a few factors are examined. Also, the area and yield decomposition is unsatisfactory because the data were not sufficient to permit separating the area-increase component further into growth due to multiple cropping and to expansion of net cropped area. Nevertheless, some broad trends may be discerned. The superiority of the performance of the traditional importers over the exporters clearly emerges, particularly in the middle period, when the HYV revolution was at its height. The tapering-off of that advantage in the last period is also clear. The steady, if unspectacular, production growth of the East Asian countries may also be noted, particularly that of Japan.

Shifts in Consumption in Asia

Table 10 assembles data and various estimates of certain important consumption

[15] Statistically, we find that this periodization is an appropriate one for the production series as judged by the t-statistic of the coefficient for time, and more importantly by the lack of autocorrelation, as reflected in the Durbin-Watson statistic. The only exception is Pakistan, where there appears to be a dramatic jump between 1968 and 1969. For Pakistan, we have used instead the periods 1961-69, 1968-69, and 1969-80.

Figure 6—Real rice prices and the exchange rate, Republic of Korea, 1961-80



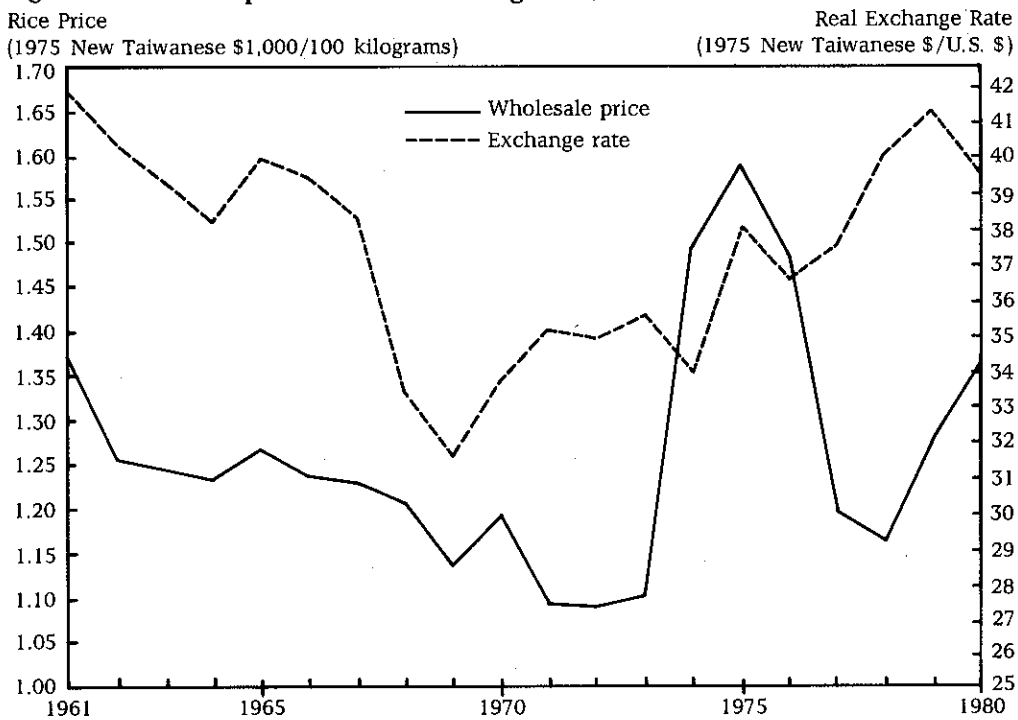
Sources: Price (wholesale, good quality in 1975 won per 80 kilograms): Republic of Korea, National Bureau of Statistics, Economic Planning Board, *Korean Statistical Yearbook, 1973* (Seoul: National Bureau of Statistics, 1973); Republic of Korea, National Bureau of Statistics, Economic Planning Board, *Korean Statistical Yearbook, 1981* (Seoul: National Bureau of Statistics, 1981); and Republic of Korea, National Bureau of Statistics, Economic Planning Board, *Major Statistics of the Korean Economy* (Seoul: Economic Planning Board, 1978). Nominal exchange rate and GDP deflator: International Monetary Fund, *International Financial Statistics: Supplement on Exchange Rates* (Washington, D.C.: IMF, 1981); and International Monetary Fund, *International Financial Statistics: Supplement on Prices* (Washington, D.C.: IMF, 1981). U.S. dollar deflator: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, 1982).

parameters for the 14 selected Asian countries. The data on consumption are generally poorer than production data. Our attempt to decompose consumption growth into that due to population growth (which equals income elasticity times the growth of GNP per capita), and that due to domestic real price movements (which equals price elasticity times the rate of price increase) must be regarded cautiously, as the disaggregated figures depend largely on elasticity parameters that are somewhat fragile.

Bearing these caveats in mind, broad conclusions may nevertheless be drawn from Table 10. Quantitatively, the generally dominant influence of sheer population growth as opposed to income and price effects should be noted. This is an encouraging result, inasmuch as the estimates of the population effect are more robust than those of the other two effects. On the other hand, since the population experience has been uniform for all of the countries listed in Table 10, except the East Asian countries, it is necessary to consider income and price effects to explain the variations in consumption growth experience.

With a few exceptions to be discussed below, the measurable effects of prices and incomes have been low, both because the

Figure 7—Real rice prices and the exchange rate, Taiwan, 1961-80



Sources: Price (wholesale price, ponglai second grade, Taipei in New Taiwanese $ per kilogram): Taiwan, Council for Economic Planning and Development, *Taiwan Statistical Data Book* (Taipei: Council for Economic Planning and Development, 1980); Taiwan, Directorate Council of Budget, Accounting and Statistics, *Monthly Bulletin of Statistics* 8 (Taipei: Directorate Council of Budget, Accounting and Statistics, July 1980). Nominal exchange rate and Taiwan GDP deflator: Asian Development Bank, *Key Indicators of Developing Member Countries of ADB*, various issues (Singapore: Federal Publications, various years). U.S. dollar deflator: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, 1982).

elasticities are low and because incomes and prices have only moved slightly. Japan is noteworthy in this respect. Contrary to the general belief, the real price of rice for Japanese consumers (in constant yen) has gone up only a little since 1961. The only discernible influence on Japanese rice consumption has been from income growth, which at Japanese income levels can be expected to be negative. Even here the effect is relatively small, although it is possible (given the discrepancy in the last column) that the income elasticity has become even more negative over the years.

The countries that show large income or price effects are Indonesia, Sri Lanka, Burma, and the People's Republic of China. The Indonesian growth is certainly due to the rapid growth in aggregate income, particularly since 1966, and is one of the major reasons why Indonesia is a major importer despite an impressive production performance throughout the period. Sri Lanka's experience has been somewhat erratic, and income and price are clearly inadequate explanations, as a major role has probably been played by changes in the rationing system.[16] The same applies to Burma. The People's Republic of China seems to have enjoyed a high rate of consumption increase. Without adequate price series, it is difficult to judge how much of it is due to prices, although the

[16]See James D. Gavan and Indrani Sri Chandrasekera, *The Impact of Public Foodgrain Distribution on Food Consumption and Welfare in Sri Lanka*, Research Report 13 (Washington, D.C.: International Food Policy Research Institute, 1979).

Table 9—Growth of production, area, and yield, selected Asian countries, 1961-80

Country	1961-67				1967-73				1973-80			
	Area	Yield	Production	Contribution of Yield Growth to Production Growth	Area	Yield	Production	Contribution of Yield Growth to Production Growth	Area	Yield	Production	Contribution of Yield Growth to Production Growth
	(percent/year)											
Traditional importers												
Bangladesh	1.84	0.41	2.25	18	0.46	-0.15	0.31	Negative	0.47	2.22	2.68	83
India	0.76	-1.23	-0.47	Negative	0.67	3.05	3.72	82	0.92	0.72	1.65	44
Indonesia	2.11	0.25	2.37	11	1.30	3.48	4.78	73	0.94	2.93	3.87	76
Malaysia	2.86	2.27	5.13	44	4.32	2.65	6.97	38	-1.76	0.70	-1.06	n.a.
Philippines	-0.07	2.58	2.51	103	0.52	2.19	2.71	81	1.56	3.93	5.49	72
Sri Lanka	-0.48	5.13	4.65	110	0.60	1.90	2.50	76	2.49	2.46	4.95	50
Traditional exporters												
Burma	1.91	-0.21	1.70	Negative	-0.22	0.81	0.59	137	0.18	3.30	3.48	95
Nepal	0.91	-0.76	0.15	Negative	1.25	1.02	2.27	45	0.46	-1.52	-1.06	Negative
Thailand	2.06	-1.11	0.95	Negative	1.64	1.79	3.43	52	3.48	-0.94	2.54	Negative
Others												
China, People's Republic of	2.22	7.75	9.97	78	2.75	0.47	3.23	15	-0.04	3.02	2.98	101
Japan	0.43	1.06	1.48	72	-3.39	1.54	-1.85	n.a.	-0.63	1.08	0.45	240
Korea, Republic of	1.61	0.85	2.46	35	-0.57	1.90	1.33	143	0.65	4.83	5.49	88
Pakistan	3.06	2.81	5.07	55	-0.04	32.30	28.13	115	2.80	1.14	3.94	29
Taiwan	0.14	3.63	3.77	96	-0.15	0.07	-0.08	n.a.	-1.28	1.77	0.49	361

Source: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains,* FG-22-82 (Washington, D.C.: USDA, September 30, 1982).

Notes: n.a. means not applicable. Estimations for Thailand and the People's Republic of China are made from data for 1962-80. The periodization for Pakistan is 1961-68, 1968-69, and 1969-80. Bangladesh was East Pakistan prior to 1971.

Table 10—The effects of changes in population, income, and prices on the growth of rice consumption, selected Asian countries, 1961-80

Country	Years	Population Effect	Income Effect	Consumption Growth at Constant Prices[a]	Price Effect	Predicted Consumption Growth	Actual Consumption Growth	Discrepancy[b]
				(percent/year)				
Traditional importers								
Bangladesh	1961-67	2.65	0.63	3.28	−0.31	2.97	2.09	−0.88
	1967-73	2.56	−1.11	1.45	−1.90	−0.45	0.28	0.73
	1973-80	2.26	1.78	4.04	−0.83	3.21	2.62	−0.59
India	1961-67	2.29	0.41	1.88	−0.56	1.32	−0.16	−1.48
	1967-73	2.15	0.52	2.67	−0.33	2.34	3.55	1.21
	1973-80	2.08	0.87	2.95	0.65	3.60	1.46	−2.14
Indonesia	1961-67	2.51	−0.52	1.99	1.93	3.92	0.88	−3.04
	1967-73	2.64	2.74	5.38	4.61	9.99	5.57	−4.42
	1973-80	1.99	2.62	4.61	−0.13	4.48	4.05	−0.43
Malaysia	1961-67	2.44	0.17	2.61	−0.30[c]	2.31	3.09	0.78
	1967-73	2.58	0.21	2.79	0.24	3.03	3.90	0.87
	1973-80	2.63	0.26	2.89	1.50	4.39	−1.15	−5.54
Philippines	1961-67	3.00	0.41	3.41	−0.23	3.18	2.30	−0.88
	1967-73	2.90	0.65	3.55	−0.70	2.85	3.59	0.74
	1973-80	2.57	0.96	3.53	2.17	5.70	2.83	−2.87
Sri Lanka	1961-67	2.49	0.45	2.94	−0.52[d]	2.42	2.78	0.36
	1967-73	1.79	1.86	3.65	−6.09	−2.44	−0.32	2.12
	1973-80	1.65	1.23	2.88	3.49	6.37	3.18	−3.19
Traditional exporters								
Burma	1961-67	1.80	0.18	1.98	−0.47	1.51	8.18	6.67
	1967-73	2.05	0.12	2.17	−5.29	−3.12	1.90	5.08
	1973-80	2.21	0.83	3.04	2.69	5.73	3.05	−2.68
Nepal	1961-67	1.99	1.17	3.76	−1.94[e]	1.82	−1.51	−3.33
	1967-73	2.30	−0.32	1.98	1.67	3.65	3.34	−0.31
	1973-80	2.13	0.28	1.85	1.07	2.92	1.08	−1.84
Thailand	1961-67	3.39	0.15	3.54	−0.50	3.04	1.93	−1.11
	1967-73	3.13	0.10	3.23	0.08	3.31	5.07	1.76
	1973-80	2.35	0.15	2.50	0.49	2.99	0.76	−2.23
Others								
China, People's Republic of	1961-67	2.53	3.28	5.81	n.a.	n.a.	4.34	n.a.
	1967-73	2.77	1.45	4.24	n.a.	n.a.	4.18	n.a.
	1973-80	1.64	2.40	4.04	n.a.	n.a.	2.95	n.a.
Japan	1961-67	0.97	−1.07[f]	−0.10	−0.42[g]	−0.52	−0.78	−0.26
	1967-73	1.30	−0.71	0.59	0.22	0.81	−0.12	−0.93
	1973-80	1.06	−0.25	0.81	−0.36	0.45	−2.16	−2.61
Korea, Republic of	1961-67	2.83	0.00	2.83	0.46	3.29	3.63	0.34
	1967-73	2.15	0.00	2.15	−0.33	1.82	1.56	−0.26
	1973-80	1.59	0.00	1.59	−0.17	1.42	5.20	3.78
Pakistan	1961-68	2.62	0.77	3.39	0.65	4.04	8.90	4.86
	1969-80	2.74	0.39	3.13	−0.78	2.35	2.64	0.29
Taiwan	1961-67	2.77	0.00	2.77	0.20	2.97	2.37	−0.60
	1967-73	2.10	0.00	2.10	−0.10	2.00	1.73	−0.27
	1973-80	1.94	0.00	1.94	−0.11	1.83	−2.77	−4.60

Sources: Population, income (GDP), and price (GDP) deflators: International Monetary Fund, *International Financial Statistics Yearbook, 1981* (Washington, D.C.: IMF, 1981); International Monetary Fund, *International Financial Statistics* 25 (Washington, D.C.: IMF, December 1982); and International Monetary Fund, *International Financial Statistics: Supplement on Prices* (Washington, D.C.: IMF, 1982), unless otherwise noted.

Income and price elasticities: R. W. Herdt, "Projecting the Asian Rice Situation: A Policy Framework," International Rice Research Institute, Manila, 1982 (mimeographed), unless otherwise noted.

Consumption: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, various issues (Washington, D.C.: USDA, various years).

(continued)

Table 10—Continued

Bangladesh: GDP: IMF, *International Financial Statistics* 25; and International Bank for Reconstruction and Development, *World Atlas* (Washington, D.C.: IBRD, 1976 and 1979). Prices (medium quality, Dacca, 1975 takas per maund; 1 maund = approximately 37.3 kilograms): Bangladesh, Bureau of Statistics, *Monthly Statistical Bulletin of Bangladesh* (Dacca: Bangladesh Government Press, September 1981); Bangladesh, Bureau of Statistics, *Statistical Pocketbook of Bangladesh* (Dacca: Bangladesh Government Press, 1979); and Bangladesh, Bureau of Statistics, *Statistical Digest of Bangladesh*, various issues (Dacca: Bangladesh Government Press, various years); Pakistan, Ministry of Finance, Planning and Development, Economic Affairs Division, Central Statistical Office, *Twenty-Five Years of Pakistan in Statistics, 1947-1972* (Karachi: Manager of Publications, 1972).

India: consumer price index: IMF, *International Financial Statistics* 25; price (wholesale rice price index, 1975 = 100): India, *Economic Survey, 1969/70* (New Delhi: Controller of Publications, 1970); India, *Economic Survey, 1981/82* (New Delhi: Controller of Publications, 1982).

Indonesia: price (average annual wholesale price in 1975 rupiahs per 100 kilograms): Indonesia, Central Bureau of Statistics, *Statistical Yearbook of Indonesia* (Jakarta: Central Bureau of Statistics, 1979); Indonesia, Central Bureau of Statistics, *Monthly Statistical Bulletin* (Jakarta: Central Bureau of Statistics, March 1982).

Malaysia: GDP (1970 U.S. $): International Bank for Reconstruction and Development, *World Atlas* (Washington, D.C.: IBRD, 1976 and 1980). Price (average wholesale price, Malaysian Kedah no. 2, in Malaysian $ per picul; 1 picul = approximately 60.48 kilograms): Richard H. Goldman, "Staple Food Self-Sufficiency and the Distributive Impact of Malaysian Rice Policy," *Food Research Institute Studies* 14 (No. 3, 1975): 251-293; Malaysia, Department of Statistics, *Monthly Statistical Bulletin of West Malaysia* (Kuala Lumpur: Department of Statistics, November 1976).

Philippines: price (Macan, first class, Manila, in 1975 pesos per 56 kilograms): Adelita C. Palacpac, *World Rice Statistics* (Los Baños: International Rice Research Institute, 1981).

Sri Lanka: GNP deflator and price (free-market retail price in 1979 rupees per pound): Richard Goldman and C. Peter Timmer, "The Scope and Limits of Food Price Policy in Sri Lanka," Harvard Institute for Development, Cambridge, Mass., August 1980. (Mimeographed.)

Burma: price (free manlart paddy price in kyat per long ton of Ngasein): T. R. Paris, S. K. Jayasuriya, and U. Thein Oo, "Changes in the Burma Rice Economy," Agricultural Economics Department Paper 82-10, International Rice Research Institute, Los Baños, 1982. (Mimeographed.)

Nepal: price (retail consumer price index for coarse rice, 1972/73 = 100): Nepal Rastra Bank, *Quarterly Economic Bulletin* 16 (Nos. 2-3, 1982).

Thailand: price (wholesale, 5 percent broken, Bangkok, 1975 baht per metric ton): Palacpac, *World Rice Statistics*.

People's Republic of China: GNP (billions of 1980 U.S. $): Arthur G. Ashbrook, Jr., "China: Economic Modernization and Long-Term Performance," in *China Under the Four Modernizations*, Part 1, ed. U.S. Congress, Joint Economic Committee (Washington, D.C.: Government Printing Office, 1982), p. 104.

Japan: price (government resale price to wholesalers in 1975 yen per 100 kilograms): Nosui Chosa Iinkai, *Kaitei Nihon Nogyo Kiso Tokei* [Revised Japanese Basic Agricultural Statistics] (Tokyo: Norin Tokei Kyokai, 1977), p. 376; Japan, Ministry of Agriculture, Forestry and Fishing, Bureau of Economics, Department of Statistical Information, *Pokketo Norin Suisai Tokei* [Pocket Statistics for Agriculture, Forestry and Fishing] (Tokyo: Norin Tokei Kyokai, 1981), p. 195.

Republic of Korea: price (wholesale price, good quality, in 1975 won per 80 kilograms): Republic of Korea, National Bureau of Statistics, Economic Planning Board, *Korean Statistical Yearbook*, various issues (Seoul: National Bureau of Statistics, various years); Republic of Korea, National Bureau of Statistics, Economic Planning Board, *Major Statistics of the Korean Economy* (Seoul: Economic Planning Board, 1978).

Pakistan: price (wholesale price index): Pakistan, Ministry of Finance, Planning and Coordination, Statistics Division, *Pakistan Statistical Yearbook*, various issues (Karachi: Manager of Publications, various years); and Pakistan, Central Statistical Office, *Twenty-Five Years*.

Taiwan: price (wholesale price, ponglai second grade, Taipei in New Taiwanese $ per kilogram): Taiwan, Council for Economic Planning and Development, *Taiwan Statistical Data Book* (Taipei: Council for Economic Planning and Development, 1980); Taiwan, Directorate Council of Budget, Accounting and Statistics, *Monthly Bulletin of Statistics* 8 (Taipei: Directorate Council of Budget, Accounting and Statistics, July 1982).

Notes: n.a. means not applicable. Bangladesh was East Pakistan prior to 1971. Figures in this table are based on ordinary least squares estimates of growth rates of the specification:

$$\ln Y = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \varepsilon,$$

where

$Y \equiv$ population, GDP per capita, or real price,

$T_1 \equiv$ 1, 1961; 2, 1962; 3, 1963; . . . 7, 1967
7, 1968-80

$T_2 \equiv$ 0, 1961-67
1, 1968; . . . 6, 1973
6, 1974-80

(continued)

Table 10—Continued

$T_3 \equiv$ 0, 1961-73; 1,1974; . . . 7, 1980

$\beta_1 \equiv$ annual growth rate 1960-67,

$\beta_2 \equiv$ annual growth rate 1967-73, and

$\beta_3 \equiv$ annual growth rate 1973-80.

[a] Growth predicted as the sum of population and income effects where income effect is the product of the estimated growth rate and income elasticity.

[b] This is the actual minus the predicted consumption growth rate.

[c] Prices for 1961-76 only are used with an estimated growth rate of 42.5 percent between 1973 and 1974.

[d] This is a retail price.

[e] These are retail prices for 1962-80 only.

[f] An income elasticity of −0.1 is assumed.

[g] This is a wholesaler's resale price.

population and income effects between them seem to explain much of the increase that was observed.

A final point is to be noted. Consistently, for all of the countries included, the explained growth exceeds the actual growth during the period 1973-80—sometimes by substantial amounts. Two explanations suggest themselves. First, the income elasticity, which was mostly estimated from historical data, may have become too high by the 1970s, and second, worldwide economic changes that have taken place since 1973 may have shifted income distribution away from the high rice consumers in all these countries. At this time, the data are too limited for us to make any sound judgment.

Interaction with the Wheat Market

As a result of rice prices being high relative to wheat prices, a purely postwar phenomenon, wheat has made significant inroads in the rice market. We have constructed a long time series of the ratio of rice and wheat prices.[17] The results are shown in Figure 8. There is no doubt that the trend has been upward. The average ratio for the subperiod 1920-36 is 1.19, for 1950-66 is 1.91, and for 1967-77 is 2.74.

Explanations for this upward trend are problematic. Lack of adequate data prevent any further analysis of the increase in the postwar ratio relative to the prewar. Even for the postwar period, the following discussion should be regarded strictly as a preliminary attempt to explain a very complex phenomenon.

Table 11 provides some comparative data on worldwide wheat and rice production. Between the three different dates, the two cereals exhibit only slightly different growth rates in the volume produced (and consumed). This near parity in the outcome may result from significantly different shifts in demand and supply. In fact, the movements in relative prices clearly indicate that the two sources of changes do contribute differently.

Figure 9 shows the methods for decomposing demand and supply shifts that will be used below. During the time period examined, the quantity of cereal k (where k may be wheat or rice) produced and consumed increased from antilog OQ° to antilog OQ' because the equilibrium moved from point A to B. On the supply side, the actual

[17] For rice, the prewar data refer to Siam No. 1 f.o.b. Bangkok. The prewar data are derived from Wickizer and Bennett, *Rice Economy of Monsoon Asia*, and the postwar data are for the 5 percent broken f.o.b. Bangkok listed in the International Bank for Reconstruction and Development, *Commodity Trade and Price Trends*. For wheat we have used data for No. 1, 13 percent protein, No. 2 Hard and Dark Winter, and No. 2 Hard Winter, Kansas City, from the U.S. Department of Agriculture, *Agricultural Statistics*, various issues (Washington, D.C.: USDA, various years).

Figure 8—Ratio of world rice prices to world wheat prices, 1920-80

Sources: Rice, 1920-36 (Thai No. 1, white): V. D. Wickizer and M. K. Bennett, *The Rice Economy of Monsoon Asia* (Stanford, Cal.: Food Research Institute, Stanford University Press, 1941), p. 28. Exchange rates, 1920-36: James C. Ingram, *Economic Change in Thailand, 1850-1970* (Stanford, Cal.: Stanford University Press, 1971); and U.S. Federal Reserve System, Board of Governors, *Banking and Monetary Statistics* (Washington, D.C.: Government Printing Office, 1943). Rice, 1950-80 (Thai, 5 percent broken): International Bank for Reconstruction and Development, *Commodity Trade and Price Trends,* various issues (Washington, D.C.: IBRD, various years). Wheat, 1920-46 (Kansas City No. 2, hard winter) and wheat, 1947-77 (Kansas City No. 2, hard and dark hard): U.S. Department of Agriculture, *Agricultural Statistics,* various issues (Washington, D.C.: USDA, various years). Wheat, 1978-80 (Kansas City No. 1, 13 percent protein): U.S. Department of Agriculture, *Wheat Outlook and Statistics* (Washington, D.C.: USDA, November 1981 and July 1982).

realized change may be decomposed into a supply shift component, measured by AX, and a supply response component, measured by XB. Similarly, we may decompose the same change from A to B into a demand shift component (AY) and a demand response component (YB). Because the main purpose of this exercise is to explain why the real prices of rice and wheat have moved differently, the primary concern here is with the relative sizes of the demand and supply shifts. Notice that this decomposition assumes a competitive market, an assumption that is denied in other parts of the report. The justification for adopting this assumption is that in this section long-term changes are examined. The imperfections described in other sections would affect these calculations only slightly compared to the underlying demand and supply factors.

Exigencies of data and parameter availability have led us to adopt different tactics in estimating the supply and demand shifts. On the production side, supply elasticity estimates of 0.2 for rice and 0.4 for wheat are used in order to remove the price effect from

Table 11—Average world wheat and rice production and average rate of growth, selected periods

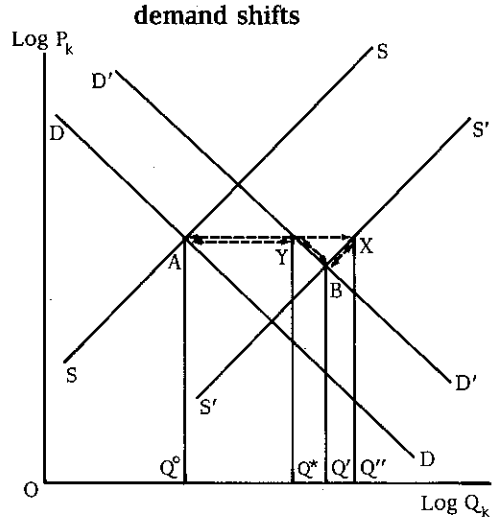
Period	Production: Wheat	Production: Milled Rice
	(million metric tons)	
1951-53	194.1	125.2
1965-67	289.2	179.0
1977-79	417.9	247.9

Period	Rate of Growth: Wheat	Rate of Growth: Milled Rice
	(percent)	
1951-53 – 1965-67	2.9	2.6
1965-67 – 1977-79	3.1	2.8
1951-53 – 1977-79	3.0	2.7

Sources: 1951-53: U.S. Department of Agriculture, Economic Research Service, *Twenty-six Years of World Cereal Statistics, 1950-1975* (Washington, D.C.: USDA, July 1976). After 1965: wheat: U.S. Department of Agriculture, Foreign Agricultural Service, "World Grains Situations/Outlook," *Foreign Agriculture Circular—Grains*, FG-11-81 (Washington, D.C.: USDA, March 12, 1981); rice: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-39-82, December 1982.

Note: Rice in this table is milled rice.

Figure 9—Decomposition of supply and demand shifts



the observed production change in Table 11.[18] Taking average prices in 1951-55 as a base and in 1976-80 as end points, the real wheat prices declined by 2.3 percent per year and the real rice prices by 0.54 percent per year. This means that the supply shifts taking place in rice were 2.8 percent per year and in wheat were 3.9 percent per year.[19] (Because world prices are used, the shift component also includes changes in policies that translate the world price into the domestic price of individual countries.) Obviously, these estimates are relatively insensitive to the estimate of rice price elasticity, but are sensitive to that of wheat price elasticity.

Such calculations obviously measure the extent of the supply shift that leads to the relative price change. Since the sizes of the price changes themselves are an important ingredient, the extent of the supply shift cannot be used to explain the price changes.

Next the consumption side is explored. As data are available only for the period 1961-80, the analysis below pertains to that period. We shall try to decompose the various factors that shift the demand for rice and wheat. The worldwide demand for the two cereals may be expressed:

$$C_k = \Sigma N_j \, f_{jk} \, (Y_j, \ldots),$$

where

[18] Valdés and Zietz report these figures, which were obtained by roughly averaging a number of estimates for individual countries. See Alberto Valdés and Joachim Zietz, *Agricultural Protection in OECD Countries: Its Cost to Less-Developed Countries*, Research Report 21 (Washington, D.C.: International Food Policy Research Institute, 1980), Appendix 2.

[19] These figures equal the growth figures in Table 11, plus the product of supply elasticity and price decrease per year. Thus, for rice the 2.7 percent per year reported in Table 11 has 0.54 × 0.2 percent = 0.1 percent added to it, and for wheat, the 3.0 percent has 2.25 × 0.4 = 0.9 percent added to it.

k ≡ rice or wheat,

C_k ≡ worldwide consumption of cereal k,

N_j ≡ population in country j,

$f_{jk}(.)$ ≡ per capita consumption function in country j of cereal k, and

Y_j ≡ per capita income in country j.

The function $f_{jk}(.)$ may include variables other than Y_j, including relative prices.

Taking total differentials and dividing by C_k:

$$dC_k/C_k = \sum_j (dN_j/N_j)\,[N_j\, f_{jk}(.)/C_k]$$

$$+ \sum_j N_j\, df_{jk}(Y_j, \ldots)$$

$$= \sum_j (dN_j/N_j)\,[N_j\, f_{jk}(.)/C_k]$$

$$+ \sum_j [N_j\, f_{jk}(.)/C_k] \cdot \partial f_{jk}/\partial Y_j$$

$$\cdot\ Y_j/f_{jk}(.) \cdot dY_j/Y_j$$

$$+ \text{ effects of excluded variables in } f_{jk}(.).$$

Thus,

$$C_k^* = \sum_j s_{jk} N_j^* + \Sigma s_{jk} \eta_{jk} Y_j^* + \text{remainder}, \quad (1)$$

where s_{jk} is the share of country j in world consumption of cereal k and η_{jk} is the income elasticity of k in j. The asterisk denotes the proportionate rate of growth of the variable to which it is attached.

Before presenting the results, we would like to point out what we are omitting by dumping residuals into the "remainder" term. The intention is to examine the more easily identifiable demand shifters in order to explain the relative price movements between wheat and rice. Price terms from the shifters are intentionally excluded.

Also excluded intentionally is the shift between food and feed use, which is particularly relevant for wheat. (Note that the income elasticity η_{jk} is income elasticity for direct human consumption only.) We believe that much of the shift of wheat into feed use is a consequence of the lowered real price of wheat and cannot therefore be used as an explanatory variable.

As U.S. Department of Agriculture (USDA) data do not provide income elasticities, data from the Food and Agriculture Organization of the United Nations (FAO) is used for this section only. The results of these calculations are presented in Table 12, together with the earlier results for the supply side. The row for population effect measures the first term on the right-hand side of equation (1), and the row for income effect measures the second term.

The results clearly show that the population of rice eaters ($\Sigma s_{jr} \cdot N_j$) has been growing faster than that of wheat eaters, largely because the consumption of rice is heavily concentrated in Asia, a part of the world whose population increase has in fact been between 2 and 3 percent per year, while wheat is still the preferred cereal of the temperate zone where the population increase has been more modest.

The results for the income effect are no less striking, although readers are again warned that the calculations rest on estimates of income elasticities that are somewhat fragile. The negative effect on wheat occurs because the negative income elasticity in temperate countries dominates the positive elasticities in the developing countries.[20]

We have thus analyzed three factors that could explain the movements of the relative prices of rice and wheat (Table 12). The results show that, first, the supply of wheat has been expanding faster than that of rice; second, the population in predominantly rice-consuming areas has been growing faster than that in predominantly wheat-consuming areas; and, third, the income elasticities among rice eaters are higher than among wheat eaters. Each of these three factors contributes to the tilting of the relative prices of rice and wheat by the same order of magnitude.

Let us stress that this analysis is an attempt to explain changes in the relative price of rice to wheat. There is no attempt here to explain why the level of rice prices tends to persist above that of wheat prices, even though the calorie contents of the two cereals are almost the same—a situation many consider paradoxical. It is sufficient to note that such a comparison is not valid

[20] The dominance of the U.S.S.R. in wheat consumption makes the results somewhat sensitive to assumptions regarding the income elasticity of that country; thus, a change in the value from −0.3 to 0 would make the aggregate income effect term for wheat change from −0.21 to 0.05.

Table 12—Autonomous shifts of supply and demand for rice and wheat, selected periods

Variable	Period	Rice	Wheat	Difference
		(percent/year)		
Supply shifts	1951-80	2.8	3.9	(+) 1.1
Demand shifts				
Population effect	1961-80	2.20	1.42	(+) 0.78
Income effect	1961-80	0.70	−0.21	(+) 0.91

Notes: The signs indicate the effect on the rice/wheat price ratio. Thus, for supply shifts, a positive difference refers to the excess of wheat supply shifts over rice supply shifts. For demand shifts, it is the other way around.

inasmuch as it sets the price of milled rice, a commodity that requires little further processing or preparation before eating, against wheat grain, which requires relatively more expensive and time-consuming processing and preparation. Once these processing costs are taken into account, the cost advantage of wheat over rice is no longer so clear-cut.[21]

Product Differences

Different qualities of rice are bought and sold in the world market. Rice is classified as short-, medium-, or long-grained and, of secondary importance, as nonglutinous or glutinous.

Of the different types of rice, long- and medium-grained rice dominate the production, consumption, and trade of rice. The short-grained variety is the preferred rice only in Japan, Korea, and Taiwan—in the last instance, that preference was the direct consequence of 60 years of Japanese occupation. Its role in the international market consequently depends on the extent to which these countries are buying or selling it. Glutinous rice consumption is even more specialized. It is produced and consumed as a staple food in the swathe of territory stretching from the Shan areas of northern Burma, northern and northeastern Thailand, the Lao People's Democratic Republic, and on into the mountain areas of Vietnam. It is also consumed in small quantities as dessert on festive occasions, or is fermented into rice wine, in most countries of East and Southeast Asia. Very little of this rice—about 100,000 tons out of an annual production of about 5-8 million tons—enters international trade. The bulk of the world rice trade is in nonglutinous rice.

Further grading is done according to the milling out-turn. The characteristic most often used in grading is the percentage of the grain that is broken. This is the standard adopted by the two major exporters, the United States and Thailand.

Although it is difficult to obtain numbers to compare precisely the price differences among the various grades and qualities of rice as against those of other cereals such as wheat and maize, the differentials were judged to be much larger for rice. To take an extreme example, one ton of Basmati rice will bring more than $600 per metric ton, while Thai C1 broken rice will bring less than $200. The two grades are not very different in nutritional value. We surmise that because rice prices are so high, rice is used almost entirely as human food; consequently aesthetic elements play a larger role in the pricing of the different grades than in cereals, which are also used as animal feed and where prices are more likely to reflect nutritional content alone.

These different grades and qualities further fragment an already thin market. Luckily there are possibilities for substitution, mostly in production. For example, although the different regions of the United States specialize in growing different types of rice, considerable substitution between medium- and long-grain rice is possible in Texas and between short- and medium-grain in California. These substitution possibilities tend to have the effect of reunifying the market. In an empirical study of rice prices, Petzel and Monke[22] argue that rice markets, spe-

[21] Nyberg makes this point concerning Indonesia. See Albert J. Nyberg, "Food Policy—Import Substitution or Import Dependence," *Kajian Ekonomi Malaysia* 14 (Nos. 1 and 2, 1979): 175-201.

[22] Todd E. Petzel and Eric A. Monke, "The Integration of the International Rice Market," *Food Research Institute Studies* 17 (No. 3, 1979/80): 307-326.

cifically the United States and Thai export markets, which account for about half the world trade, are essentially linked. Even though we accept their argument—much of our econometric work in Chapter 4 cannot be carried out without doing so—we have to be careful in interpreting the results. The United States and Thai prices are the only publicly quoted prices of rice in international trade. To the extent that the quotations are public, it is difficult to imagine the two series departing significantly from one another.[23] The covariation need not reflect integration since actual transaction prices can and do depart from the quoted prices—as we argue at length below.

The Thinness of the Rice Market

Rice market thinness is a much commented upon phenomenon. Given the vagueness that surrounds the term "thin market," it is by no means certain that there is as much agreement on the actual facts of the case as is implied by common terminological usage.[24]

As a starting point we shall characterize a thin market as one with relatively high transaction costs, more specifically, with high search costs. Despite, or perhaps because of, the prevalence of state trading almost everywhere, the international rice market seems to be able to support a number of brokerage houses located in the United States, Europe, Singapore, and Hong Kong that are able to earn not insignificant brokerage fees. Hard data for these fees do not exist, but fees of 5 or 10 percent are not uncommon. Such rates are almost inconceivable in the wheat trade.

Another clue that search costs are high is the lack of any clear price-discovery process. There is no "central" market price for rice prices, compared to, say, the London daily price or the New York world market price for sugar, or the Chicago Board of Trade futures prices for wheat, maize, or soybeans. The weekly quotations for the Bangkok f.o.b. price, which are used in the literature and will also be used later in this report, are not of much value in this price-discovery process. They are posted prices. Thai government regulations have made the posted price the minimum price that private exporters must demand of their buyers, otherwise no export license will be issued. In reality, when markets are soft, illicit discounts (on the order of 5-10 percent of the price) are given. When markets are tight, higher than posted prices are the norm.[25] It is clear then that there is considerable scope for price variation at any given time.

We digress at this point to justify our use of the f.o.b. Bangkok price series despite the misgivings expressed above. The discussion above is about the usefulness of the current quotation of that price to actual participants in the market wishing to buy and sell rice. There is clearly very little. On the other hand, the series does track the scarcity of rice fairly well, particularly as only annual averages of the price are used in this report.

A third clue that search costs are high is the experience of many countries that find themselves with a temporary surplus. In most instances they discover that it is not at all easy to unload their surpluses onto the world market. Frequently, the would-be

[23] An exception may occur when the price in the United States is at the floor set by the loan rate. During the period 1958-73 this floor was well above the world price, and the gap was covered by an export subsidy. Significantly, the subsidy was set at a rate equal to the difference between the U.S. domestic price and the weekly posted price of Thai rice.

[24] In an earlier survey Hayenga found only one use of the term, without an adequate definition. The concepts in the book are somewhat biased by a too simplistic division of markets into active ones with futures markets or inactive ones that are disappearing and likely to be replaced by vertically integrated firms or long-term contracts. There is no suggestion that thin markets may be a steady state. See Marvin L. Hayenga, *Pricing Problems in the Food Industry (With Emphasis on Thin Markets)*, North Central Regional Research Publication 261 (Madison, Wis.: University of Wisconsin Press, 1979).

[25] This is because export quotas are usually stringent when markets are tight. The Thai government usually varies its export taxes to absorb the quota-rents. The posted prices are set by a committee of private exporters, who have every incentive to keep these postings low during a tight market. When markets are soft, on the other hand, there is no quota-rent to be absorbed because nonbinding quotas are normally set. Then the committee (encouraged by the Ministry of Commerce) would try to act as a cartel, but exporters would in actual fact compete furiously against one another by giving discounts on the price set. For a picture of the working of this "cartel," see D. Usher, "The Thai Rice Trade," in *Thailand: Social and Economic Studies*, ed. T. H. Silcock (Canberra: Australian National University Press, 1967), Chapter 9.

sellers find that the quality of the rice they export is unacceptable to the buyers, which gives many of the sellers the impression that the only grades of rice that move in the world market are the better-quality ones. This is a mistaken impression: a great deal of the rice that moves internationally is of very low quality. What facilitates trade is not high or low quality as such, but whether the grades are sufficiently standardized to reduce the cost of the transaction. Temporary or new exporters are at a great disadvantage, as many of them do not possess the milling facilities to ensure standardization, nor is their exposure in the market long enough to generate stable expectations about the quality of rice they export. In other words, their rice has not acquired a reputation. Because buyers face high risks, they impose large discounts on the would-be sellers.

We have chosen to pin the label of "thinness" by using a performance criterion, namely the high search costs. What structural characteristics are responsible for this outcome? Traditionally, the answer has been the small number of participants. As shown in the section on trading patterns, however, this characteristic may turn out to be less relevant in the grain market, and probably not in any thin market.

The number of participants may not be as important as the stability of their presence. A market where the number of participants is small but stable and where the participants stay in the market continuously cannot survive long as a market, at least as an arm's-length market.[26] Sooner or later, vertical integration or long-term agreements between pairs of buyers or sellers will emerge to blunt the power that one or two buyers or sellers may be able to exert from time to time. A thin market may survive temporarily during the period before the vertical integration or before the conclusion of long-term agreements, but it must be regarded as an ephemerally thin market.

It is for this reason that we stress the importance of the instability of participation in the rice market. It is precisely because of this that we can observe a persistent thin market in rice. As long as participants float in or out of the market, long-term agreements are not a viable alternative. As long as trade channels are not established ruts, search costs are high. These high search costs can persist for considerable periods of time if the secular trend in the pattern of world production and consumption has been, as is the case with rice, "antitrade biased." This means that, over time, importing countries have been gaining in comparative advantage relative to exporting countries, so that growth in the volume of trade tends to lag behind the growth in production.

On top of this basic shift in comparative advantage, governments, swayed by their generally unpleasant experiences in the international market, have pursued a policy of maintaining a balance between domestic supply and consumption; in other words, a policy of self-sufficiency plus a policy of maintaining large domestic stocks. It is fair to say, however, that without the new technology, the desire for self-sufficiency would have been just that. It is the peculiar thrust of the technology that makes the desire a reality. The consequence for the world rice market has been to thin it considerably, particularly in the early 1970s.

[26] An "arm's-length" market is one in which participants select trading partners at random; that is, they do not trade regularly with the same partners.

3

CONDUCT

The world market influences the conduct of its participants, the national governments, in two ways. One way is through the price signal, a standard task performed by any market. Another influence is the "ambience" of the market. This term refers to two general structural features of the market: first, owing to the smallness of the market, a sudden entry or exit by a government may affect the market price. That is, the marginal cost (revenue) for the importer (exporter) is perceived to be greater (less) than the price. Second, the transaction cost is high because of the need to search for supplies (markets). The search may bring gains to both importer and exporter, but it inevitably entails costs: either out-of-pocket costs, such as brokerage fees, or costs in time lost, which may be valuable given the delicate role of rice in many countries' political affairs. This ambience of the rice market is the constant background against which its participants conduct their trade. It clearly has an impact on how they act.

Long- and short-run conduct are both considered in this report. The section on long-run conduct primarily addresses questions about rice production and investments to promote it, but there are also a few cases, such as rationing, in which policies affect long-run consumption. Both production and consumption policies, although domestically oriented, obviously affect the traded volume in the long run. The section on short-run conduct examines how governments cope with year-to-year fluctuations through trade and perhaps through storage strategies.

Long-Run Production Programs

As pointed out in Chapter 2, the proportion of rice that enters into trade, particularly in Monsoon Asia, is small. That domestic demand and supply are essentially in balance implies that domestic prices are not bound to the international price and, for any given year, may vary considerably across countries.[27] Domestic real rice prices of 13 Asian countries were correlated with the international real rice prices and the median value of the correlation coefficients was found to be only 0.28.[28]

Why do governments pursue a self-sufficiency policy? In particular, do price signals affect the pace at which that goal is pursued? To a small extent and in an indirect fashion, they do. Thus, Kikuchi and Hayami, using data for the Philippines, argue that the government of the Philippines varies its investment in irrigation in response to the expected rate of return on it.[29] A major factor influencing the social rate of return in their model is the current world price of rice. Thus, the pace of new construction in irrigation is, according to them, quite responsive to the current world price.

One possible mechanism through which the world rice price could enter into irrigation policies is the criterion adopted by international lending agencies, which are the main sources of finance for these projects. This point is also made by Kikuchi and Hayami. The World Bank, in particular, follows the orthodox economic method of

[27] See C. Peter Timmer and Walter P. Falcon, "The Political Economy of Rice Production and Trade in Asia," in *Agriculture in Development Theory*, ed. Lloyd Reynolds (New Haven: Yale University Press, 1975), pp. 373-408. See particularly Table 12.2, p. 376.

[28] The domestic rice prices were obtained from the sources listed in Table 10 and World Bank figures were used for world prices (International Bank for Reconstruction and Development, *Commodity Trade and Price Trends*).

[29] M. Kikuchi and Y. Hayami, "New Rice Technology and National Irrigation Development Policy," in *Economic Consequences of the New Rice Technology* (Los Baños: International Rice Research Institute, 1978), pp. 315-335.

valuing the rice produced by irrigation projects at the expected world price. The Asian Development Bank, another major source of funds for irrigation projects, also follows the World Bank's forecasts in its project evaluation. It would be interesting to consider how responsive the World Bank's forecasts are to current market prices and, incidentally, how accurate they are. However, the available time series was not long enough for a rigorous statistical study of the forecasts.

Figure 10 shows a comparison of the forecast in year *t* of what the price of rice (in 1970 U.S. dollars) will be in the year 1980, against the market price current in year *t*. From this slim data, only tentative conclusions may be drawn. First, current market conditions do appear to affect the forecast, the turning points of the latter following that of the former by about two years. Second, the amplitude of fluctuations in the forecast price is considerably smaller than the actual market price. Thus, in the long run, there seems to be a link between the price signal from the world rice market and government production policies. The evidence for the link, and perhaps the link itself, is weak, however.

It is our hypothesis that the market ambience is a more important factor influencing the behavior of national governments (particularly in Asia) than price, because foreign supplies of rice are believed to be unreliable. In this view, rice supplies from domestic sources are held to be more valuable than similar rice available from foreign sources in the sense that a shortfall (relative to trend) in domestic rice will be a greater spur to government efforts to increase home production than an equivalent shortfall in availability of foreign rice.[30] The evidence supporting this view, it must be admitted, is scanty and subjective, but we nevertheless feel strongly that this is the more reasonable hypothesis.

Our first bit of evidence is obtained by tracing the actual behavior of some governments. Take the case of the Philippines. When it launched the Masagana 99 program to increase rice production in May 1973, world rice prices were rapidly rising; thus lending support to the view that the price signal was the main inducement. Actually, the program followed a particularly disastrous harvest from typhoons and the tungro virus in 1972/73.[31] Much of the preparatory work for the program was done as a consequence of these domestic production problems, well before the change in the international market situation in late 1972 and in 1973. No doubt the difficulties faced by the Philippine procurement agency eased the task of the program advocates, but the primary reason the program was adopted, in our view, was the domestic supply problem.

The Indonesian experience in the mid and late 1970s is even more conclusive. Its harvests in 1975/76, 1976/77, and 1977/78 were persistently poor because of heavy brown planthopper (wereng) infestation, at a time when rice was available at a low price in the international market. Furthermore, the plentiful foreign exchange earnings from petroleum would normally have adversely affected production of all tradable crops, and indeed production of Indonesia's export crops was stagnating at the time. The general presumption then was that rice would be no exception.

However, the prospect of importing rice in ever larger quantities—Indonesia was then importing about 2 million tons per year—led to some major policy shifts. Irrigation projects were accelerated and rice prices were increased. Of greater importance, however, were a sharp increase in fertilizer subsidies and a stepping up of research efforts.

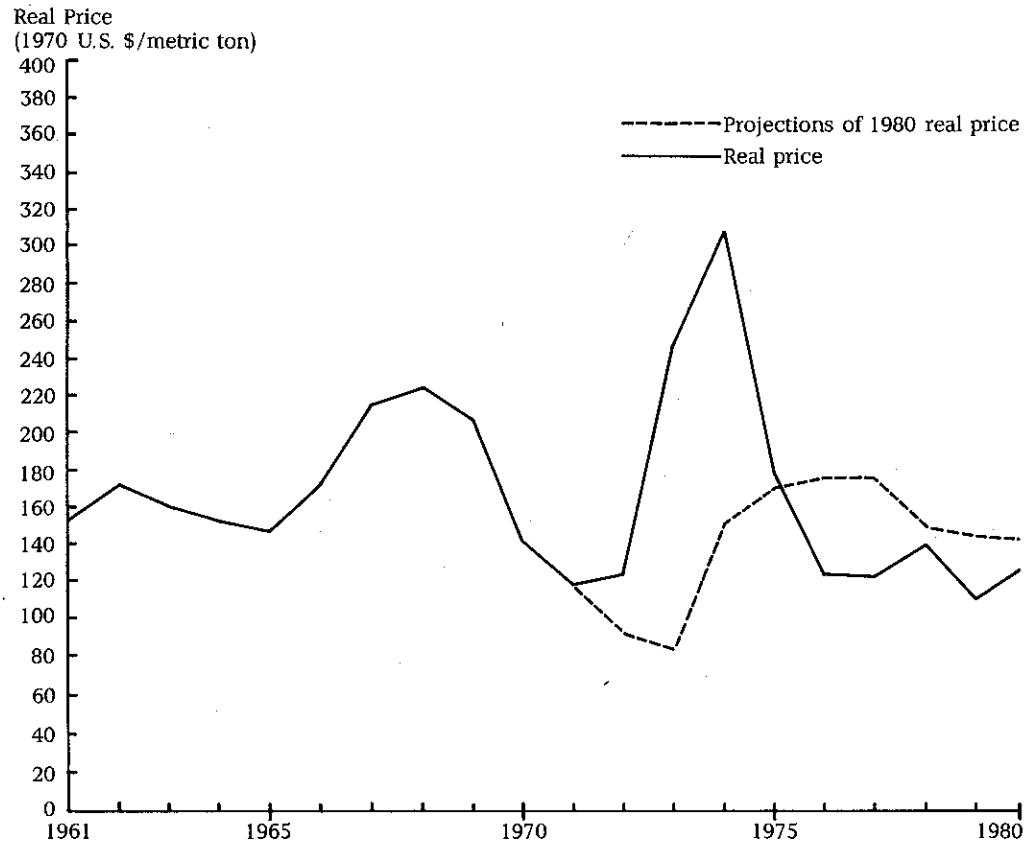
On fertilizer, there was a sharp downward revision in the urea/paddy price ratio from 2.46 in September 1978 to 1.11 in December 1978.[32] This was done in connection with a devaluation of the rupiah. Rice prices were allowed to move up almost the full extent of the devaluation, but fertilizer prices were

[30] At the level of the present argument, we need not be too precise about what will make the two shortfalls equivalent, but the two shortfalls should increase domestic prices by equal amounts. For countries that are small participants, where foreign elasticity of supply (or demand in the case of exporters) is infinite, the issue would never arise, and the hypothesis is irrelevant.

[31] The problem was compounded by a large drawing down of stocks in 1971/72, preceding the elections in 1972.

[32] See Adelita C. Palacpac, *World Rice Statistics, 1982* (Los Baños: IRRI, 1982), p. 91.

Figure 10—Constant world rice prices, 1961-80, and projected prices, 1971-80



Sources: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, 1982); and International Bank for Reconstruction and Development, Economic Analysis and Projections Department, unpublished data.

kept essentially at the same level, making the Indonesian fertilizer/rice price ratio one of the most favorable in Asia.

At the same time, the government also proceeded vigorously on the research front. Although it relied at first on planthopper-resistant varieties developed by IRRI, it recognized the need to develop within Indonesia the research capacity that is essential to cope with the constantly evolving biotypes of the brown planthopper. Already, this new research capacity has contributed to the development of newer varieties of rice.[33]

Our third strand of evidence concerning the higher value placed on domestic supply lies in the asymmetry in the attitudes of the governments of importing and exporting countries toward production growth. Of particular interest are the policies followed in the wake of the HYV revolution of the mid-1960s. Consistently, it is the importing countries that have aggressively pushed for the adoption of these new techniques. The Bimas-Inmas programs to increase production in Indonesia and the Masagana 99 program in the Philippines are Southeast

[33] See R. H. Bernsten, B. H. Siwi, and H. M. Beachill, *The Development and Diffusion of Rice Varieties in Indonesia,* Research Paper 71 (Los Baños: International Rice Research Institute, 1982).

Asian examples. Before these programs, India had experimented with a variety of programs designed to stimulate foodgrain production.[34] It was not until the late 1970s that an exporting country, Burma, launched a similar program. Thailand, the main Asian rice exporter, has always been ambivalent about promoting rice production. In line with the points that we have been making, its policies have generally been directed toward marketing its rice overseas rather than promoting production at home. When the government did expend resources that resulted in increased production, for example, on irrigation, it was motivated more by the desire to increase farmers' income than to obtain more rice. There is another contrast between the importers' programs and Thailand's. The importers' programs tend to be "wagers on the strong," in a geographical sense, favoring already wealthy and productive areas and resisting the political temptation to spread out thinly. The deeply felt need to increase production is responsible for this approach. The Thai government policy on production, on the other hand, lacks this clear focus.

Long-Run Consumption Programs

Long-run conduct may be affected not only by production policies, but by government programs on the distribution and consumption side. Almost all South Asian countries, for example, have rationed food distribution or food-for-work programs whose origins go back to the Second World War.[35] These ration shops impose a constraint on government policies. They must be "fed" with foodgrain supplies. The requirements thus imposed by the system have led governments to expand their role in the foreign trade of foodgrains to the point of monopolizing it. Over time, the ration shops have come to be supplied by government domestic procurement and by imports.

For these governments, the availability of wheat, with its already low price, relative to rice, further cheapened by food aid programs, has been a major factor in expanding the role of wheat in such predominantly rice-eating areas as Sri Lanka, South India, and Bangladesh. The mix of available foodgrains in these shops has tilted in favor of wheat. Table 13 indicates some comparative levels and growth rates of wheat consumption in three South Asian rice-eating countries with consumption programs as against four Southeast Asian rice-eating countries without such a program. Because the bases from which the growth rates are computed are small, we feel that the comparative levels are a better guide to the inroads made by wheat. Even excluding Indian figures, somewhat inflated by a sizable wheat-eating population, the consumption rates in South Asia tend to be larger than those in Southeast Asia.

Long-Term Policies of Three Major Countries

The People's Republic of China, India, and the United States are driven by different considerations in their formulation of rice policies and so are treated separately. For reasons that will become obvious, the ambience of the rice market is irrelevant in our consideration of these countries.

People's Republic of China

The People's Republic of China has been a regular importer of wheat for the last two decades and an exporter of rice since 1951. Many explanations have been put forward for this phenomenon. One has been the argument that China's internal transport system is so poor that it is probably more economical to export surplus rice and to import wheat to feed the deficit areas, which

[34] J. S. Sarma, *Growth and Equity: Policies and Implementation in Indian Agriculture,* Research Report 28 (Washington, D.C.: International Food Policy Research Institute, 1981).

[35] See: P. S. George, *Public Distribution of Foodgrains in Kerala—Income Distribution Implications and Effectiveness,* Research Report 7 (Washington, D.C.: International Food Policy Research Institute, 1979); Raisuddin Ahmed, *Foodgrain Supply, Distribution, and Consumption Policies within a Dual Pricing Mechanism: A Case Study of Bangladesh,* Research Report 8 (Washington, D.C.: International Food Policy Research Institute, 1979); Gavan and Chandrasekera, *The Impact of Public Foodgrain Distribution.*

Table 13—Wheat consumption in selected Asian countries, 1961 and 1980

Country	1961 Consumption		1980 Consumption		Annual Growth Rate	
	Total	Per Capita	Total	Per Capita	Total	Per Capita
	(1,000 metric tons)	(kilograms)	(1,000 metric tons)	(kilograms)	(percent)	
South Asia						
Bangladesh	178.8	3.25	2,588.0	29.29	10.9	8.4
India	14,218.0	32.39	36,027.0	54.29	5.0	2.8
Sri Lanka	311.0	30.67	750.0	50.88	6.5	4.6
Southeast Asia						
Indonesia	156.0	1.64	1,388.0	9.38	18.0	15.6
Malaysia	280.0	33.61	410.0	30.51	2.6	0.1
Philippines	393.0	13.94	799.0	16.51	3.3	0.5
Thailand	32.0	1.18	190.0	4.09	8.9	5.9

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980 (computer printout); U.S. Department of Agriculture, "Reference Tables on Wheat, Corn, and Total Coarse Grains, Supply-Distribution for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-13-82 (Washington, D.C: USDA, April 26, 1982); and Bangladesh, Bureau of Statistics, *Statistical Digest of Bangladesh* 9 (Dacca: Bangladesh Government Press, 1973).

Notes: Annual growth rates are based on logarithmic trend estimates. For Bangladesh, which was East Pakistan prior to 1971, wheat imports for 1961-71 are used as a proxy for wheat consumption.

are primarily the three major cities, Beijing, Shanghai, and Tianjin.[36] Although this hypothesis has been strongly criticized, it does raise interesting issues, the solutions to which remain elusive.[37] From where is rice procured for export? Why is it easy to ship rice out and difficult to move it around? How does the central government obtain rice from provincial and lower-level authorities?[38] The answers to these questions are essential if we are to understand fully the question that is of primary interest for this study: how does the central government decide on the long-term level of rice exports? Unfortunately, the answers are to this day shrouded in a great deal of controversy, compounded by a lack of adequate data.

A second line of attack sidesteps these microeconomic issues and hypothesizes that the Chinese government wishes to minimize the foreign exchange cost of attaining a target consumption level measured in calories.[39] The export of rice is then economically rational, as the ratio of its price relative to wheat is about 2, whereas the ratio of calorie content in the two cereals is about 1. This hypothesis carries a great deal of weight, because it is backed by statements made by the Chinese themselves.[40] As an explanation for short-run behavior, it is probably as good an explanation as any. It is important to note, however, that the Chinese production strategy concerning the relative weights to be placed on the two cereals is probably guided by

[36] Audrey Donnithorne, *China's Grain: Output, Procurement, Transfers and Trade* (Hong Kong: Economic Research Center, The Chinese University of Hong Kong, 1970).

[37] Feng-Hwa Mah, "Why China Imports Wheat," *China Quarterly* 45 (January/March 1971): 116-129.

[38] This question was raised by Donnithorne in the late 1960s. It is probably even more relevant now with decentralization explicitly part of government policy. See Donnithorne, *China's Grain*.

[39] Dennis L. Chinn, "A Calorie-Arbitrage Model of Chinese Grain Trade," *Journal of Development Studies* 17 (July 1981): 357-370. Similar views have been expressed in Mah, "Why China Imports Wheat," and numerous other publications. Chinn, however, develops an explicit model and attempts to test it. His finding that wheat imported over and above that required to restore the loss arising from grain exports has become negative in the 1970s rests on the inclusion of both rice and soybeans exports.

[40] Dick Wilson, "Interview with Chen Ming," *Far Eastern Economic Review*, May 21, 1964, p. 367. This is liberally quoted in various works discussing the issue, including Mah, "Why China Imports Wheat."

purely domestic considerations rather than by the fine calculations involved in the calorie-arbitrage model. The model would predict a bias against investments to expand wheat production and toward those to expand rice production, because at world prices rice investments are more remunerative. This certainly was not the case. A great deal of irrigation investment in the 1950s, for example, went to the wheat-growing regions of the North. In fact, wheat output expanded a little faster than rice between 1950 and 1960, in large part because of this emphasis on irrigation in the North.

Not to be overlooked is the government policy on grains versus nongrains. It appears from scattered evidence that surplus rice comes largely from the densely populated coastal areas centered around the Yangtze and the Pearl River deltas. These are relatively prosperous areas close to large urban centers.[41] Consequently, these areas have more competing activities and possibilities. Grain production has been generally unremunerative compared to other crops. A deemphasis on grains, we surmise, would have a stronger negative impact on rice production than on wheat, as cultivators have more possibilities to exit from rice production, but there is as yet only a small amount of evidence to substantiate this hypothesis.[42]

India

Domestic policies in India have always been directed toward self-sufficiency in foodgrains as a whole. There has been no measure—explicit or implicit—aimed at tilting government resources or taxation one way or the other between the rice and wheat components of the total foodgrain requirements. Because rice supplies are perceived to be generally tighter than wheat, however, there has been more intervention in the rice market. Domestic paddy and wheat prices are usually maintained close to unity, implying about a two-to-one ratio for milled rice to wheat grain, which is the same as the long-term international price ratio.

Unlike the People's Republic of China, however, India has not explicitly followed an arbitrage policy in the world market. Thus, India tends to obtain most of its wheat supplies from abroad when there is an aggregate foodgrain deficit, and usually unloads rice in the world market when the aggregate foodgrains are in surplus. A policy of simultaneously exporting rice and importing wheat has not been followed.

The United States

Foreign trade is a substantial component of U.S. rice production. But, despite its importance, the U.S. government does not exert close control over foreign trade. The main policy instrument used to attain price objectives has been to control production by controlling acreage, which at times has been quite tight. This is in sharp contrast to the less-developed Asian countries (including the exporters), where a tight control on foreign trade accompanies a somewhat uncertain hold on production levels.[43]

The central policy of the United States in rice is the price-support policy. Between 1957 and 1973, it caused U.S. prices to be higher than world prices. This gap was then closed by an export subsidy that varied monthly so as to equalize U.S. domestic and non-U.S. export prices.

The same period also saw the United States enlarge its role from that of a small exporter to become the largest exporter in the world. This enlargement was carefully controlled, and the main instrument of control was the acreage restriction. To be eligible for support prices, farmers had to agree to restrict their planting to their allotted acreage. There was, of course, no control on yield and, as will be shown below, yield increased rapidly while the acreage restriction was in effect. Congress would probably have permitted a more rapid expansion of acreage if yield had not increased.

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[41] Peter Nolan, *Growth Processes and Distributional Change in a South Chinese Province: The Case of Guangdong*, Research Notes and Studies 5 (London: Contemporary China Institute, London University, 1983).

[42] Ibid. Nolan reports that as a result of such shifts, Guangdong Province moved from a consistently surplus position (in rice) to an occasionally deficit position.

[43] See Leon A. Mears, "The Political Economy of Rice in the United States," *Food Research Institute Studies* 14 (No. 4, 1975): 319-357, for an interesting listing of contrasts between the United States and Asian producers.

Throughout the period 1958-73, the acreage decisions of the United States were quite responsive to world market conditions, which is one reason why the rice program never grew into an open-ended commitment to purchase and store. One important consequence was that the United States never became a seller (and storer) of last resort as it did with wheat. The world rice market, therefore, lacked an important stabilizing device that was available in the wheat market.

From 1973 until recently, the support price was below the world price and the allotment system was thus inoperative.

An Econometric Model of Short-Term Conduct

The Model

With the aid of an econometric model, we will now examine the short-run response of the governments to fluctuating world prices and domestic production.

The basic model is an extremely simple one. We focus on the net trade position of each country and write the following set of equations:

$$RX_i = \beta_0 + \beta_{1i}P + \beta_{2i}TV_i + \sum_{j=3}^{n} \beta_{ji}Z_{ji} + u_i, \quad (2)$$

where

$RX_i \equiv$ the net export of rice from country i,

$P \equiv$ the world price of rice,

$TV_i \equiv$ the production shortfall in the i_{th} country, and

$Z_{ji} \equiv$ various exogenous variables relevant for each country.

PW (world price of wheat) is included in the exogenous variables. For the United States, we have developed a more basic model involving production and consumption from which the RX equation is obtained.

These equations are closed by the equilibrium condition

$$\sum_i RX_i = 0. \quad (3)$$

Equations (2) and (3) together determine P and the individual RX_i's.

This specification is similar to earlier work by Badrul Islam and Falcon and Monke.[44] The methods adopted by these authors and in this report are quite distinct from the ones followed by Grant et al., Chaipravat and Pariwat, and Tsujii, all of whom attempt to go behind the net trade equation (2) to explain the more fundamental demand and supply behavior of consumers and farmers.[45] Because we have chosen a simpler model when these more complex models are available, some justification is necessary.

If we were to implement the latter, more structural approach, we would have to assume that the two basic sets of actors in the world rice markets are the consumers and producers whose behavior is to be captured by the estimated demand and supply equations. Government interventions where measurable, for example in tax rates or import or export quotas, would be entered as exogenous variables. Where there is a qualitative shift, it would be inserted through a dummy variable. There are two objections to this procedure, one pragmatic, the other theoretical.

First, it is impractical to list all policy measures, particularly the nontariff trade barriers that are so important in world rice trade.[46] In those quite common cases where importing or exporting is done solely by a government agency, it is not possible to

[44] Badrul Islam, "Price, Income, and Foreign Exchange Reserve Elasticity for Asian Rice Imports," *American Journal of Agricultural Economics* 60 (August 1978): 532-535; and Falcon and Monke, "International Trade in Rice."

[45] Warren R. Grant, Troy Mullins, and William R. Morrison, *World Rice Study: Disappearance, Production, and Price Relationships Used to Develop the Model*, ERS-608 (Washington, D.C.: U.S. Department of Agriculture, 1975); Olarn Chaipravat and Sayan Pariwat, *An Econometric Model of World Rice Markets*, Discussion Paper DP/76/14 (Bangkok: Bank of Thailand, 1976); and Hiroshi Tsujii, "An Econometric Model of the International Rice Market and Analyses of the National Rice Policies in Thailand, Indonesia, Japan and the U.S." (Ph.D. thesis, University of Illinois, 1974).

[46] FAO's Intergovernmental Group on Rice has done an excellent job of collecting the policy measures undertaken by the individual countries on an annual basis, but even so there are listings under the heading "levy or cess" labeled simply "variable," which is inadequate for an econometric specification.

separate government policy from actually observed trade data.

Second, even if we could specify all the policy variables unambiguously, these variables are not truly exogenous because they are not independent of the error terms: for example, in the supply equation. Governments do vary their policies in response to production fluctuations. In principle, it is possible to build and estimate a structural model for each country including an equation or equations for government behavior. Examples of such a model are Scobie's work on Egypt and Krishna and Chhibber's work on India.[47] But each of these models represents a major research effort. With the primary focus in this report placed on interaction among all the countries in the world rice market, it would be extremely expensive to undertake such an intensive research strategy.

We therefore avoid this approach and take the alternative tack of assuming that the government is itself an actor—in fact, the only actor that is relevant for the world market. To be sure, production and consumption within a country do influence the volume traded, but only after their assessment by the government. This is captured by the TV variable in equation (2).

The precise definition of TV varies from country to country depending upon the particular situation of the country and the exigencies of the data (see Appendix 1). A typical definition for country i is

$$TV_{it} = Q_{it} - C^*_{it} + S_{it} - S^*_{i,\,t+1},$$

where

Q_{it} ≡ the actual production of rice (or in some cases rice and wheat) in year t,

C^*_{it} ≡ the planned consumption for year t,

S_{it} ≡ the actual level of stock at the start of year t, and

$S^*_{i,\,t+1}$ ≡ the planned level of stocks at the end of year t.

C^*_{it} is alternatively the level of consumption that must be met to maintain either trend or mean per capita consumption. Similarly, $S^*_{i,\,t+1}$ is that estimated level of stocks that preserves a certain relationship between stocks and production during the entire period. As variables other than Q_{it} are data imposed a priori, which fluctuate little, TV primarily reflects the production fluctuations for the country.

P is the common world price of rice, taking the f.o.b. Bangkok price for 5 percent broken rice as an indicator. The use of this common price for the entire model reflects the assumption that, with all its imperfections, the rice market is nevertheless essentially interlinked and unified.[48]

The Z variables in equation (2) are chosen to reflect the specific variables that may affect the net trade of a given country. Some examples are the world price of wheat, foreign exchange availability, and the election-year dummy.

Conspicuous by its absence is the domestic price of rice. The reason for its exclusion is that the TV variable already reflects a particular planned domestic price policy of the government that is implicit in a choice of C^*_{it}. It is our hypothesis that C^*_{it} is what affects the planned import volume. The actual volume of imports determined by equation (2) may or may not enable the government to attain its target C^*_{it}. If it does not, the planned domestic price will also be unrealized. In this report, the question of whether the government succeeds in reaching its objectives and the domestic repercussions will be ignored.

Because data and information on the United States are readily accessible, and also because its policy has been directed more to production support and control rather than the volume of trade, a more structural approach was adopted for this U.S. submodel. See Appendix 1 for details concerning the data employed and the treatment applied to them.

It is necessary to reiterate that the aim of this exercise is to capture the behavior of governments, in particular their response to their own production shortfalls and to world prices. Our objective is not to build a forecasting model of rice prices. The model

[47] Grant M. Scobie, *Government Policy and Food Imports: The Case of Wheat in Egypt*, Research Report 29 (Washington, D.C.: International Food Policy Research Institute, 1981); and Raj Krishna and Ajay Chhibber, *Policy Modeling of a Dual Grain Market: The Case of Wheat in India*, Research Report 38 (Washington, D.C.: International Food Policy Research Institute, 1983).

[48] Petzel and Monke, "The Integration of the International Rice Market."

would be most inefficient for that purpose, for at any given moment there would be available a host of time-specific information about the intentions of the individual governments that would affect prices at least as strongly as the variables in our equations. For reasons already given, it was not possible to incorporate these time- and country-specific data into our equations.

Estimation Procedure

In the estimation procedure, the countries or groups of countries were first divided into two categories: the "small" price-taking participants in the world rice market, in the technical sense that for them the world price of rice can be considered exogenous, and therefore the ordinary least squares (OLS) procedure is justifiable, and those singled out as "large" participants, for which OLS is less appropriate. This latter group of countries includes Burma, the People's Republic of China, Indonesia, Thailand, and the United States. For these countries we experimented with various simultaneous-equation estimation techniques, in particular the instrumental-variable technique, as well as with the OLS method. The results obtained through the more sophisticated methods yielded either statistically poor results or results that were not substantially different from OLS. We have chosen to report only the OLS estimates in the text, and the alternative estimates in Appendix 2.

There are a number of equations that display autocorrelation problems. For these equations the Cochrane-Orcutt procedure was followed for reestimation.

We have adopted a frankly opportunistic approach to the choice of exogenous variables, experimenting for each country with a large number of possible candidates and choosing to report only those equations that perform best. There are, nevertheless, some countries or groups of countries whose behavior does not conform to any detectable patterns. These are Hong Kong, North Vietnam,[49] Zaire, and Ecuador, Peru, and Venezuela.[50] Their import levels are treated as exogenous.

Results

Tables 14, 15, and 16 present the estimates of equations for the small country groups. Tables 14 and 15 give the estimates for those countries where food aid in the form of rice plays no role or a minor one. The equations that require adjustments for autocorrelation are separated from the others and are shown in Table 15. In scanning the table, note that the dependent variable is net exports in every equation; imports are counted as negative exports. The results for the behavior of importing countries have to be interpreted carefully. In particular, if import demand varies inversely with price, then the coefficient for price in the trade equation must have a positive sign, the same sign as exporters.

Of the 42 country groups reported in Tables 14 and 15, only 13—less than one third—show any price responsiveness, with only Australia having a perverse sign. These results confirm our fear that there is an insufficient degree of responsiveness in the world rice market. On the other hand, rice production has been less volatile than production of other crops. Moreover, when production variation does occur, only a small part of it is transmitted to the world market, because the estimated coefficients of TV in the equations are almost universally less than 1.

Table 16 shows the results for those countries where aid flow has been significant. The dependent variable is net commercial exports. If the coefficient of variable A on the right-hand side takes a value close to 1, it implies that the aid replaces commercial imports, as is the case in Kampuchea and the Lao People's Democratic Republic, and in Cuba. If its coefficient is close to 0, it means that commercial imports proceed regardless of the volume of aid. This appears to have been the case in South Vietnam. For Bangladesh, the availability of foreign aid seems to have stimulated a further increase in commercial rice imports. Shipments received from the western half of Pakistan before 1971, when Bangladesh became a separate country, seem to have had little

[49] Estimates for South Vietnam for the period 1961-74 were significant, whereas estimates for North Vietnam were not significant (see Table 14). As a result, imports of North Vietnam for 1961-74 and the Socialist Republic of Vietnam (both North and South Vietnam), 1975-80, are treated as exogenous.

[50] Ecuador, Peru, and Venezuela are aggregated for the regression analysis.

Table 14—Net rice export regression results using ordinary least squares for 34 price-taking country groups, 1961-80

Country/Country Group	Independent Variables and Estimated Coefficients (t-Statistics)	R^2 ($\bar{R}^2$)	D.W.
Angola	$-12.937 + 0.021\ P + 0.999\ TV_{t-1}$ (−2.52) (2.52) (5.52)	0.74 (0.73)	1.15
Argentina and Uruguay	$10.598 + 0.945\ TV$ (0.48) (6.07)	0.67 (0.67)	1.72
Australia	$62.601 - 0.086\ P + 0.836\ TV$ (2.72) (−2.56) (16.84)	0.95 (0.95)	2.36
Austria, Greece, Norway, Portugal, Spain, Sweden, and Switzerland	$-60.587 + 0.074\ P + 0.660\ TV$ (−1.81) (1.47) (2.95)	0.40 (0.37)	1.88
Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and Yugoslavia	$-86.405 + 0.640\ TV$ (−1.22) (2.18)	0.21 (0.21)	2.37
Canada	$-21.201 + 0.037\ P - 0.429\ Y75C^{\dagger}$ (−2.28) (3.63) (−9.14)	0.86 (0.86)	1.63
Chad, Mali, and Upper Volta	$-46.635 + 0.024\ P + 0.291\ \frac{TV_t + TV_{t-1}}{2} + 111.04\ BOP$ (−5.36) (2.03) (3.53) (3.26)	0.74 (0.71)	1.04
Colombia	$-24.242 + 0.235\ TV + 181.76\ BOP$ (−2.61) (5.90) (3.95)	0.77 (0.75)	1.74
Cyprus and Turkey	$-0.883 + 0.588\ TV - 36.86\ BOP$ (−0.04) (2.68) (−0.34)	0.34 (0.31)	1.95
Dominican Republic, Haiti, Jamaica, and Trinidad and Tobago	$35.684 + 0.540\ TV - 362.22\ BOP$ (1.33) (2.60) (−2.25)	0.64 (0.62)	1.53
Guyana and Surinam	$32.786 + 0.281\ TV + 0.455\ TV_{t-1}$ (3.02) (3.85) (5.63)	0.81 (0.80)	1.81
India	$-939.28 + 0.036\ WSTV$ (−13.69) (11.13)	0.87 (0.87)	1.22
Iran	$-29.804 + 1.031\ TV_{t-1}$ (−1.06) (7.41)	0.76 (0.76)	2.24
Iraq	$-1.457 + 0.990\ TV$ (−0.10) (10.26)	0.85 (0.85)	1.77
Israel	$-81.310 + 0.011\ P - 1.410\ T + 250.64\ BOP$ (3.20) (1.33) (−6.22) (2.64)	0.79 (0.76)	2.37
Jordan, Lebanon, and Syria	$25.427 + 1.296\ TV$ (0.98) (4.77)	0.56 (0.56)	2.37
Korea, Democratic People's Republic of	$-68.094 + 0.173\ P + 0.782\ TV$ (−1.05) (1.73) (6.18)	0.69 (0.68)	1.62
Korea, Republic of	$-965.90 + 0.784\ P + 0.532\ TV + 1{,}833.1\ BOP$ (−4.51) (3.32) (5.68) (2.77)	0.75 (0.72)	1.39
Kuwait; Yemen Arab Republic; and Yemen, People's Democratic Republic of	$4.518 + 1.055\ TV$ (0.39) (8.13)	0.79 (0.79)	1.75
Madagascar	$30.278 + 0.287\ TV - 0.399\ PCI$ (1.79) (2.51) (−3.32)	0.74 (0.73)	1.93

(continued)

Table 14—Continued

Country/Country Group	Independent Variables and Estimated Coefficients (t-Statistics)	R^2 ($\bar{R}^2$)	D.W.
Mauritius, Mozambique, and Reunion	−78.789 − 5.282 T (−6.32) (−5.08)	0.59 (0.59)	0.94
Mexico	−138.47 + 614.51 BOP (−2.97) (2.85)	0.31 (0.31)	1.53
Nigeria	−105.07 + 0.300 P − 15.065 PO (−1.02) (1.94) (−4.27)	0.60 (0.57)	1.52
Pakistan	639.71 + 0.639 (TV · PD) − 1,757.7 BOP (5.06) (5.66) (−2.94)	0.78 (0.77)	3.09
Papua New Guinea	−12.979 − 3.150 T (−4.72) (−13.728)	0.91 (0.91)	1.54
Philippines	183.53 + 0.432 TV − 1,241.0 BOP − 181.73 ED (1.77) (3.79) (−2.64) (−2.34)	0.58 (0.53)	1.40
Saudi Arabia	−175.25 + 0.232 P − 6.739 PO − 8.203 T (−3.05) (2.84) (−2.07) (−1.98)	0.80 (0.77)	1.16
Singapore	−229.23 + 0.140 P + 0.009 AX − 0.009 Y75C‡ (−8.26) (3.80) (3.38) (−2.94)	0.57 (0.52)	2.69
Somalia and Tanzania	−6.837 − 4.663 T (−0.57) (−4.66)	0.55 (0.55)	1.80
South Africa	−35.595 − 3.420 T (−7.98) (−9.19)	0.82 (0.82)	1.83
Sri Lanka	116.72 + 0.471 TV_{t-1} − 0.469 QF (1.00) (2.26) (−3.18)	0.56 (0.53)	1.89
U.S.S.R.	−55.377 + 0.222 P + 1.213 TV (−0.47) (1.74) (5.63)	0.75 (0.74)	1.65
United Kingdom	−22.460 − 1.047 Y75C§ (−1.33) (−6.01)	0.67 (0.67)	1.69
West Africa	−214.46 − 21.071 T (−3.80) (−4.47)	0.53 (0.53)	0.98

Sources: Rice and wheat production, consumption, exports, imports, and stocks: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Prices: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, August 1978). The 1973 rice price is an estimate from the International Food Policy Research Institute based on IBRD data.

Total imports, foreign exchange, GNP, GDP, and population: International Monetary Fund, *International Financial Statistics Yearbook, 1979* (Washington, D.C.: IMF, 1979); International Monetary Fund, *Direction of Trade Yearbook*, various issues (Washington, D.C.: IMF, various years); International Bank for Reconstruction and Development, *World Atlas*, various issues (Washington, D.C.: IBRD, various years); United Nations, Department of International Economic and Social Affairs, *Demographic Yearbook*, various issues (New York: UN, various years); Food and Agriculture Organization of the United Nations, *Trade Yearbook*, various issues (Rome: FAO, various years); and U.S. Department of Commerce, Bureau of the Census, *World Population, 1977*, ISP-WP-77 (Washington, D.C.: Government Printing Office, 1978).

Pakistan: Pakistan, Ministry of Finance, Planning and Development, Economic Affairs Division, Central Statistical Office, *Twenty-Five Years of Pakistan in Statistics, 1947-1972* (Karachi: Manager of Publications, 1972).

Sri Lanka: rice ration: James D. Gavan and Indrani Sri Chandrasekera, *The Impact of Public Foodgrain Distribution on Food Consumption and Welfare in Sri Lanka*, Research Report 13 (Washington, D.C.:

(continued)

Table 14—Continued

International Food Policy Research Institute, 1979); and Central Bank of Ceylon, *Annual Report*, various issues (Colombo: Central Bank of Ceylon, various years).

Notes: Net rice exports are gross rice exports less gross rice imports in 1,000 metric tons milled equivalent on a calendar year basis. Observations for Angola, Chad, Mali, Upper Volta, Guyana, Surinam, Iran, and Sri Lanka are for the years 1962-80. West Africa includes Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Senegal, and Sierra Leone. Pakistan excludes East Pakistan or Bangladesh.

P represents International Food Policy Research Institute estimates of Thai 5 percent broken f.o.b. Bangkok rice prices in 1977 constant U.S. dollars per metric ton. TV is actual production less estimated consumption of rice in 1,000 metric tons milled equivalent in the USDA world production year prior to the corresponding calendar year of trade. Estimated consumption is time-fitted per capita rice consumption times annual population, if the time trend is found significant; otherwise it is average per capita consumption times population. TV_{t-1} is TV lagged one year. BOP represents a balance of payments constraint. If the ratio of annual foreign exchange reserves to total annual merchandise imports is less than 0.25 (that is, three months), the ratio is used; if the ratio is greater than or equal to 0.25, the constraint is set at 0.25. WSTV is the shortfall variable for wheat adjusted for stock computed as production plus beginning stocks minus estimated consumption and end-of-year stocks based on time trends. T = time, 1961 = 1, 1962 = 2, ... PCI is the index of coffee prices, export unit value basis, for Madagascar, 1975 = 100. PO is the price of petroleum in 1980 U.S. $ per barrel, Saudi Arabian realized price. ED is a dummy variable for the Philippine election year; ED = 1 in 1961, 1963, 1965, 1967, 1969, and 1971 election years, and ED = 0 in all other years. More rice is consumed in election years. AX is Singapore's total merchandise exports to regional trading partners as approximated by the sum of the total merchandise imports of Malaysia and Indonesia in millions of current U.S. dollars. QF represents the quantity of rice offtake from ration and subsidy programs in Sri Lanka on a 1,000 metric tons milled basis. PD is a political dummy variable, where PD = 0 from 1962 to 1972 and PD = 1 from 1963 to 1978, representing the effect of Bangladesh's independence through TV.

† This is GNP in billions of 1975 constant Canadian dollars.

‡ This is GDP in millions of 1975 constant U.S. dollars.

§ This is GDP in billions of 1975 constant British pounds sterling.

effect on commercial imports from other sources.

Table 17 reports the results for four large participants in the world rice trade: Burma, the People's Republic of China, Indonesia, and Thailand. The first two yield satisfactory results from both the theoretical and statistical points of view.

Results for Indonesia and Thailand are less satisfactory, despite strenuous efforts to find proper specifications. Because our primary interest is in price responsiveness, the results from the model are double checked by looking at the relationship between domestic and world prices. The correlation between the two is statistically insignificant for Indonesia, so that there are grounds for believing that its import level is unresponsive to world prices. The correlation for Thailand is significantly positive, suggesting that perhaps the unresponsiveness shown in the model is downward-biased. The actual responsiveness of the Thai domestic price to world price is quite small, however. A one dollar increase in the world price will trickle down to an increase of only about five cents in domestic prices. Using estimates of domestic demand and supply elasticities,[51] we estimate that in 1980 this five-cent increase in domestic price will elicit a thousand-ton increase in exportable surplus. Because this estimate is obtained by a special procedure, separate from the rest, we shall henceforth refer to it as an ad hoc estimate.

[51] The demand elasticity used is −0.31 as reported in Prasarn Trairatvorakul, "Food Demand and the Structure of the Thai Food System" (Ph.D. thesis, Harvard University, 1981), Table 9.8. (There are separate estimates for nonglutinous and glutinous rice, but using these does not affect the results a great deal.) The supply elasticity is assumed to be zero, based on ongoing research by Trairatvorakul and Siamwalla. Given these parameters and the coefficient relating movement of domestic prices to that of world prices, a $1 increase in the world price leads to a 1.1-baht increase in domestic price. This 1.1-baht increase will reduce consumption by $1.1 \times 0.31 \times Q/P$. The quantity of rice consumed (Q) in 1980 was 10.4 million tons and the price of rice (P) in that year was 3,570 baht. Thus the increase in exportable surplus consequent to a $1 increase in price is 993 tons. This increase is assumed to equal a decline in consumption.

Table 15—Net rice export regression results using ordinary least squares and the Cochrane-Orcutt technique, selected price-taking country groups, 1962-80

Country/Country Group	Independent Variables and Estimated Coefficients (t-Statistics)	R^2 ($\bar{R}^2$)	D.W.	ρ†
Algeria, Libya, and Morocco	0.575 + 0.912 TV (0.27) (16.81)	0.88 (0.87)	2.05	−0.566
Belgium-Luxembourg; France; Germany, Federal Republic of; Italy; and the Netherlands	20.203 + 1.022 TV (0.44) (4.51)	0.61 (0.59)	1.70	0.532
Brazil	16.073 + 0.287 TV_{t-1} (0.23) (2.67)	0.34 (0.30)	1.92	0.340
Egypt	289.055 + 0.440 TV − 116.449 PD (3.07) (4.19) (−1.83)	0.86 (0.85)	1.75	0.718
Japan	−309.005 + 0.788 P + 0.224 STV (−0.83) (2.23) (4.59)	0.82 (0.80)	2.29	0.839
Malaysia	−202.829 + 0.320 TV (−3.43) (1.86)	0.30 (0.26)	1.61	0.407
Nepal	52.435 + 0.274 TV + 0.491 TV_{t-1} (0.99) (2.36) (3.90)	0.66 (0.62)	1.97	0.664
Taiwan	97.191 + 0.289 STV (1.52) (2.56)	0.59 (0.56)	1.83	0.702

Sources: Rice and wheat production, consumption, exports, imports, and stocks: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Prices: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, August 1978). The 1973 rice price is an estimate from the International Food Policy Research Institute based on IBRD data.

Total imports, foreign exchange, GNP, GDP, and population: International Monetary Fund, *International Financial Statistics Yearbook, 1979* (Washington, D.C.: IMF, 1979); International Monetary Fund, *Direction of Trade Yearbook*, various issues (Washington, D.C.: IMF, various years); International Bank for Reconstruction and Development, *World Atlas*, various issues (Washington, D.C.: IBRD, various years); United Nations, Department of International Economic and Social Affairs, *Demographic Yearbook*, various issues (New York: UN, various years); Food and Agriculture Organization of the United Nations, *Trade Yearbook*, various issues (Rome: FAO, various years); and U.S. Department of Commerce, Bureau of the Census, *World Population, 1977*, ISP-WP-77 (Washington, D.C.: Government Printing Office, 1978).

Notes: Net rice exports are gross rice exports less gross rice imports in 1,000 metric tons milled equivalent on a calendar year basis. Estimates for Brazil and Nepal are for 1963-80 only. TV is actual production less estimated consumption of rice in 1,000 metric tons milled equivalent in the USDA world production year prior to the corresponding calendar year of trade. Estimated consumption is time-fitted per capita rice consumption times annual population, if the time trend is found significant; otherwise it is average per capita consumption times population. TV_{t-1} is TV lagged one year. The dummy variable, PD is 1 for 1961-68 and for 1974-80, when PL480 aid was received from the United States; PD is 0 for 1969-72, when no aid was received. P represents International Food Policy Research Institute estimates of Thai 5 percent broken f.o.b. Bangkok rice prices in 1977 constant U.S. dollars per metric ton. STV is the stock-adjusted shortfall variable for rice computed as production plus actual beginning stocks minus estimated consumption and end-of-year stocks. Estimates of end-of-year stocks are based on time trends.

†ρ is the coefficient of the regression of present and lagged residuals, where $u_t = pu_{t-1} + \varepsilon_t$.

Table 16—Net commercial rice export regression results using ordinary least squares estimates, selected aid-receiving price-taking countries, selected periods

Country/Country Group	Independent Variables and Estimated Coefficients (t-Statistics)	R^2 ($\bar{R}^2$)	D.W.	Period
Bangladesh	−586.77 + 0.489 P + 0.081 TV − 2.142 A + 0.292 WA (−5.65) (2.85) (1.97) (−6.26) (2.87)	0.81 (0.77)	2.56	1961-80
Bangladesh, net trade with Pakistan	−139.33 − 0.197 TP (−5.53)(−2.73)	0.45 (0.45)	1.79	1961-71
Cuba	−161.02 + 0.668 A − 0.082 PS (−8.69) (3.56) (−2.31)	0.56 (0.54)	1.60	1961-80
Kampuchea and the Lao People's Democratic Republic	−117.690 + 0.230 TV + 0.982 A (−0.73) (3.67) (2.80)	0.78 (0.75)	1.89	1962-80
South Vietnam	63.293 + 0.206 TV (2.27) (3.35)	0.48 (0.48)	2.05	1961-74

Sources: Rice and wheat production, consumption, exports, imports, and stocks: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains,* FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Prices: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, August 1978). The 1973 rice price is an estimate from the International Food Policy Research Institute based on IBRD data.

Total imports, foreign exchange, GNP, GDP, and population: International Monetary Fund, *International Financial Statistics Yearbook, 1979* (Washington, D.C.: IMF, 1979); International Monetary Fund, *Direction of Trade Yearbook,* various issues (Washington, D.C.: IMF, various years); International Bank for Reconstruction and Development, *World Atlas* (Washington, D.C.: IBRD, various years); United Nations, Department of International Economic and Social Affairs, *Demographic Yearbook,* various issues (New York: UN, various years); Food and Agriculture Organization of the United Nations, *Trade Yearbook,* various issues (Rome: FAO, various years); and U.S. Department of Commerce, Bureau of the Census, *World Population, 1977,* ISP-WP-77 (Washington, D.C.: Government Printing Office, 1978).

Pakistan: Pakistan, Ministry of Finance, Planning and Development, Economic Affairs Division, Central Statistical Office, *Twenty-Five Years of Pakistan in Statistics, 1947-1972* (Karachi: Manager of Publications, 1972).

Food aid for Bangladesh, Kampuchea, and the Lao People's Democratic Republic: International Food Policy Research Institute estimates.

Food aid for South Vietnam: U.S. Department of Agriculture, Economic Research Service, *U.S. Agricultural Exports under P.L. 480,* ERS-Foreign 395 (Washington, D.C.: USDA, 1974).

Notes: Net commercial exports are gross rice exports less commercial rice imports, where commercial rice imports are total rice imports less food aid in rice in 1,000 metric tons milled equivalent. Bangladesh was East Pakistan prior to 1971; net commercial exports exclude trade with West Pakistan. Observations for net trade between Bangladesh and Pakistan are for total net rice trade between East and West Pakistan, 1961-71.

P represents International Food Policy Research Institute estimates of Thai 5 percent broken f.o.b. Bangkok rice prices in 1977 constant U.S. dollars per metric ton. TV is actual production less estimated consumption of rice in 1,000 metric tons milled equivalent in the USDA world production year prior to the corresponding calendar year of trade. Estimated consumption is time-fitted per capita rice consumption times annual population, if the time trend is found significant; otherwise it is average per capita consumption times population. A is rice aid in 1,000 metric tons for Bangladesh and Kampuchea and the Lao People's Democratic Republic. For Cuba A represents Cuban concessional rice imports from the People's Republic of China, 1961-66, estimated as total rice imports from the People's Republic of China during this period. WA is wheat aid in 1,000 metric tons. TP stands for a shortfall for a trading partner—West Pakistan. PS is the world price of sugar in 1980 constant U.S. dollars per metric ton.

Table 17—Net rice export regression results using ordinary least squares, selected major rice-exporting countries, 1961-81

Country	Independent Variables and Estimated Coefficients (t-Statistics)	R^2 ($\bar{R}^2$)	D.W. (ρ)	Period
Burma	801.74 + 4.589 (PD · P) − 0.737 [(1 − PD) · P] + 0.298 [(1 − PD) · TV] − 1,675.5 PD (5.55) (2.00) (−3.46) (3.06) (−1.36)	0.92 (0.91)	2.08	1961-80
China, People's Republic of	−598.50 + 1.700 P + 119.746 TT (−1.55) (4.44) (3.37)	0.82 (0.79)	1.90 (0.43)	1962-80
Indonesia	4.796 − 29.201 PO − 4,368.6 BOP − 487.67 PD (0.02) (−2.18) (−3.61) (−2.35)	0.73 (0.69)	2.01	1961-80
Thailand	512.29 + 0.479 TV − 0.585 CDXT (1.33) (4.40) (−3.43)	0.64 (0.60)	1.56 (0.69)	1962-81

Sources: Rice and wheat production, consumption, exports, imports, and stocks: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Prices: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, August 1978). The 1973 rice price is an estimate from the International Food Policy Research Institute based on IBRD data.

Total imports, foreign exchange, GNP, GDP, and population: International Monetary Fund, *International Financial Statistics Yearbook, 1979* (Washington, D.C.: IMF, 1979); International Monetary Fund, *Direction of Trade Yearbook*, various issues (Washington, D.C.: IMF, various years); International Bank for Reconstruction and Development, *World Atlas*, various issues (Washington, D.C.: IBRD, various years); United Nations, Department of International Economic and Social Affairs, *Demographic Yearbook*, various issues (New York: UN, various years); Food and Agriculture Organization of the United Nations, *Trade Yearbook*, various issues (Rome: FAO, various years); and U.S. Department of Commerce, Bureau of the Census, *World Population, 1977*, ISP-WP-77 (Washington, D.C.: Government Printing Office, 1978).

Notes: Net rice exports are gross rice exports less gross rice imports in 1,000 metric tons milled equivalent on a calendar year basis. The Cochrane-Orcutt technique is used for the People's Republic of China and Thailand. PD is a political dummy variable; it equals 1 for 1961-65 and 0 for 1966-80. P represents International Food Policy Research Institute estimates of Thai 5 percent broken f.o.b. Bangkok rice prices in 1977 constant U.S. dollars per metric ton. TV is actual production less estimated consumption of rice in 1,000 metric tons milled equivalent in the USDA world production year prior to the corresponding calendar year of trade. Estimated consumption is time-fitted per capita rice consumption times annual population, if the time trend is found significant; otherwise it is average per capita consumption times population. TT is a time trend, where

$$TT \equiv \begin{array}{l} 0,\ 1961;\ 1,\ 1962;\ \ldots;\ 9,\ 1970 \\ 10,\ 1971\text{-}80. \end{array}$$

PO is the price of petroleum in 1980 U.S. $ per barrel, Saudi Arabian realized price. BOP is the balance of payments constraint. CDXT is the cumulative sum of RX minus TV starting with 0 in 1961, where RX is net exports.

The Model for the United States

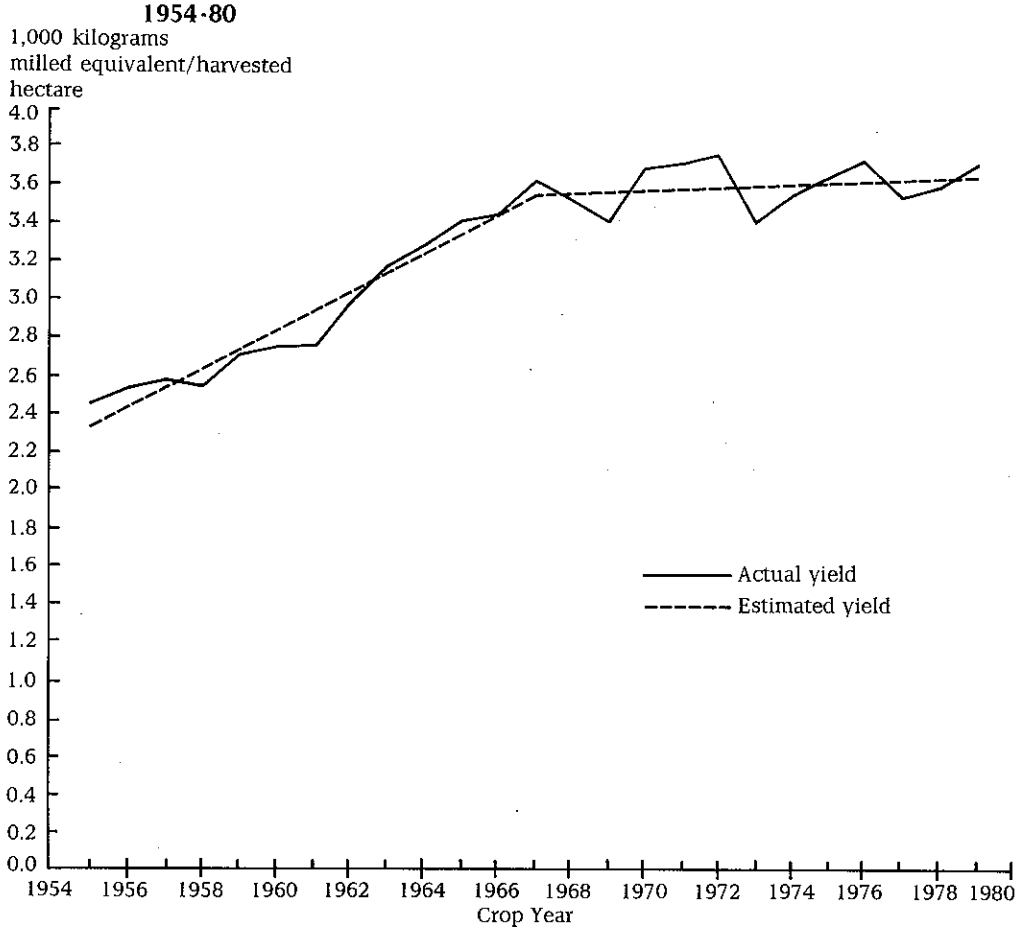
Like many other governments, the U.S. government intervenes substantially in the rice market, but it is unique among the larger participants in the rice trade in having no quantitative restrictions on the volume of its exports. The intervention has largely been effected through controls on production, supplemented by an export subsidy. For this reason and, it has to be admitted, because data are more easily available, we have singled it out for more detailed study. The reason for this exercise is to explain U.S. net exports.

The total output of rice is the product of three components: yield per hectare harvested, area planted, and the proportion of area planted that is harvested. The last is considered exogenous and in fact does not vary a great deal. The best explanation for yield seems to be time (see Figure 11). The following kinked trend function is therefore chosen:

$$YFX = \underset{(43.40)}{2325.23} + \underset{(15.58)}{102.87}\, T_1 + \underset{(1.14)}{7.56}\, T_2;$$

$$\bar{R}^2 = 0.95;\ D.W. = 1.56,$$

Figure 11—Actual and estimated rice yields in milled equivalents, the United States, 1954-80



Sources: Shelby Holder and Warren Grant, *U.S. Rice Industry*, Agricultural Report 433 (Washington, D.C.: U.S. Department of Agriculture, 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "World Grain Situation/Outlook," *Foreign Agriculture Circular—Grains*, FG-39-82 (Washington, D.C.: USDA, December 14, 1982).

where $T_1 = 0, 1, \ldots 12$ for 1956-68 and is constant at 12 for 1969-80, and $T_2 = 0$ for 1956-68 and 0, 1, . . . 11 for 1969-80.

The following estimate is obtained for area planted (APM) during the period 1956-80:

$$APM = \underset{(7.17)}{584.854} - \underset{(-0.06)}{4.723}\, D_2 + \underset{(3.47)}{0.425}\, P_{-2}$$

$$- \underset{(-3.24)}{0.225}\,(D_1 \cdot S_{-1}) + \underset{(3.25)}{0.554}\,(D_2 \cdot BS_{-1});$$

$\bar{R}^2 = 0.87$; D.W. = 1.79,

where

$D_1 \equiv$ 1 for 1956-73 and 0 for 1974-80,

$D_2 \equiv$ 0 for 1956-73 and 1 for 1974-80,

S $\equiv$ beginning total stocks, and

BS $\equiv$ beginning private stocks.

S and BS are lagged one year, and P is lagged two years.

This result is remarkable inasmuch as the effective ceiling on the area planted in the United States was the acreage allotment controlled by Congress. The ratio between area planted and the acreage allotment was between 83.0 percent and 99.4 percent for all crop years between 1957/58 and 1971/72. If we exclude the years when the program was being put in place, 1958 and 1959, the range for the ratios was 97.3-99.1 percent. The equation thus implies that Congress was controlling acreage and was as responsive as the farmers to prices, even though the reaction is lagged by as much as two periods.

The reaction of area planted to total stocks is of some interest. We have split the stock variable into two periods. Before 1973, total stock (mostly held by the Commodity Credit Corporation) is the variable, but after 1974, only private stock is included. The first variable affects area planted negatively. Thus, large involuntary public stocks were a factor in the decision of Congress to limit production. Private stocks, on the other hand, are voluntarily held. If they are large, it is because prices are expected to climb in the future, thus inducing farmers to plant more. In this view, the stock level is a proxy for the price level in the future relative to the present price.

Consumption per capita is estimated to be a function of income per capita (in 1975 dollars) for the period 1951-80:

$$RC/N = \underset{(5.15)}{2.152} + \underset{(7.96)}{0.0005289}\, Y/N;$$

$\bar{R}^2 = 0.69$; D.W. = 1.43,

where

RC $\equiv$ rice consumption in 1,000 metric tons,

N $\equiv$ population in millions, and

Y $\equiv$ GNP in 1975 U.S. $.

Production minus consumption equals exportable surplus. To obtain actual exports, we have to subtract stock changes, which are treated as exogenous. As Figure 12 shows, and as explained earlier in the chapter, stock changes are fairly small, except in the few years preceding or following major policy shifts. The reason for the large stockpiling at these times is the failure of policy to adjust fast enough. Thus, the increase in storage in 1976 was due to the policy permitting open access to price support by all farmers without any quantitative restriction. This was followed in 1977 by an income-support scheme available only to farmers with allotments. The policy lags that lie behind such stock movements are hard to model and therefore stock changes are regarded as exogenous.

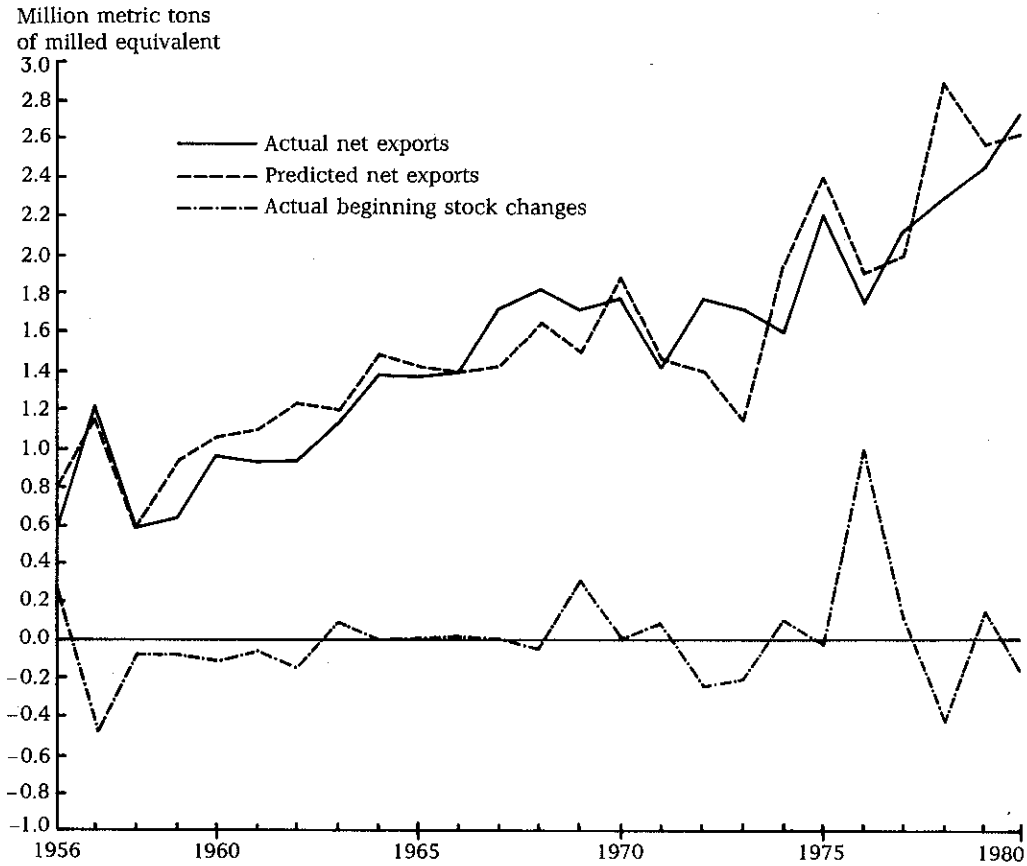
The figures on estimated exportable surplus, actual and estimated exports, and on stock changes are shown in Figure 12.

Some Conclusions from the Model

From the equations describing the behavior of the 55 country groups that we have estimated, a few more conclusions may now be drawn about the conduct of participants in the rice market.

First, the role of price in clearing the world rice market is extremely limited. During the period under consideration, only 17 of the 55 country groups showed any price

Figure 12—Beginning stock changes and actual and predicted net exports of rice, United States, 1956-80



Sources: Shelby Holder and Warren Grant, *U.S. Rice Industry*, Agricultural Report 433 (Washington, D.C.: U.S. Department of Agriculture, 1979); U.S. Department of Agriculture, Foreign Agricultural Service, "World Grain Situation/Outlook," *Foreign Agriculture Circular—Grains*, FG-39-82 (Washington, D.C.: USDA, December 14, 1982); and International Monetary Fund, *International Financial Statistics Yearbook, 1979* (Washington, D.C.: IMF, 1979).

responsiveness in their trade behavior. Table 18 lists all 17 countries for which there is some evidence of price responsiveness, that is, where the coefficient of the listed price variable is significant. Two figures are presented for Burma because there was a switch in policy. Throughout the following discussion the high figure for Burma will be ignored because it is no longer relevant. For the United States, it is area that is responsive to price. To obtain tonnage responsiveness, the price coefficient in the price equation is multiplied by the yield, which has a time trend. The product would then vary over time. We have selected three points in time and presented data for these periods in the table.

The sum of the coefficients listed in Table 18 (counting Burma's coefficient as -0.737) is 4.136, and if we add to this the final 1980 figure for the United States, we would have a coefficient of 5.678.[52] This

[52] We have slurred over the fact that the United States' response is lagged by two years.

Table 18—Estimated responsiveness of rice trade to changes in world price, 1961-80

Country	Period	Coefficient
		(1,000 metric tons/ U.S. $ 1 change)
Burma	1961-65	4.589
	1966-80	-0.737
China, People's Republic of		1.700
United States	1961	1.194
	1970	1.511
	1980	1.542
Japan		0.788
Korea, Republic of		0.748
Bangladesh		0.489
Nigeria		0.300
Saudi Arabia		0.232
U.S.S.R.		0.222
Korea, Democratic People's Republic of		0.173
Singapore		0.140
Austria, Greece, Norway, Portugal, Spain, Sweden, and Switzerland		0.074
Canada		0.037
Chad, Mali, and Upper Volta	1962-80	0.024
Angola	1962-80	0.021
Israel		0.011
Australia		-0.086

Sources: See Tables 14, 15, and 16 for price-taking countries, Table 17 for Burma and the People's Republic of China, and the section on the model in Chapter 3 for the United States.

Note: The response to price for the United States is lagged by two years.

implies that a dollar increase in price toward the end of this period would elicit only 5,700 tons of extra rice. With the ad hoc estimate for Thailand, the response is increased to 6,700 tons.

We next split the countries listed in Table 18 into exporters and importers, and calculate the implied elasticities of demand and supply in the world market for the year 1980. The results show the elasticity of import demand to be 0.08 and that of export supply to be 0.12. If we include the ad hoc estimate of Thai response, the latter figure would be increased to 0.14. These are minuscule numbers.

The relative sizes of the responsiveness coefficients are just as interesting. The adjustment in traded volume seems to have fallen largely to the exporters, with the People's Republic of China taking a leading role. Monsoon Asia's role as a whole is surprisingly high; the sum of the coefficients for the region being 4.038 out of the total 4.136 (excluding the United States), with East Asia taking a lion's share of 3.409.

This finding throws some doubt on our earlier hypothesis that the shift in trade away from Monsoon Asia may lead to greater price instability, because that hypothesis was based on the assumption that the countries of Monsoon Asia would be less price responsive than those outside it, which is incorrect as far as the 1960s and 1970s are concerned.

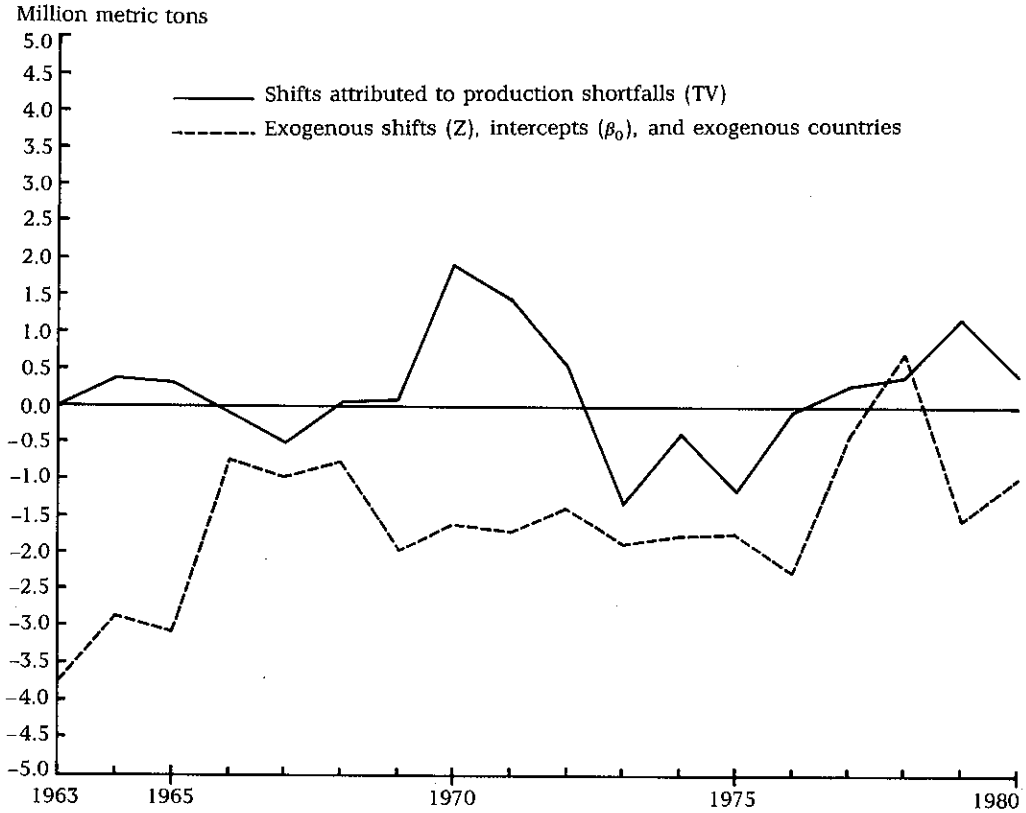
Next, the shifters in the equations are analyzed. We have separated them into two major components. One consists of TV shifters (that is, the shifts attributable to production shortfalls) and the other of all the remaining nonprice terms including the Zs in equation (2), intercept values (β_0), and total net trade of those country groups for which no trade equation was fitted (exogenous countries). We then calculate the shifts due to these terms and graph them as in Figure 13. The TV terms are by definition detrended, and the results are as expected. The remaining terms, consisting of a mixed bag of shifters, display a strong upward trend, which indicates a persistent tendency for net exports to expand.

We then decompose these two components of the shifters to see how much can be attributed to countries inside Monsoon Asia and how much outside. Figure 14 shows these decompositions for Monsoon Asia and Figure 15 for the rest of the world. The strong upward trend in net exports seems to have occurred mostly in Monsoon Asia. This is in line with the argument presented in Chapter 2, which stresses the decline of imports among the Asian importers. The main movement outside of Asia seems to be a slight downward trend, largely resulting from increased imports in the set of countries for which we could not fit the trade functions (Hong Kong, North Vietnam, Zaire, and Ecuador, Peru, and Venezuela).

A Diagnosis of Price Instability

The above econometric analysis partially explains why world rice prices are so unstable

Figure 13—Decomposition of shift components of net exports for the world rice market, 1963-80



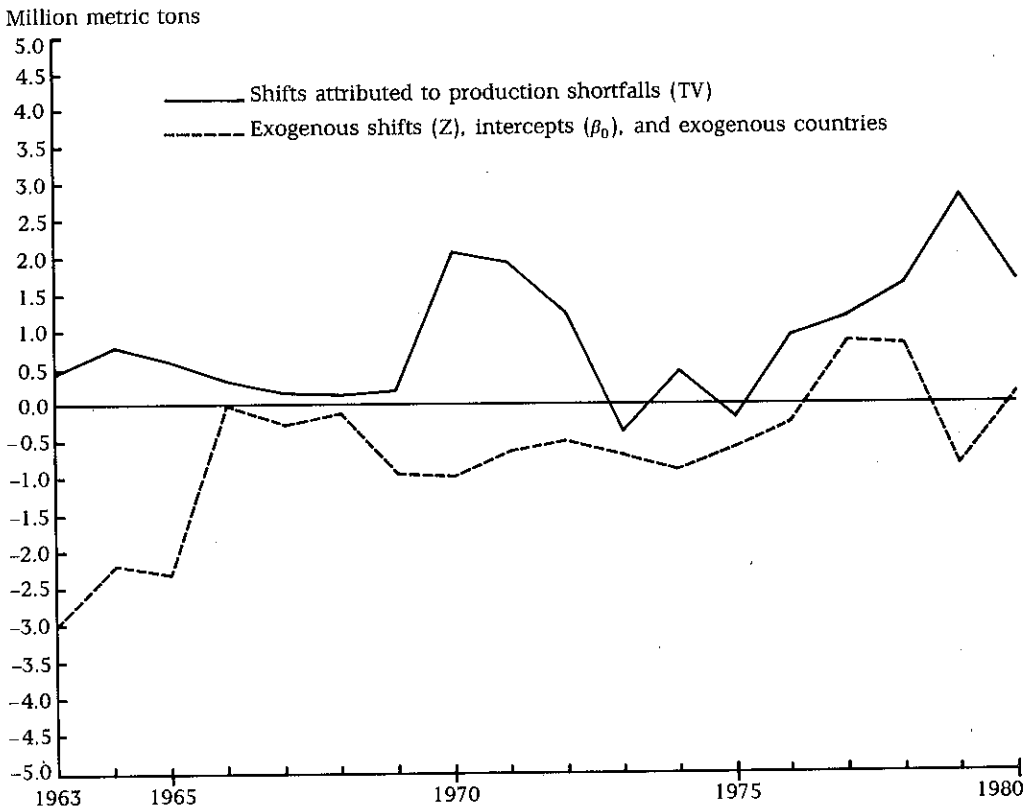
Sources: Derived from Tables 14, 15, 16, and 17.

in comparison with wheat prices. In fact, it may explain too much. Given that there is so little responsiveness to price, a high variability—much higher than actually experienced—would be expected. The main reason for this attenuation in the actual variability is that most major rice producing and consuming countries do not "export" their entire domestic variability to the world market. The values of the coefficients of the TV variables are almost universally less than 1.

Because most countries do succeed in stabilizing domestic rice prices relative to unstable world prices (see Table 19), it appears that their domestic price policies accomplish their objective. The two countries with coefficients of variation of domestic prices higher than that of world price also have extensive subsidized distribution systems. The free market's volatility captured in Table 19 thus exaggerates the variability that consumers face. The key role in price stabilization appears to be played by storage, although, unfortunately, the quality of data in this area is not strong enough to rigorously document this claim.[53] But even the most casual acquaintance with the policy statements and actual conduct of the various

[53] Most existing data sets obtain changes in stocks as a residual from production after deducting a fixed level of consumption. The correlation between production and stock changes, which would support our claim, would be largely spurious.

Figure 14—Decomposition of shift components of net exports for the rice market, Monsoon Asia, 1963-80



Sources: Derived from Tables 14, 15, 16, and 17.

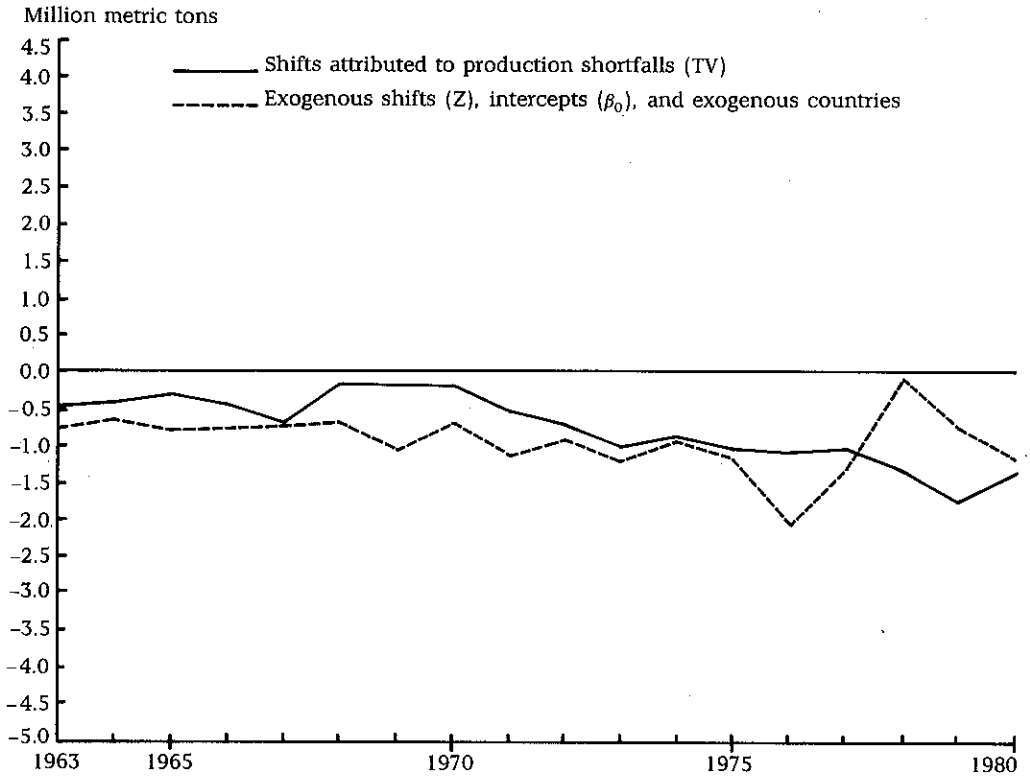
food trading agencies, particularly after 1973, would lead to the conclusion that in years of excess production there is an overstocking of rice rather than an attempt to export the surplus or to consume it—even when stock levels are high. This behavior is consistent across the board, whether the country is large, like India or Indonesia, or small, like the Philippines.

If the world rice market functioned as well as the wheat market, for instance, then such storage behavior would be irrational.[54] Unfortunately, the world rice market is imperfectly competitive. Within such a context, the policy may well be rational.

The question that needs to be raised is why the instability in the international market itself is not modulated by relevant stockholding. By relevant stockholding we mean stocks that are immediately accessible to the world market. For example, in any given year India may hold a large stock of rice, but this is largely irrelevant in the determination of the world rice price, as India enters the world market somewhat irregularly and unpredictably.

[54]See, among others, D. Gale Johnson, "Grain Insurance, Reserves and Trade: Contributions to Food Security for LDC's," in *Food Security for Developing Countries*, ed. Alberto Valdés (Boulder, Colo.: Westview Press, 1982), pp. 255-286; and Shlomo Reutlinger and David Bigman, "Feasibility, Effectiveness and Costs of Food Security Alternatives in Developing Countries," in *Food Security for Developing Countries*, pp. 185-212.

Figure 15—Decomposition of shift components of net exports for the rice market, rest of the world, 1963-80



Sources: Derived from Tables 14, 15, 16, and 17.

Now, for most grains, the bulk of the relevant storage is carried out by temperate-zone exporters, primarily the United States, which is also a major—though not an overwhelmingly predominant—exporter of rice. As already shown, the United States has chosen in the past not to store an equivalent quantity of rice. No other government, except the People's Republic of China to a small extent, has taken up the seller-of-last-resort role that the United States has played for wheat throughout most of the postwar years.

Private trade also appears to have played only a slight role in stabilizing prices through speculative storage. A high degree of domestic price stability discourages private storage in exporting countries such as Thailand. Taking a position in the world market was made difficult by the lack of any legal device or physical storage space where once stored, the rice could actually be traded at a price unaffected by the various taxes and quotas imposed by national governments. True, Hong Kong and Singapore were centers of such international speculative activity before the war, and they have remained so, but on a much reduced scale since the war. In more recent times, some international brokers and traders have taken positions by buying rice from Asia and shipping it to Africa without having any committed buyers. Such activities remain limited and at best play a role in smoothing out short-term fluctuations of a few weeks or months.

Table 19—Coefficients of variation for real domestic rice prices and for world prices, selected periods

Country	Period	Coefficient of Variation	
		Domestic Price	World Price
		(percent)	
Burma	1961-79	38.73	30.24
Sri Lanka	1961-80	35.65	30.29
Indonesia	1961-80	30.25	30.29
	1967-80	22.09	35.47
	1971-80	11.37	41.56
Bangladesh	1961-80	17.67	30.29
Malaysia	1961-76	13.07	28.82
Pakistan	1961-80	12.80	30.29
Thailand	1961-80	12.25	30.29
Philippines	1961-80	12.22	30.29
Korea, Republic of	1961-80	11.91	30.29
Japan	1961-80	10.81	30.29
Taiwan	1961-80	10.77	30.29
Nepal	1962-80	10.57	29.35
India	1961-80	8.27	30.29

Sources: For prices, see Table 10; for the price deflator, see International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, various years).

Notes: The coefficient of variation of world prices differs because of different time periods. Japanese prices are government prices for resale to wholesalers. Bangladesh was East Pakistan prior to 1971.

4

PERFORMANCE

The performance criteria to be examined in this chapter are stability; efficiency in the static sense, and in the dynamic sense of encouraging technological improvements; and income distribution. We are concerned with the specific influence of the structure and conduct of the world market on each of these criteria. But, because world market conditions are only a part—and a small part at that—of the many influences at work, to isolate that specific component quantitatively would require more precision in our data and methods than they possess. Much of what we venture to say in this chapter will therefore be speculative. Skeptical readers may regard the remarks below more in the light of hypotheses to be tested.

Stability

Stability questions are at the center of our analysis of the world rice market. It is against the poor performance of rice on this point that the market's performances in other areas are to be understood and measured.

We sought an explanation for the instability in world rice prices in Chapter 3. However, only the instability of measured rice prices was considered there. If we broaden the concept of "price" to include the transaction costs discussed in Chapter 2, one must conclude that the market performed rather poorly in assuring the participating governments that they will always be able to obtain rice when it is needed. As a consequence, governments have followed a policy of somewhat excessive and costly storage of rice when their production is above trend. On the other hand, should production fall below trend at a time when stocks are low, the world market provides an inadequate recourse. The only alternative is to allow the domestic price to rise substantially, to the detriment of consumption.

Nevertheless, most governments manage to keep domestic price variability substantially below the variability in the world price, which suggests that the cost borne by the governments has probably been in the form of excess storage. Unfortunately, as pointed out in Chapter 3, our stock data are not complete enough to measure the extent of the costs.

However, when Amanda Te compared a trade-dependent regime with a closed-economy regime, using data from the Philippines, she found that the cost of avoiding foreign trade in rice as a means of evening out fluctuations is quite small for the economy as a whole.[55] In Table 20 the present value of the benefits and losses (at an 8 percent real rate of discount) of a 300,000-ton initial reserve averaged over 15 years is compared with free trade without reserves. At the price of rice prevailing in the Philippines in 1972, the benefit from free trade would be about 480 million pesos, which would then purchase more than 400,000 tons of milled rice. Thus, the 15-year present value is equivalent to only about 10 percent of the annual production at the start of the period. If annualized, it would be less than 1 percent of rice production. The model presupposes a smoothly functioning international market.

Note, however, that although the net effect on the Philippine economy as a whole is small, the redistribution between consumers and producers is large. This result is not specific to the Philippines but is quite general. It follows that if any policy causes a change in the price equilibrium of Δp and in the quantity equilibrium of Δq, then the net welfare loss is $(1/2)\Delta q \Delta p$, whereas for redistribution it is $q\Delta p$, a whole order of magnitude larger. It is difficult to generalize whether the beneficiaries of a storage policy would be producers or consumers.

[55] Amanda Te, *An Economic Analysis of a Reserve Stock Program for Rice in the Philippines*, Rice Policies in Southeast Asia Project, Working Paper No. 7 (Washington, D.C.: International Food Policy Research Institute, 1982).

Table 20—Benefits or losses of reserve stocks without trade and free trade without reserve stocks, the Philippines, 1978-92

Loser or Beneficiary	Stocks Without Trade	Free Trade Without Stocks
	(million pesos)	
Producers	–31	3,574
Consumers	40	–3,329
Storage agency	–50	235
Total	–41	480

Source: Amanda Te, *An Economic Analysis of a Reserve Stock Program for Rice in the Philippines.* Rice Policies in Southeast Asia Project, Working Paper No. 7 (Washington, D.C.: International Food Policy Research Institute, 1982).

Notes: The present value is in 1972 million pesos at an 8 percent rate of discount over 15 years. The reference model against which the above alternatives are compared is one with no public stocks and no trade.

Of greater importance than reserve stocks, which are designed to smooth year-to-year output fluctuations, are working or pipeline stocks. Given the imperfections of the rice market outlined in this report, it is imperative for countries, particularly importing countries, either to store a comfortable level of working stocks or to arrange import flows sufficiently in advance to minimize the probability of a shortage at the target price. Again, data are not available for a firm inference, but in our judgment, many Asian countries, most notably Indonesia, quickly learned and applied the lessons of the period 1973-74, and import and stock management practices have become considerably more sophisticated than in the 1960s. While this is in itself encouraging, the diversion of management and capital resources for this activity in many poor countries is made necessary by the failure of the international market to provide a smoother and probably more economical alternative.

We shall return to the question of redistribution in the section on equity. In the meantime, we may conclude that governments do try to achieve stability in domestic prices and have largely succeeded, but they find it easier and possibly less risky to do so by means of domestic storage than by relying on the world market. Given the unobserved but real cost of using the world market, this may well be a rational choice.

Another stability issue that needs to be discussed is the lack of "offshore" storage. By this we mean rice that is immediately accessible for trading in the world market without the possibility of intervention by any government.[56] One would think that the instability in the world rice prices engendered by the domestic stabilization policies of both exporting and importing countries would have generated such offshore storage. The high transaction costs involved are again to be blamed. If storers cannot unload the rice that they hold without incurring transaction costs, much of their gain from price speculation will disappear.

We have also pointed out in our earlier discussion that the fine-tuning of U.S. rice production policies has generally been so successful that no publicly funded storage program for rice has arisen that is even remotely comparable to that the United States maintained in the 1960s for wheat. The very different price histories of the two commodities are the result.

Another developed country, Japan, has also engaged in extensive storage as a consequence of its support policy, but because all of its rice is short grain, it is incompatible with the world market demand. And its rice trading policies—in particular, the freedom to give large export subsidies—are somewhat constrained by U.S. pressures. However, in 1972, a year of extreme shortfall, most of Japan's stocks were released onto the world market, which relieved the shortage in the years 1973-74 to some degree.

A possible action that may be taken to improve the international rice trade is the development of a central market for "world" rice. For such a market to have the necessary liquidity, it must be physically possible to store the rice where it is beyond any intervention by any government. Trading in this rice or in titles to such rice will then take over the function of making price more transparent. This will in itself reduce the

[56] As to where such rice might be physically stored, Singapore and Hong Kong have at times allowed such storage, and there is no reason why bonded storage facilities cannot be introduced or expanded within these two jurisdictions.

transaction cost of the rice trade, not only for trade that takes place in the central market, but also for that which takes place outside the market, as the buyers and sellers will then have a credible benchmark price against which to measure their own bargains.

Given present trade patterns, it appears best to place such a market and storage facility in or near an exporting country, preferably with the blessing of its government.[57] Two candidates suggest themselves, the United States and Thailand. For the United States one must ask why the function of the central market was not adopted under the existing system. During the years preceding 1974 and following 1981, U.S. domestic prices were well above the world price and essentially set by the loan rate. This means that there is little fluctuation in U.S. domestic prices. Such a climate does not favor the development of a central market. The period between 1974 and 1981, on the other hand, could have led to such an evolution, and indeed the New Orleans futures market for rice was set up, unfortunately toward the very end of the period, when its potential for growth was stunted by the reemergence of a floor on the loan rate for rice. U.S. prices have since remained well above rice prices in the rest of the world, with the result that the U.S. role in the world rice market has been declining since 1981. In fact, as this report was going to press, the New Orleans Commodity Exchange was forced to close its doors.

Thailand, on the other hand, has not taken a deep interest in the development of a central market. Despite its major role in in the world market during most of the postwar period, rice exports are regarded as instruments to regulate domestic supplies and prices. In any given year, the Thai government is concerned about the best way to unload that year's surplus on the world market, but there has been little attempt to look at export prospects in the long run. More recently, with exportable surplus consistently exceeding 2 million tons a year for the past five years, the government has begun to adopt a longer range approach to rice exports and to look into various ideas on export market development. Among these ideas is one involving a bonded warehouse system that would enable Thai exporters to store rice offshore. Another is long-term barter arrangements with oil exporters such as Indonesia. Little has come of these schemes so far.

Efficiency and Technological Progress

The wide dispersion among countries of the ratio between domestic and world prices of rice, converted at official exchange rates, is well known. In fact, the dispersion is larger than can be explained by differences in the ratio of the shadow or "true" exchange rates to the official exchange rates. Even if we finesse the whole question of exchange rates by comparing the price ratio of rice to fertilizer, the dispersion remains substantial.[58] For those who believe in the application of the domestic resource cost (DRC) to agricultural commodities, a study directed specifically to rice in Asia shows a similarly wide dispersion.[59] All these contribute to inefficiency at a given point in time in the distribution of rice production among countries, as production can be profitably trans-

[57] A location within an exporting country has been suggested because rice is cheaper closer to its origins, and therefore less investment would be needed. Further, as exports are more concentrated than imports (see Table 6), placing stocks near the export point would make it easier to rechannel them to various countries as shortfalls develop. Similar arguments have been used in the case of wheat (see Daniel T. Morrow, *The Economics of the International Stockholding of Wheat,* Research Report 18 [Washington, D.C.: International Food Policy Research Institute, 1980], p. 11).

[58] See Timmer and Falcon, "Political Economy of Rice Production," pp. 373-410, for an early statement and recent issues of the International Rice Research Institute's *World Rice Statistics,* by Adelita C. Palacpac, for more up-to-date figures.

[59] See the special issue of *Food Research Institute Studies* 15 (No. 2, 1976). We are skeptical about the usefulness of the DRC concept because the estimates are based on the average cost of production of rice, which means they do not capture comparative advantage at the margin very well. Among the exceptions is the paper by Herdt and Anden-Lacsina, who look at the DRC within a project and conduct their analysis in terms of the incremental DRC within that project area (Robert W. Herdt and Teresa Anden-Lacsina, "The Domestic Resource Cost of Increasing Philippine Rice Production," *Food Research Institute Studies* 15 [No. 2, 1976]: 213-231).

ferred from countries where rice prices are high and therefore costs are high to countries where prices are low. The question that concerns us, however, is the extent to which the imperfections in the world rice market have specifically contributed to the adoption of protective policies within these countries.

The arguments and evidence presented in the first few sections of Chapter 3 suggest strongly that the level of world price per se has only a slight impact on the choice of policies within individual countries, particularly in Asia. In this sense the resulting static inefficiency may be attributed to the specific policy measures adopted by governments and not to the failure of the world rice market as such.

The data in Chapter 2 suggest that the physical capacities of importing countries make them more likely to benefit from use of the new HYV technology, but it is argued in Chapter 3 that the ambience of the market has caused the governments of importing countries to pursue production policies much more aggressively. Once the HYV revolution held out the promise of good results from policies to promote production through packaged credit, fertilizer subsidies, and irrigation, importing countries were quicker to adopt them. Thus the chronic uncertainties affecting the world rice market have actually been a positive stimulus to technical advancement, at least in the importing countries. By the same token, however, these uncertainties have restrained the governments of Asian exporters, such as Thailand, from pursuing a goal of high production through technical advancement. These dynamic technological and policy developments have probably reduced the gap in the marginal costs of production of rice between exporters and importers, and therefore have reduced any static inefficiency that may have arisen from various antitrade devices adopted by both groups of countries.

Income Distribution

To trace the impact of the world rice market on income distribution among and within countries, the following factors are relevant: the real world price of rice has moved downward only slightly during the postwar period; the developed countries' share of exports has increased, and their share of imports has declined; and technological change has been adopted faster by traditional developing-country importers than by traditional exporters. Output has also expanded in many developed countries, although the high level of protection needed to induce this output growth may well be immiserising to (or lower the welfare of) the countries themselves. The United States is the sole exception, as the level of protection accorded to rice, while positive, is relatively small compared to that of other OECD countries, so that it is improbable that its policies have been immiserising.

Thus, although the slightness of the decline in the real world price shows that there has been only a small change in the barter terms of trade, the emergence of developed countries (particularly Japan) as exporters and their decline as importers indicate that, without the high protection rate in these countries, the barter terms of trade would have been more favorable to the traditional exporters. By the same token, traditional developing-country importers have benefited somewhat from this emergence. If their consumption preferences allow them to escape to the wheat market, where the fall in prices has been more dramatic, their gains will be correspondingly larger.

There has also been an income gain for the traditional Asian importing countries relative to the exporting countries as a result of their faster adoption of the new technology. The more important influence of technological progress is, of course, on the distribution of income within individual countries, on which much has been written. Here we shall merely note that once the possibility of technological progress opened up, many governments of importing countries responded by using resources (fertilizer subsidies, credit, and irrigation, for example) to induce producers to grow more rice. Although undocumented, this direct resource transfer probably dominated the implicit negative transfer arising from pricing the domestic price below world prices at "correct" exchange rates. True, the motivation behind this direct resource transfer may well have been to keep urban prices low, but the fact remains that, with the HYV technology, local farmers (as distinct from foreign supply sources) have had something tangible to sell to the governments, and thus to extract resources back from them. And the govern-

ments were more than willing to concentrate their transfers in regions with the capacity to adopt HYVs.[60]

The contrast in the behavior of the importing countries after the introduction of HYVs to that before 1965 is striking. Then, their shortfalls were largely met by imports even when foreign exchange was scarce; no attempts were made to close the import gap by realigning domestic prices, despite the rhetoric of self-sufficiency.[61]

The Asian exporters' behavior throughout the postwar period is also striking. The net resource flow has primarily been away from the rice sector in the form of taxation on rice exports. The pressure for a production increase was never strong, and, given environmental conditions that worked against a rapid adoption of HYVs, the producers were not in a position to sell their governments on the idea of supporting them. The end result is only a small change in the relative position of the farmers in these countries.

The world rice market is usually perceived as penalizing the importing countries, which may be true in the short run. However, these countries have used this perception as a spur to the adoption of policies and production strategies that will enable them to become independent of it. In the long run, the exporters are the ones who are hurt. (Included among "exporters" are those erstwhile importers who have managed to expand their production so much that they now have a surplus.)

The participants in the world rice market—importers and exporters alike—are in an n-country version of the prisoner's dilemma game.[62] It surely is in the interests of everyone—importer or exporter—to have a well-functioning international rice market, yet each country has found it to be in its own best interests to avoid relying too much on it. This pursuit of individual interest has consequently led the rice market to become a residual market, and therefore an imperfectly functioning one. Without a collective and binding agreement, a movement to a more active world rice market appears to be impossible. If conditions remain unchanged, the prisoner's dilemma game implies that unilateral action on the part of the exporters, say, to improve the functioning of the market, will bring no benefits to them. Hence they are disinclined to undertake such an action.

From a long-range perspective, there is reason for some optimism. The United States and now Thailand have become major exporters on a regular basis, with volumes exceeding 2 million tons yearly. Pakistan and perhaps Burma are also now regular exporters with volumes of about 1 million tons each. These exporters stand to gain from becoming regular sources of supply. On the import side, regular buyers, largely from the Middle East and Africa, are beginning to emerge. This increased regularity indicates the resurgence of a trading pattern based on specialized production capabilities or on clear comparative advantage similar to the pre-1939 scenario. Such a development cannot but bring a greater degree of coherence and orderliness to a market that has been an unreliable source for importers and an unreliable outlet for exporters. This coherence need not take the form of an efficient market similar to that of wheat, for example. It is just as likely that a more extensive use of bilateral long-term agreements, designed to lower search costs, not necessarily to reduce price fluctuations, could emerge, with deleterious consequences for transient traders, but a more stable environment for regular participants.

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[60] Note that governments that wish to maximize support from rural areas would be more inclined to spread their munificence across the whole country rather than to specific areas.

[61] Malaysia is the sole exception in Asia. Ethnopolitical reasons were instrumental in inducing its government to protect its rice industry and to pursue a generally high price policy. See R. H. Goldman, "Staple Food Self-Sufficiency and the Distributive Impact of Malaysian Rice Policy," *Food Research Institute Studies* 14 (No. 3, 1975): 251-293.

[62] In the prisoner's dilemma game a prisoner must choose between cooperating with the jailers in an attempt to secure leniency for himself or maintaining silence for the possible benefit of himself and other prisoners.

APPENDIX 1: DATA

Trade Data

All trade data used in this study, unless otherwise noted, are taken from the calendar year export and import series for individual countries, furnished by the USDA Foreign Agricultural Service.[63] The trade variable used in the regression analysis is net exports: total exports minus total imports. These USDA data represent all countries with significant participation in international rice trade and provide associated production and consumption data for the period 1961-80.

Two problems were encountered in using the USDA data, which appear to be characteristic of both USDA and FAO data of this nature.[64] First, world export and import totals are not fully reconciled; second, due to political boundary changes, treatment of data for specific countries may be inconsistent over time.

A world total net export series was generated at the International Food Policy Research Institute (IFPRI) based on the USDA data for the 98 countries involved in the regression analysis. In the IFPRI world net export series, exports exceeded imports at the average rate of 645,600 metric tons per year between 1961 and 1980. The years with the largest excesses were 1971 and 1980, when 1.1-1.2 million tons of reported exports were uncompensated by imports. These differences may be explained in part by omissions of minor importers, reporting errors, and the possible double counting of reexports.[65]

Adjustments were made to USDA data involving Bangladesh, Pakistan, North and South Vietnam, and the People's Republic of China. For the period 1961-71, this study attributes East Pakistan's trade to the Bangladesh series; only West Pakistan's trade is included in the Pakistan series. Because USDA data represent trade net of flows between the two wings of Pakistan for the period 1961-71, data derived from the Government of Pakistan were used to adjust the data to provide a total net export series. No explicit adjustments were needed for the two series after 1972, as the USDA data reflect trade between Bangladesh and Pakistan once it resumed. These adjustments are reported in Table 21.

The October 1978 USDA grain printout provides explicit trade series for both North and South Vietnam, but beginning with the December 1978 *Foreign Agriculture Circular* for grains, the data for the two Vietnams are combined into a series called the Socialist Republic of Vietnam. South Vietnamese data extend from 1961 to 1975 when the two countries were combined. In this report, a data series for North Vietnam representing the entire 1961-80 period was derived by subtracting the 1978 grain printout series for South Vietnam (1961-75) from the 1982 *Foreign Agriculture Circular* series for the Socialist Republic of Vietnam (1961-80). This derived series for North Vietnam differs from the one presented in the 1978 grain printout. This difference is attributed to the updating of the data and to the inclusion of trade between North Vietnam and the People's Republic of China within the 1979 consolidation of Vietnamese trade data. On this basis, the discrepancy between the Socialist Republic of Vietnam series and the 1978 North and South Vietnam series, which co-

[63] U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, FG-20-79, FG-38-80, and FG-22-82 (Washington, D.C.: USDA, December 1979, December 1980, and September 1982), and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., October 1978 and December 1980. (Computer printout.)

[64] Leonardo A. Paulino and Shen Sheng Tseng, *A Comparative Study of FAO and USDA Data on Production, Area, and Trade of Major Food Staples*, Research Report 19 (Washington, D.C.: International Food Policy Research Institute, 1980), pp. 39 and 73.

[65] There are minor differences between the USDA and the IFPRI series on net exports, part of which are explained by the inclusion of Denmark and the United Arab Emirates after 1974. The average difference between total exports and imports for the three series are: USDA world total, 422,400 metric tons; IFPRI 98 countries, 645,600 metric tons; and IFPRI 100 countries, 589,500 metric tons.

Table 21—Net exports of Bangladesh and Pakistan with adjustments for the internal trade of Pakistan, 1961-80

Year	Unadjusted Data			Adjusted Data	
	Pakistan	Bangladesh	Pakistan Net Exports to Bangladesh	Pakistan	Bangladesh
			(1,000 metric tons)		
1961	125	-492	95	219	-587
1962	128	-229	64	192	-293
1963	102	-419	137	239	-556
1964	164	-283	218	382	-501
1965	135	-82	104	239	-186
1966	213	-330	112	325	-442
1967	140	-372	213	353	-585
1968	81	-283	193	274	-476
1969	135	-240	169	304	-409
1970	130	-510	291	421	-801
1971	196	-348	358	554	-706
1972	191	-658	n.a.	191	-658
1973	771	-171	n.a.	771	-171
1974	478	-58	n.a.	478	-58
1975	498	-440	n.a.	498	-440
1976	861	-280	n.a.	861	-280
1977	860	-404	n.a.	860	-404
1978	703	-18	n.a.	703	-18
1979	1,366	-652	n.a.	1,366	-652
1980	968	-168	n.a.	968	-168

Sources: The first columns for Pakistan and Bangladesh are taken from U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, various issues (Washington, D.C.: USDA, various years). The second set of figures for Pakistan and Bangladesh is derived from figures calculated by the International Food Policy Research Institute. Figures for trade between the two wings of Pakistan from 1961 to 1971 (before Bangladesh became a separate country) were supplied by Pakistan, Ministry of Finance, Planning and Development, Economic Affairs Division, Central Statistical Office, *Twenty-Five Years of Pakistan in Statistics, 1947-1972* (Karachi: Manager of Publications, 1972), p. 172.

Note: n.a. means not applicable.

incides with USDA and FAO data on trade between North Vietnam and the People's Republic of China, is taken as a proxy for that trade (see Table 22).

Based on analysis of USDA and FAO documents, it was determined that, first, the USDA Foreign Agricultural Service series does not reflect trade between the Democratic People's Republic of Korea and the People's Republic of China during the 1961-80 period and that, second, the series for the People's Republic of China must be adjusted to treat trade with North Vietnam in a way consistent with the adjustments made in the Vietnamese series. For 1961-68, no trade between North Vietnam and the People's Republic of China is represented in either series: thus the USDA *Foreign Agriculture Circular* series is used for this period. For 1969-80, judgments were made about the level of trade between the two countries. Each source consulted provided a different series, but a general pattern emerged. Annual trade of 0.5-0.6 million tons per year for 1969-76 was reported by both USDA and FAO, based primarily on foreign attaché and country reports.[66] A higher level of 1.0-2.5 million tons annually was also generated

[66] U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, various issues; U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, *Agricultural Situation: People's Republic of China*, various issues (Washington, D.C.: USDA, various years); Food and Agriculture Organization of the United Nations, Committee on Commodity Problems, Intergovernmental Group on Rice, *Report*, various issues (Rome: FAO, various years).

Table 22—Net exports of North and South Vietnam and adjustments for trade with the People's Republic of China, 1961-80

Year	Unadjusted Data			Adjusted Data	
	Socialist Republic of Vietnam	South Vietnam	North Vietnam[a]	Net Exports from North Vietnam to the People's Republic of China	North Vietnam[b]
	(1,000 metric tons)				
1961	170	152	18	...	18
1962	38	42	-4	...	-4
1963	320	323	-3	...	-3
1964	40	49	-9	...	-9
1965	-164	-127	-37	...	-37
1966	-436	-434	-2	...	-2
1967	-772	-750	-22	...	-22
1968	-701	-678	-23	...	-23
1969	-880	-348	-5	-527	-532
1970	-1,057	-580	-12	-465	-477
1971	-597	-137	-27	-433	-460
1972	-907	-315	-27	-565	-592
1973	-760	-270	0	-490	-490
1974	-865	-301	0	-564	-564
1975	-639	-10	0	-629	-629
1976	-803	n.a.	-134	-669	-803
1977	-259	n.a.	-259	...	-259
1978	-145	n.a.	-145	...	-145
1979	-250	n.a.	-250	...	-250
1980	-47	n.a.	-47	...	-47

Source: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, various issues (Washington, D.C.: USDA, various years).

[a] Excludes North Vietnamese net exports to the People's Republic of China.

[b] Includes North Vietnamese net exports to the People's Republic of China.

through FAO food gap analysis and was echoed in USDA Economics, Statistics, and Cooperatives Service publications.

Although no series can be accepted with certainty, the lower series were judged to be more consistent with the USDA Foreign Agricultural Service data set being used for this study. There is reason, however, to suspect an understatement of actual trade. Since it was necessary to choose among several series for the North Vietnam-People's Republic of China trade in the 0.5-0.6 million ton range, the series, which was derived from the adjustment of Vietnamese data mentioned above, was judged to be the most appropriate. The 1969 and 1970 *Foreign Agriculture Circular* values for trade of the People's Republic of China excluded trade with North Vietnam, so they were adjusted upward using the bilateral trade series. For 1971-80 the *Foreign Agriculture Circular* series included the People's Republic of China's trade with North Vietnam. Because bilateral trade between the People's Republic of China and the Democratic People's Republic of Korea was omitted from the trade series for both countries, no adjustment was made for this trade. The omission has no bearing on the derived world total net export series (see Table 23).

The 98 countries analyzed were aggregated into 55 country groups. Smaller importers and exporters, particularly those with low levels of rice production, were grouped on a regional basis where similarities in behavior were expected. Thus, 59 of the countries for which data were available are

Table 23—Net exports of the People's Republic of China with adjustments for trade with North Vietnam, 1961-80

Year	Unadjusted Data for the People's Republic of China[a]	Adjusted Data: Net Exports from the People's Republic of China to North Vietnam	Adjusted Data: People's Republic of China
	(1,000 metric tons)		
1961	444.0	...	444.0
1962	578.0	...	578.0
1963	640.0	...	640.0
1964	784.0	...	784.0
1965	752.6	...	752.6
1966	1,264.4	...	1,264.4
1967	1,197.8	...	1,197.8
1968	966.6	...	966.6
1969	811.2	527	1,338.2
1970	976.0	465	1,441.0
1971	1,032.0	433	1,465.0
1972	972.0	565	1,537.0
1973	2,191.0	490	2,581.0
1974	1,882.0	564	2,446.0
1975	1,276.0	630	1,905.0
1976	644.0	669	1,313.0
1977	1,033.0	...	1,033.0
1978	1,435.0	...	1,435.0
1979	982.0	...	982.0
1980	1,035.0	...	1,035.0

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, various issues (Washington, D.C.: USDA, various years); U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *Agricultural Situation: People's Republic of China*, various issues (Washington, D.C.: USDA, various years); and Food and Agriculture Organization of the United Nations, Committee on Commodity Problems, Intergovernmental Group on Rice, *Report*, various issues (Rome: FAO, various years).

aggregated into 16 groups; an additional 39 countries were analyzed individually.[67]

Rice Price Data

The rice price series used in all regressions is the 1980 constant U.S. dollar price for 5 percent broken, milled rice, f.o.b. Bangkok, for 1961-80. This series is adopted from the *Commodity Trade and Price Trends* of the World Bank and is considered to be representative of the world price of rice.[68] Because Thailand banned exports in the middle of 1973, Bangkok prices are quoted for only the earlier months of 1973. Thus the World Bank price, which is an average of monthly prices, is biased downward. In order to capture the movement in world prices more accurately, the following adjustment is made to the 1973 Thai price: the current dollar monthly Thai prices are regressed on the U.S. export prices (Houston long grain, f.o.b. mill minus export payments) for the years 1960-61 – 1972-73.[69]

[67] Most of the 98 countries, including 15 of the country aggregations, are listed in Tables 14, 15, and 16. The sixteenth country group is comprised of Ecuador, Peru, and Venezuela. Among the individual countries, Burma, Hong Kong, Indonesia, North Vietnam, the People's Republic of China, Thailand, the United States, and Zaire are discussed separately.

[68] International Bank for Reconstruction and Development, *Commodity Trade and Price Trends*, various issues.

[69] U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, *Rice Situation*, various issues (Washington, D.C.: USDA, various years).

The estimated equation, in log linear form, is:

$$\ln(P_t) = 0.183 + 0.92989 \ln(P_u);$$
$$(1.82) \quad (51.19)$$

$R^2 = 0.92$;

where

P_t = price of 5 percent broken, milled, f.o.b. Bangkok, current U.S. $ per metric ton, and

P_u = price of long grain, f.o.b. mill, Houston minus U.S. export payments, current U.S. $ per ton.

The t-statistics are in parentheses.

The results are used to estimate the 1973 current dollar Thai price on the basis of the U.S. price. This estimate is then converted to a 1980 constant dollar basis using the World Bank's c.i.f. international price index from *Commodity Trade and Price Trends* for 1973.[70]

Production, Consumption, and TV

The variable TV is the difference between rice production and expected rice consumption for each year. Expected rice consumption is computed as the product of expected per capita consumption and population. Production and consumption data are taken from the supply utilization tables of the USDA Foreign Agricultural Service.[71] Population data are taken from the International Monetary Fund's *International Financial Statistics*, where available, or the U.S. Department of Commerce's *World Population*.[72]

For most countries the definition of expected per capita consumption is the trend value. Linear estimates of per capita rice consumption trends for 53 country groups are summarized in Table 24.[73] For 15 country groups, where time trends were not judged statistically significant, average observed per capita consumption is used in place of trend values in order to calculate expected consumption levels.[74]

For three of the countries, alternative specifications of TV were adopted. For India, the difference between production and expected consumption of rice plus wheat, based on trend per capita consumption, was used for the regression analysis.[75] Japan's rice TV was adjusted by expected stock changes; that is, actual beginning stocks less expected ending stocks, where expected stocks are trend values.[76] For Bangladesh, where specific information was available, the target per capita consumption level of 15.5 ounces per day was used to calculate desired consumption.[77]

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[70] International Bank for Reconstruction and Development, *Commodity Trade and Price Trends*, August 1981, p. 30.

[71] U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, various issues.

[72] International Monetary Fund, *International Financial Statistics*, various issues; and U.S. Department of Commerce, Bureau of the Census, *World Population, 1977*, ISP-WP-77 (Washington, D.C.: Government Printing Office, 1978).

[73] North Vietnam and the United States are excluded.

[74] The countries included are: Australia; Cuba; Argentina and Uruguay; Belgium-Luxembourg, France, the Federal Republic of Germany, Italy, and the Netherlands; Cyprus and Turkey; Guyana and Surinam; Jordan, Lebanon, and Syria; Chad, Mali, and Upper Volta; the Philippines; Malaysia; Mexico; Nepal; Sri Lanka; Thailand; and West Africa (including Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Senegal, and Sierra Leone).

[75] The estimated trend for 1961-80 is:

$$C_{rice} + C_{wheat}/N = 105.47 + 1.005\ T.$$
$$(4.79)$$

[76] The estimated stock (S) trend for 1961-80 is:

$$S_{rice} = 934.45 + 207.88\ T.$$
$$(3.07)$$

[77] Raisuddin Ahmed, personal discussions, 1978 and June 17, 1982.

Table 24—Regression results for per capita rice consumption using ordinary least squares, 53 country groups, 1961-80

Country/Country Group	Estimates		t-Statistic
	α	β	
Algeria, Libya, and Morocco	0.922	0.057	4.54
Angola	2.704	0.113	2.47
Argentina and Uruguay	5.295	0.018	0.47
Australia	3.574	0.063	1.58
Austria, Greece, Norway, Portugal, Spain, Sweden, and Switzerland	5.658	0.035	2.27
Bangladesh	179.97	−1.685	−4.38
Belgium-Luxembourg; France; Germany, Federal Republic of; Italy; and the Netherlands	3.466	0.014	1.17
Brazil	51.650	−0.373	−2.13
Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and Yugoslavia	2.907	0.036	2.53
Burma	128.79	2.555	4.28
Canada	1.773	0.092	5.56
Chad, Mali, and Upper Volta	12.385	−0.098	−1.39
China, People's Republic of	68.357	1.171	7.56
Colombia	15.137	1.229	8.07
Cuba	40.427	0.410	1.01
Cyprus and Turkey	4.303	0.024	1.22
Dominican Republic, Haiti, Jamaica, and Trinidad and Tobago	17.630	0.665	9.59
Ecuador, Peru, and Venezuela	16.320	0.230	3.90
Egypt	28.301	0.475	3.05
Guyana and Surinam	83.233	1.270	1.25
Hong Kong	113.03	−2.586	−8.04
India[a]	75.325	−0.150	−0.85
Indonesia	97.180	1.810	6.56
Iran	20.873	0.639	5.85
Iraq	12.537	0.974	5.01
Israel	6.787	0.216	3.16
Japan	131.12	−2.194	−13.33
Jordan, Lebanon, and Syria	7.646	0.060	1.55
Kampuchea and the Lao People's Democratic Republic	235.58	−3.655	−2.78
Korea, Democratic People's Republic of	95.499	3.046	14.51
Korea, Republic of	118.59	1.551	3.17
Kuwait; Yemen Arab Republic; and Yemen, People's Democratic Republic of	7.016	0.413	4.60
Madagascar	157.38	0.772	1.82
Malaysia	130.75	−0.564	−1.20
Mauritius, Mozambique, and Reunion	24.294	−0.252	−3.12
Mexico	4.975	0.021	1.26
Nepal	124.38	−0.858	−1.98
Nigeria	3.069	0.338	5.34
Pakistan	19.603	0.416	2.71
Papua New Guinea	9.227	0.820	10.83
Philippines	87.297	0.191	1.22
Saudi Arabia	13.890	1.515	4.23
Singapore	102.13	−1.199	−2.47
Somalia and Tanzania	7.414	0.186	3.06
South Africa	2.480	0.058	4.05
South Vietnam	201.47	1.387	1.55
Sri Lanka	109.03	−0.390	−1.21
Taiwan	169.65	−2.380	−6.48
Thailand	184.38	−0.066	−0.09
United Kingdom	1.842	0.036	4.93
U.S.S.R.	0.785	0.346	20.64
West Africa	50.512	0.186	1.46
Zaire	3.853	0.145	4.92

(continued)

Table 24—Continued

Sources: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980 (computer printout); International Monetary Fund, *International Financial Statistics Yearbook 1981* (Washington, D.C.: IMF, 1981); and U.S. Department of Commerce, Bureau of the Census, *World Population 1979*, ISP-WP-79 (Washington, D.C.: Government Printing Office, 1980).

Notes: Rice consumption is milled equivalent per capita in kilograms. Estimates are of the form

$$C_{it}/N_{it} = \alpha + \beta T + \varepsilon,$$

where

$C_{it}/N_{it} \equiv$ per capita consumption for country i in year t; and

$T \equiv$ time, where 1961 = 1, . . . , 1980 = 20.

Unless otherwise noted, all estimates are for 1961-80; and t-statistics reported are for the estimated coefficients for time (T). Observations for South Vietnam are for 1961-74. West Africa includes Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Senegal, and Sierra Leone.

[a] Where $C_t^* \equiv$ per capita rice and wheat consumption for India,

$$C_t^*/N_t = 105.47 + \underset{(4.79)}{1.005}\ T.$$

APPENDIX 2: INSTRUMENTAL VARIABLE ESTIMATIONS

Burma, Indonesia, the People's Republic of China, Thailand, and the United States are considered to be large participants in the world rice trade. As such, their trade behaviors are expected to influence world prices and thereby the trade volumes of one another. Consequently, in addition to OLS, the instrumental variables (IV) technique was used in the reestimation of trade equations for these countries. In order to allow for the possibility of correlation between the rice prices and the error terms of each equation, an IV for price was estimated. For the reestimation of the trade equation for the large participants, a matrix of instruments was then created using the price instrument, a constant term, and the set of exogenous variables from the corresponding OLS equation.

The IVs for price were estimated as a function of the aggregate shifters for the 50 small-participant country groups and the individual exogenous variables from each of the 5 large participants. The OLS estimate from which estimated values are adopted as the price instrument is given below.

$$
\begin{aligned}
P = {} & 569.82 - \underset{(2.74)}{} \; 0.122 \; \underset{(-2.93)}{SFT_{50}} \\
& - \underset{(-1.01)}{0.088} \; [(1-PD_1)\, TV_{BM}] - \underset{(-0.71)}{10.550} \; PO \\
& - \underset{(-2.35)}{0.125} \; TV_{TH} + \underset{(2.61)}{0.168} \; CDXT_{TH} \\
& - \underset{(-1.62)}{0.634} \; (PD_2 \cdot S_{t-1,\, US}) \\
& - \underset{(-0.91)}{0.305} \; [(1-PD_2)\, BS_{t-1,\, US}] \\
& + \underset{(1.59)}{1{,}104.6} \; BOP_{IA};
\end{aligned}
$$

$R^2 = 0.67$; $\bar{R}^2 = 0.43$; D.W. = 2.10; and $F_{(8,9)} = 2.23$.

In this equation SFT_{50} is the sum of the product of exogenous variables and the OLS estimated coefficients for all price-taking country groups, including exogenous countries and intercepts. PD_1 is 1 for the period 1961-65 and 0 for the period 1966-73; PD_2 is 1 for the period 1961-73 and 0 for the period 1974-80. t-statistics are in parentheses.

The subscripts

BM ≡ Burma,
TH ≡ Thailand,
IA ≡ Indonesia, and
US ≡ the United States.

See Tables 14-17 for other definitions.

For Burma and the People's Republic of China, estimations reported in Table 17 are reestimated using IV and the results are reported in Table 25. Use of IV entails loss of the observations for 1961 and 1962 for the trade estimation. For Burma, where trade equations specify differing behavior before and after 1966, the loss of two observations has a substantial impact on the estimated parameters for the first period, 1961-65. For the 1966-80 period, IV provides a more negative estimated price coefficient and has little effect on TV. The IV coefficient for price, however, is within one standard error of the OLS coefficient. The price coefficient for the People's Republic of China is similarly affected, with the IV estimation increasing the price coefficient by approximately one standard error. The composite effect of the two reestimations is approximately 0 for the estimation of aggregate response to world price changes. Because of the relationship of the IV and OLS estimates for Burma and the People's Republic of China and the loss of the second degree of freedom in using IV, the OLS estimates are retained from the analysis in Chapter 3.

For Indonesia, price is added as an explanatory variable in the reestimation using IV, but the price coefficient is not statistically significant. Therefore, the OLS estimate that excludes price as an explanatory variable is retained. Similarly, for Thailand, the inclusion of price in the OLS and IV estimation yields a strongly perverse parameter. The OLS estimate excluding price is thus retained. As price enters trade estimation for the United States only with a lag, it is treated as a predetermined variable and the use of IV is not necessary.

Table 25—Instrumental variable estimations for net rice exports of selected major rice-exporting countries, 1963-80

Country	Estimated Coefficients and Dependent Variables (t-Statistics)	R^2 ($\bar{R}^2$)	D.W.	F (df)
Burma	919.742 + 8.726 (PD · P) − 0.936 [(1−PD)· P] + 0.294 [(1−PD) TV] − 3947.94 PD (1.67) (−3.36) (2.83) (−1.46)	0.88 (0.85)	1.85	24.89 (4,13)
China, People's Republic of	−815.632 + 2.104 P + 120.2 TT (4.53) (4.87)	0.75 (0.72)	1.25	22.35 (2,15)
Indonesia	−205.886 + 0.308 P − 28.307 PO − 4240.60 BOP − 423.714 PD (0.49) (−1.90) (−3.11) (−1.48)	0.73 (0.65)	2.04	8.96 (4,13)
Thailand	2,694.55 − 2.691 P + 0.207 TV − 0.203 CDXT (−3.09) (1.23) (−1.55)	0.61 (0.52)	1.82	7.16 (3,14)

Sources: Rice and wheat production, consumption, exports, imports, and stocks: U.S. Department of Agriculture, Foreign Agricultural Service, "Reference Tables on Rice Supply-Utilization for Individual Countries," *Foreign Agriculture Circular—Grains*, FG-20-79 (Washington, D.C.: USDA, December 1979); and U.S. Department of Agriculture, Foreign Agricultural Service, "Grain Printouts," Washington, D.C., January 1980. (Computer printout.)

Prices: International Bank for Reconstruction and Development, *Commodity Trade and Price Trends* (Washington, D.C.: IBRD, August 1978). The 1973 rice price is an estimate from the International Food Policy Research Institute based on IBRD data.

Total imports, foreign exchange, GNP, GDP, and population: International Monetary Fund, *International Financial Statistics Yearbook, 1979* (Washington, D.C.: IMF, 1979); International Monetary Fund, *Direction of Trade Yearbook*, various issues (Washington, D.C.: IMF, various years); International Bank for Reconstruction and Development, *World Atlas*, various issues (Washington, D.C.: IBRD, various years); United Nations, Department of International Economic and Social Affairs, *Demographic Yearbook*, various issues (New York: UN, various years); Food and Agriculture Organization of the United Nations, *Trade Yearbook*, various issues (Rome: FAO, various years); and U.S. Department of Commerce, Bureau of the Census, *World Population, 1977*, ISP-WP-77 (Washington, D.C.: Government Printing Office, 1978).

Notes: Net rice exports are gross rice exports less gross rice imports in 1,000 metric tons milled equivalent on a calendar year basis. The Cochrane-Orcutt technique is used for the People's Republic of China and Thailand. PD is a political dummy variable; it equals 1 for 1961-65 and 0 for 1966-80. P represents International Food Policy Research Institute estimates of Thai 5 percent broken f.o.b. Bangkok rice prices in 1977 constant U.S. dollars per metric ton. TV is actual production less estimated consumption of rice in 1,000 metric tons milled equivalent in the USDA world production year prior to the corresponding calendar year of trade. Estimated consumption is time-fitted per capita rice consumption times annual population, if the time trend is found significant; otherwise it is average per capita consumption times population. TT is a time trend, where

$$TT \equiv \begin{array}{l} 0,\ 1961;\ 1,\ 1962;\ \ldots;\ 9,\ 1970 \\ 10,\ 1971\text{-}80. \end{array}$$

PO is the price of petroleum in 1980 U.S. $ per barrel, Saudi Arabian realized price. BOP is the balance of payments constraint. CDXT is the cumulative sum of RX minus TV starting with 0 in 1961, where RX is net exports.

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