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Sources and Effects of Instability in the World Rice Market

by

T.S. Jayne

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SOURCES AND EFFECTS OF INSTABILITY IN THE WORLD RICE MARKET

EXECUTIVE SUMMARY

Government trade and commodity policies are normally assumed to destabilize world prices. This conclusion is the result of a large body of theoretical and empirical work indicating that governments tend to stabilize domestic markets by venting supply instability onto the world market and by preventing world price changes from being absorbed through domestic supply and demand adjustments. A major implication of this literature is that movements toward free trade in grain would appreciably stabilize world prices.

This report reassesses the causal link between domestic agricultural policies and world price instability, using the case of the rice market. Specifically, the report develops a framework for analyzing the effects of domestic policies on international price stability, identifies the conditions required for government policies to destabilize world markets and econometrically examines whether these conditions apply to the trade behavior of seven major rice trading countries over the period 1960-87. This is done by comparing the estimated transmission and absorption effects (under actual historical conditions) with those implied under free trade, by incorporating several behavioral restrictions drawn from standard trade theory. Sensitivity analysis is then used to discern how robust the results are to changes in domestic and international price elasticities.

The report also identifies major structural and behavioral factors that account for the great degree of price instability in world rice markets relative to other major grain markets, and examines the dynamic effects of these factors on the organization and performance of international rice trade.

The analysis indicates that while stabilization policies in some countries have exacerbated world price instability, this was not usually the case. Thus, the link between domestic price stability and world price instability appears, in the case of the rice market, to be exaggerated. Domestic commodity policies may take many forms, with the ultimate impact on world price stability depending on the specific rules governing pricing, stock release and trade. Therefore, contrary to conventional wisdom on the subject, movements toward free trade may not contribute greatly toward stability in world rice trade.

If domestic agricultural policies have been overemphasized as sources of instability in world rice trade, an explanation is still required for the high degree of volatility in this market. The major factors include: (1) the geographic concentration of world rice production in an area of unstable weather; (2) a persistently thin and fragmented market where price information is difficult to obtain, and where the development of coordination mechanisms to reduce trade uncertainties are

thwarted by major traders' tendency to sporadically float in and out of the market; (3) very low consumption responsiveness to domestic prices in the countries examined, which means that the ability of domestic demand to absorb world price instability, even under free trade, is limited; (4) the emerging relationship between the world rice and petroleum markets; and (5) low world stockholdings relative to production, and the absence of a major actor that stabilizes world rice prices through stock and trade policies, as in the wheat and corn markets.

Geographical concentration of world rice production: The geographical concentration of production is a paramount cause of price instability in the rice market, as it leads to positively correlated production variations in major rice importing and exporting countries. More than 80 percent of the world's rice is produced in a narrow swath of land in south and southeast Asia. The correlation coefficient of production deviations from trend between the three largest Asian rice exporters (Thailand, Burma and China) and four major Asian importers (Indonesia, Bangladesh, Vietnam and Malaysia) was .66 between 1970 and 1987. This means that poor harvests among these blocs (which account for over 60 percent of world rice production) tend to occur at the same time, putting greater pressures on the world market to cope with simultaneously rising import demand and falling export supplies (and vice versa in years of surplus). Domestic agricultural policies may exacerbate this source of instability.

Yield variation appears to be more important than area variation as a source of rice production fluctuations in most of these Asian countries. In the United States, on the other hand, area variability has been more important than yield variability. This appears due to periodic changes in U.S. rice programs that greatly influence domestic production incentives. While an important purpose of these policy changes has been to realign domestic prices with world market conditions, their success has been limited when examining annual U.S. production and world price movements. Econometric evidence presented elsewhere indicates that U.S. rice production has responded to lagged prices, but not current prices (Tyers and Anderson 1988; Zwart and Meilke 1979). Therefore, production changes in one year may have a destabilizing influence if current world market conditions are different from that of the preceding year.

Market Thinness and Fragmentation: The organization of the rice market has a profound effect on the level of world price uncertainty. First, the world rice market is very fragmented, and borders on being a misnomer. In the short-term, prices of indica and japonica varieties in various sub-markets frequently move independently of one another because of limited substitutability in consumption among the different varieties and qualities. However, evidence suggests that price movements are reasonably correlated on an annual basis.

Matching buyers with sellers of a particular type of rice is more difficult than in other grain markets such as wheat or corn because (1) grades are inadequately standardized, (2) reliable price information about a particular market may be difficult and costly to obtain, especially in the short run, and (3) the rice market lacks an established trading forum in which buyers and sellers can interact with low search costs. This has created high transactions costs of international rice trading. Partial evidence of this includes unusually high brokerage fees charged by trading houses.

Transactions costs are also raised by unreliable and unstable trade patterns that characterize the rice trade. A number of traditional importers have approached self-sufficiency in recent decades, aided by green revolution rice production technologies. As a result, relatively small changes in domestic supply or demand can cause countries such as Indonesia, Korea, India, Brazil, and Japan to enter the market either as importer or exporter in any given year. The Asian green revolution technologies, which have generally produced greater successes among traditional importers rather than exporters, has contributed to a structure of world rice trade in which numerous countries float in and out of the world market due to random and temporary aberrations in domestic supply and demand. This situation has created high search costs, market thinness, and has impeded the development of reliable long-run trade patterns, contributing to the uncertainty faced by major rice traders.

Another consequence of the unstable, thin, and fragmented nature of the rice market may be the failure of a viable internationally-accepted rice futures market to develop. Viable futures markets have always depended on sufficient volume to avoid the risk of price manipulation by large actors. But this presents a critical trade-off in the fragmented rice market. On the one hand, greater volume to lubricate the market may be achieved by standardizing price differentials between different varieties and grades of rice, and by increasing the number of delivery points. This would make more contracts fungible and make the futures market more attractive to speculators. However, the market's value to hedgers depends on the correlation between the futures price and the spot price realized when the futures contract matures, and that correlation is reduced as less substitutable contracts are made interchangeable. Because monthly spot prices among various sub-markets and varieties do not always move together, unpredictable and perverse basis movements in rice futures observed on U.S. Commodity Exchanges during the early 1980s may partially be due to contract standardization problems, which was an outgrowth of market thinness, fragmentation and uncertainty.

Low Consumption Responsiveness to Domestic Prices among Major Traders: Conventional transmission elasticity models imply that free trade would increase countries' trade responsiveness to world price and thus their ability to absorb quantity shocks on the world market. However, in many cases the magnitude of such improvements would be small in absolute terms. This is because most rice trading countries examined do not exhibit enough responsiveness to domestic prices even without trade restrictions to greatly affect these countries' responsiveness to world prices once such trade restrictions are eliminated. Therefore, low national trade elasticities can be deduced without reference to government insulation policies.

Rice-Petroleum Market Linkages: Four of the five major rice importers since 1980 are oil exporting countries. Of these, rice imports of Nigeria, Iran, and the Middle East bloc are shown to be quite sensitive to oil prices. Therefore, rice market instability is affected not just by production fluctuations, government policy, and their interaction, but also by important demand-side shocks originating from outside the rice market.

Low world stock levels and no identifiable actor to stabilize world market through domestic policy: A major distinction between the world rice and wheat markets is the amount of stocks available to stabilize the market in response to production and demand shocks. Between 1980-87, the average ratio of world stocks to world production was 29 percent in the wheat market compared with only 15 percent in the rice market. The difference is partially attributable to the diametrically opposing price policies of major wheat and rice producing countries. Wheat stock accumulation has been a direct side effect of government programs in the United States and the EC, where producer prices in the 1980s have been higher than commonly used world price indicators. By contrast, major rice producing countries such as Thailand, Burma, Pakistan, Indonesia, and India have consistently taxed rice farmers and subsidized consumers; such a policy environment is not conducive to the accumulation of large stocks. None of these countries have held stocks which amount to more than 12 percent of production during the 1980s. The greater proportion of wheat held in storage may mitigate upward price swings during shortage conditions better than in the rice market.

This analysis suggests a shift in the focus of policy work on instability in international rice markets away from government price stabilization policies per se, and toward other organizational features of the market that exacerbate instability. Given the geographic concentration of world rice production, an internationally-financed reserve would moderate the extreme fluctuations that characterize the rice market. The main value of such a reserve would be to keep sporadic importers and exporters out of the market by providing incentives for these countries to unload sporadic surpluses to the reserve, or purchase occasional imports from the reserve, thus avoiding potential disruptions to the world market.

**SOURCES AND EFFECTS OF INSTABILITY
IN THE WORLD RICE MARKET**

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1. INTRODUCTION

Introduction

Heightened instability is one of the most conspicuous features distinguishing current world grain markets from those of the 1950-60s. Because rice is the most important food grain in world consumption, increased instability in this market may have severe effects on hunger in many regions of the world. The 1986 Ministerial Declaration of the Uruguay GATT Round emphasized the "urgent need to bring more discipline and predictability to world agricultural trade by correcting and preventing restrictions and distortions...so as to reduce the uncertainty, imbalances, and instability in world agricultural markets." This report is motivated by the need to better understand the sources of instability in world rice markets and their effects on the organization, behavior, and performance of these markets.

Since 1960, the magnitude of price instability in Thailand's export market,[1] normally used as the benchmark for world prices, has far exceeded that of other major agricultural commodity markets (Schmitz *et al.* 1981, Jayne 1989).[2] Moreover, rice market instability during the 1970s and 1980s appears greater than in the 1960s. Conventional wisdom posits that much of the heightened volatility in prices is due to government insulation policies that stabilize domestic markets at the expense of international price instability, achieved by severing the link between domestic and world prices (Johnson 1975, Bale and Lutz 1979, Shei and Thompson 1978, Falcon and Monke 1979-80, Bigman 1985). Since rice is among the most heavily regulated commodities in world trade, its degree of instability is also often attributed to such insulation policies. For example, in their analysis of the rice market Falcon and Monke conclude that:

> The preference of governments for quantitative trade controls rather than tariffs isolates domestic price movements from world price movements, and fluctuations in world prices become largely irrelevant to the short-run production and consumption adjustment mechanisms within each country. The structure of trade causes the relationship between domestic and world price movements to be a function mainly of government policy, because the quantities of imports and exports, or at least the variations in these quantities over time, are largely determined by policy makers. Given this institutional context, it is understandable why past econometric studies of rice trade could not link production, consumption, and trade with world prices in a statistically significant manner (p. 288).

[1] milled 5% brokens, f.o.b. Bangkok.

[2] Schmitz *et. al.*, (1981) arrived at this finding using the coefficient of variation; Jayne (1989) used the variance of annual percentage changes and the coefficient of variation from a regression line.

This report reassesses the causal link between domestic agricultural policies and world price instability using the case of the rice market. Specifically, the report develops a framework for analyzing the effects of domestic policies on international price stability, identifies the conditions required for government policies to destabilize world markets and econometrically examines whether these conditions apply to the trade behavior of seven major rice trading countries over the period 1960-87. The report also identifies major structural and behavioral factors that account for the great degree of price instability in world rice markets relative to other major grain markets, and examines the dynamic effects of these factors on the organization and performance of international rice trade.

Research Organization and Methods

This study is divided into five sections. The remainder of this section briefly discusses the importance of instability in international grain markets, placing the study within the literature on this subject.

Section 2 examines the organization and behavior of the rice market, drawing contrasts with the wheat market. The section begins with a description of the major public and private actors in the markets, their objectives and behavior, and the institutional mechanisms through which trade is coordinated. The remainder of the section examines the trade, stock, production, and consumption patterns of the national actors in the rice markets.

Section 3 examines the relationship between government insulation policies (*i.e.*, policies that insulate domestic markets from shifts in external market conditions and/or vent domestic supply variations onto world markets) and international market instability. Following a large theoretical literature on the subject, a simple conceptual model is developed to demonstrate the mechanism by which government insulation may destabilize international markets. This theory is examined empirically in a partial equilibrium econometric model. In particular, the model examines (1) the degree to which importing and exporting countries transmit production instability onto world markets (the transmission effect), and (2) the extent to which countries stabilize the market by adjusting annual trade volumes in response to world price signals (the absorption effect). The section concludes by identifying the conditions required for government insulation policies to affect world market stability, and empirically examines whether these conditions apply to the trade behavior of seven major rice trading countries over the period 1960-87. This is done by comparing the estimated transmission and absorption effects (under actual insulation conditions) with those implied under free trade, by incorporating several behavioral restrictions drawn from standard trade theory. Sensitivity analysis is then used to discern how robust the results are to changes in domestic and international price elasticities.

Section 4 identifies a set of alternative factors – largely related to the inherent organization of the rice trade – that generate a high degree of instability and uncertainty in the world rice market relative to the wheat market.

The final section is divided into four sections. The first section synthesizes the results of Sections 2-4 with respect to the main sources of instability in the rice and wheat markets. The second section summarizes the ways in which such instability has in turn affected the structure and organization of these markets. These observations are more conjectural due to the complexity and multifaceted influences exerted on world commodity markets, and are presented as hypotheses subject to further analysis. The third section discusses the policy implications of these results, and examines the advantages and drawbacks of several alternative policy mechanisms to reduce the level of instability in wheat and rice markets. Areas for further research are discussed in the final section.

The Importance of Instability in International Grain Markets

Instability is not "bad" per se; it is the uncertainty often associated with instability that can reduce social welfare. Uncertainty is an ex-ante concept, and can be defined as the variance of a forecast error (Engle 1982, Engle *et al.* 1987, Bollerslev *et al.* 1988). Instability is more often measured as the ex-post deviation in an outcome from some combination of past outcomes, such as a mean, moving average, or historical trend. While it is crucial to retain this distinction between instability and uncertainty, there may be a high degree of correlation between the two (Brennan 1982).

Until recently, the literature relating instability and uncertainty to the behavior of market actors and welfare amounted to the study of instability under certainty (Just 1987). The often-cited works by Waugh (1944), Oi (1961), and Massell (1969) attempted to measure the welfare effects of price instability under the assumption that either there is no time lapse between resource allocation decisions and the sale of output, or that future prices, while unstable, are nevertheless known and that agents can costlessly adjust their known marginal costs to these known future prices. Yet in the real world of distributional and biological production lags, agents must often decide the amount they expect to produce (procure) without knowing the price at which they can sell (buy) it. Technically, they can respond only to the parameters of a subjective price distribution rather than to the future price itself. Abundant empirical evidence has shown that producers, due to risk aversion, often decrease acreage or production in response to increasing price uncertainty (Behrman 1968, Just 1974, Traill 1978, Brorsen, Chavas and Grant 1987), indicating that the supply curve may shift with changes in the variance of prices.

More recent literature examining economic efficiency under uncertainty, information costs, and incomplete forward and contingency markets has decoupled the link between competitive equilibrium and pareto optimality (Hart 1975, Newbery and Stiglitz 1981). The general conclusion from this literature is that when markets are incomplete, instability and risk can lead to suboptimal resource allocation in agriculture, and government stabilization policies can theoretically improve economic efficiency (Myers and Oehmke 1987). Whether they actually possess the resources or political will to do so is an empirical question.

While very valuable, this literature has confined itself to a particular aspect of instability: its effect on efficiency, holding market structure constant. There are at least two important paths by which further study can augment this literature and contribute meaningfully to policy discussion. The first is to consider explicitly a fuller range of market performance criteria beyond efficiency. Many governments in the world formulate their grain market policy goals in terms of food security, political and economic stability, growth, and equity, in addition to efficiency (Sorenson and Rossmiller 1983). Thus, policies that influence the level of instability in grain markets must be evaluated with respect to this broader range of goals.

The second addition to the instability literature is to examine its feedback effects on market organization and policy responses, and the corresponding changes in the level and distribution of risk in the system. Changes in technology, institutional arrangements, and general economic interdependence since the 1960s have clearly created new levels of uncertainty, transactions costs, and external effects in world grain production and trade. These changes have in turn created incentives for new modes of coordination, new reactive steps by private and public actors to reduce exposure or vulnerability to risk and transactions costs, creating new patterns of investments and external effects (Shaffer 1969). Therefore, institutional organization is influenced by instability and risk, just as instability and risk are influenced by institutional organization.

The above issues are related to ongoing research under North Central Regional Research Project 194 (Conner *et al.* 1988). This study attempts to contribute to this area of research by examining how instability influences market organization, government behavior, and trade patterns.

The reverse question – the effect of government behavior on market instability – has been the focus of a different set of recent studies (Zwart and Meilke 1979, Blandford and Schwartz 1983, Blandford 1983, Siamwalla and Haykin 1983, Wilde *et al.* 1985). These studies tend to substantiate the contention that government insulation policies have produced low import and export responsiveness to world prices. Blandford's study of the wheat market, for example, finds that only one country/region out of 12 (the United States) varies its net exports in response to changes in world wheat price at the 10 percent significance level. Less than one third of the 55 country groups in the Siamwalla and Haykin rice study show any short-run responsiveness to world rice prices.

Point of Departure From Existing Literature

Previous studies linking government insulation policies to world market instability have focused on two effects: the extent to which production variations have been transmitted abroad in the form of trade variations (transmission effect), and the degree to which annual trade volumes of large trading actors are sensitive to world price signals (absorption effect).[3] If the transmission effect is high and the absorption effect is low, it has commonly been concluded that government insulation policies are the cause, and that such policies have thus exacerbated world market instability (Blandford 1983, Schwartz and Blandford 1983, Falcon and Monke 1979-80, Siamwalla and Haykin 1983, Bigman 1985). According to this literature, low trade elasticities are largely attributable to government price and trade policies that insulate domestic markets from world price fluctuations. However, this approach is unwarranted in many cases because no comparison is made with the magnitude of these effects under non-insulation. Such methods can lead to inappropriate conclusions regarding the sources of instability in world grain markets. Low net export elasticities do not necessarily mean that government insulation is the cause. Nor does government insulation require that increased world price instability is the result. This paper identifies the theoretical conditions necessary for government trade/commodity policies to affect world market stability and then estimates the extent to which they have done so for seven major rice trading countries during the period 1960-87. This is done by comparing the estimated transmission and absorption effects (under actual insulation conditions) with those implied under free trade, by incorporating several behavioral restrictions drawn from standard trade theory.

Moreover, past conclusions of low absorption effects appear sensitive to model specification and definition of world price. In the rice trade for example, the national trade elasticities of many countries become much more elastic when exchange rate and domestic inflation data are included in the definition of world price, when a non-linear relationship between trade volume and world price is allowed, and when a broader range of variables affecting trade enter into the analysis.

The relationship between government insulation and world market instability is not unidirectional. National food security, economic efficiency, and political stability are greatly influenced by the performance of domestic grain markets, which are in turn affected by the stability of international grain markets. It is perhaps understandable why governments seldom allow international market forces to freely affect their constituents. Efforts to improve the performance of domestic wheat and rice markets require a better understanding of the cause-effect relationships between government insulation policies and instability in world markets. Inappropriate conclusions regarding the causes of instability may result in strategies that fail to address the roots of the problem and further entrench political opposition to multilateral market coordination stressing comparative advantage and freer interplay between domestic and world

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[3] The transmission and absorption terms are attributable to Blandford (1983), and have since been used frequently in the literature on the subject.

prices. The study attempts to document the dynamic feedback effects of world price instability on market organization and the behavior of public and private actors in the system. Finally, the study analyzes alternative strategies to reduce the instability of the world rice market and their probable consequences.

2. THE ORGANIZATION OF WORLD RICE MARKETS

Trade by Type of Rice

Rice is comprised of four distinct varieties that are of limited substitutability in major rice consuming areas. Eighty-five percent of rice traded is *indica*, a longer-grain variety that is fluffy and non-sticky when cooked. The remainder is *japonica* (a shorter-grain that is semi-sticky and moist when cooked), *aromatic* (a scented long-grain variety), and *glutinous* (waxy and gelatinous when cooked).[4] Demand for indica rice is divided into milled and parboiled types, which are both further divided into different qualities. Major quality criteria are percentage of broken grains, chalkiness, translucency of the grains, and odor when cooked. The differences in quality among internationally-traded rice is evident from the extreme variation in unit import prices among different countries (Table 1). For example, unit prices in a particular year may vary 200 percent or more.

Table 1. Rice Import Price Per Metric Ton Among Major Importers

COUNTRY	1983	1984	1985
	$ U.S. / metric ton		
Saudi Arabia	564	540	477
Nigeria	438	454	426
Iraq	420	411	400
Iran	324	420	400
Hong Kong	374	346	303
Brazil	360	487	224
Indonesia	329	319	280
Malaysia	283	270	260
Senegal	224	212	214

Source: computed from FAO (1985).

[4] Another variety, *glaberimma*, is found in West Africa, but is of minor importance in world rice trade.

Many countries have distinct preferences for one type of rice, although not all of them appear willing or able to pay a high premium for that type (Table 2). Saudi Arabia and Nigeria prefer high quality parboiled rice and are willing to pay for it. In Thailand, however, parboiled rice sells at a discount to regular milled rice. The demand for high quality U.S. and Thai milled rice is concentrated in Iran, Iraq, Western Europe, and the United States. While low-quality (more

Table 2. Major Traders by Type of Rice

TYPE	QUALITY	MAJOR EXPORTER	MAJOR IMPORTERS
Indica, Milled	brokens	Thailand, Burma	Senegal, Madagascar, South Vietnam, Gambia
	low	Thailand, Pakistan China, Burma	Indonesia, most of West Africa
	medium	United States, Thailand, Pakistan	Brazil, Hong Kong, Indonesia, USSR
	high	United States, Thailand	West Europe, Iran, Iraq,Malaysia
Indica, Parboiled Milled	low	Burma, Thailand	Bangladesh, Sri Lanka
	high	United States, Thailand	Nigeria, Saudi Arabia, West Europe
Japonica	--	Japan, China, Australia	Indonesia, South Korea,
Brown	parboiled	---	West Europe, South Africa

Source: Rastegari-Henneberry (1985).

than 20 percent broken) milled long grain rice is sold mainly to poorer countries, some countries (*e.g.*, Senegal) actually prefer this type of grain.

Because of distinct preferences, there may be a surplus in the market for one type of rice and a shortage in another at the same time. As a result, prices for indica and japonica rice may move somewhat independently of one another (Rastegari-Henneberry 1985, Petzel and Monke 1980). However, among the medium- and long-grain indica markets which account for the bulk of internationally traded rice, prices are highly integrated across countries, qualities, and time (Petzel and Monke 1980). On this basis, Falcon and Monke argue that "the price of any widely traded variety, such as Thai 5 percent brokens can serve as a reasonable indicator of movements in all world markets" (p. 284). This conclusion is supportable when the time frame of analysis is annual or even semi-annual; in the short run, however, prices across countries and varieties may move independently for a month or two at a time. Japonica markets especially may not be well integrated with indica markets such as the Thai export market (Petzel and Monke 1979-80). In this respect, the rice market is more fragmented and price information less readily available than in the wheat market.

Another major distinction between international rice and wheat trade is that the former has no universally used grades or standards. Also in contrast to the wheat market, no reliable, internationally accepted spot or futures prices can be quoted for each type or quality of rice (Rastegari-Henneberry 1985). Several past attempts to establish rice futures markets on various U.S. exchange boards have ended in failure. While the reasons for this are discussed in Section 5, the important point here is that matching buyers with sellers of a particular type and quality of rice is more difficult than in the wheat market because (1) grades are inadequately standardized, (2) reliable price information about a particular market (specifying variety, quality, time and location) may be difficult and costly to obtain, especially in the short run, and (3) the rice market lacks an established trading forum in which buyers and sellers can interact with low search costs. This conclusion is supported by the existence of numerous rice brokerage houses earning very high fees to match potential sellers with buyers (see Section 2). Because of wide differences in variety, quality, and consumption preferences, it may be more accurate to regard the world rice trade as a set of distinct markets with moderately to highly substitutable products.

Major Actors in the Rice Market

While much attention has been given to government policies as a source of grain market volatility, relatively little research has focused on instability induced by the structure and coordination of trade within the grain marketing system. An understanding of price movements in international markets requires a better understanding of how government and private actions interact (McCalla 1979). This section develops a framework for analyzing this issue.

Grain trade across borders requires coordination between at least three broad types of marketing actors: exporters, importers, and an international intermediary who links them together. Exporters are the set of firms that collect grain from inland markets and transport it to export ports. These firms include exporters who could sell the product either to international intermediaries or directly to importers. A similar set of importing firms procure grain for domestic storage, processing, and/or resale in the importing country. The third group of actors are the specialized national or multinational grain trading firms that link domestic markets together by buying from exporters and selling to importers. Such international intermediaries exist as distinct from exporters because of "the complexities of international marketing which require specialized knowledge in exchange rate conversion, ocean shipping, international legal issues, and particular information about the international market" (McCalla 1979, p.210).

Frequently, the role of exporter, middleman, or importer may be combined by a single marketing actor that vertically integrates operations either backward or forward. Integration may occur to reduce transaction costs and uncertainty across stages (Williamson 1975), to provide economies of scale, or to increase market power (Schrader *et al.* 1986). Market power, and hence pricing outcomes, may also hinge on the number of firms fulfilling the roles of exporter, importer, and international intermediary (McCalla 1979).

The actors who fill these three roles vary greatly from country to country. Exporters and importers are typically state trading agencies, farmer cooperatives, flour milling firms, multinational grain trading firms, and smaller private firms. Of these, only the large multinational traders operate extensively as intermediaries in the world wheat market. In the rice trade, cooperatives and millers are relatively more important. However, there has been an increasing trend in the rice market toward direct government-to-government contracts, especially when the countries involved possess market power. An example of this would be the Pakistani Rice Export Corporation negotiating a sale to the Indonesian rice marketing board, BULOG. In such cases, international intermediaries do not assume ownership of the grain, although they still may handle the grain in a logistical capacity. This is because state trading agencies seldom become directly involved in logistics; they sell principally on an f.o.b. basis and buy on a c.i.f. basis (Schmitz 1986). Therefore, trade across borders, even under government-to-government contracts, usually involves a middleman, normally a multinational grain trading corporation.

Domestic policies of the trading countries strongly affect the coordination of trade between exporter, middleman, and importer. A plethora of policy combinations are possible, each of which fit into one of four broad categories. The first category is that of complete transmission of world price movements to the domestic markets of both the importing and exporting country. This would be the case in a free trade environment, or one where government policy does not directly alter the relationship between domestic and world price (*e.g.*, deficiency payments or a simple tariff).[5] Category 2 is that of complete price transmission on the import side, but where the exporting government isolates its domestic price from the world price, through either price supports, variable export taxes/subsidies, or state marketing boards. The third and opposite category is that of complete world-to-domestic market price transmission on the export side, but insular policies on the import side. Category 4 represents insulation policies in both the importing and exporting country. Table 3 summarizes the possible combinations of market actors and policy environments.

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[5] I use the term "free trade" with the recognition that it is largely an abstraction, since all market exchange–free or administered–takes place within a set of legal and institutional constraints imposed by governments (Shaffer 1987). In this study, free trade refers to a condition under which world and domestic prices are equal, except for transport costs.

Table 3. Matrix of Alternative Trading Actors in World Rice Markets, 1982/83-1985/86

Policy Environment	Role in World Trade			Example
	Exporter	International Intermediary	Importer	
1	px,mt	px,mt,pm	mt,pm	-
2	px,sx,mt	px,sx,mt,pm	mt,pm	-
3	px,mt	mt	mt,pm	USA-EC
	px,mt	mt	sm	USA-Japan
4	sx	mt	sm	Pakistan-Indonesia
	sx	mt,pm	mt,pm	Pakistan-Nigeria

Sources: compiled from data in USDA (1986) and Jabara (1982).

Key
- px: private domestic exporting firm/cooperative/miller
- sx: state exporter
- mt: multinational trading corporation
- sm: state importer
- pm: private domestic importing firm/cooperative/miller

Policy Environment
- 1: Border pricing on both import and export side
- 2: Border pricing on import side; insulation policies on export side
- 3: Border pricing on export side; insulation policies on import side
- 4: Insulation policies on both import and export side

No precise data are available to determine the proportion of rice trade carried out under each policy category. Slayton (1984) reports that in 1983, state trading agencies arranged 46 percent of all rice exports (categories 2 and 4), and state importers arranged 60 percent of all rice imports (categories 3 and 4). Falcon and Monke (1979-80) estimate that 93 percent of rice imports and 76 percent of exports were affected by insulation policies. At least 30 percent of total rice trade is coordinated by government-to-government contracts.

The objectives and behavior of the five types of actors in Table 3 are now examined in more detail.

State Trading Agencies

Grain policy almost everywhere is fundamentally driven by the societal perception, in place for several millennia, that government is at least partially responsible for supplying the population with adequate food at affordable prices.[6] Governments base their grain policy decisions on a variety of objectives in addition to efficiency, the type of production, stockholding, and trade patterns suggested by domestic resource cost/comparative advantage analyses may be incompatible with existing political and social realities, regardless of their potential long-run benefits. Theory and empirical evidence indicate that many grain producing countries have stabilized domestic prices through price and trade policies that sever the link between domestic and world prices (Zwart and Meilke 1979, Falcon and Monke 1979-80, Bigman 1985). The removal of such policies may promote international price stability at the expense of domestic price instability, unless large and expensive grain stocks are held (Zwart and Meilke 1979, Paarlberg 1988). In this regard, it may be difficult to stabilize world markets through GATT-type negotiations whereby governments forfeit the right to use trade and price policies to stabilize domestic markets (Jabara 1982).[7] Recent food riots in the Sudan, Tunisia, Poland, Turkey and Morocco serve as constant reminders to other governments that they may no longer be the government if food prices exceed affordable levels.

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[6] This conception was clearly in place by the time of ancient Rome, where "bread and circuses" were a common response of Roman emperors to civil unrest. Even before this, the interrelationship between politics and food was evident from Socrates' caution that "no man qualifies as a statesman who is entirely ignorant of the problems of wheat" (in Morgan 1979).

[7] Others, of course, disagree. D.G. Johnson (1984), for example, contends that "a low cost means of increasing price stability in international markets is by liberalizing trade" (p. 741). It is unclear, however, whether many governments would consider increased domestic price instability a "low cost" to pay.

Table 4. State Trading and Other Forms of Administrative Coordination in World Rice Markets

	State Trading Agencies	Tariffs, Taxes, Subsidies	Quotas, Restrictive Licensing	Variable Levies
Exporters:				
Pakistan	x			
Thailand	a			
Burma	x			
United States		x		
China	x			
Importers:				
Soviet Union	x			
Egypt	x			
Japan	x		x	
Brazil	x			
S. Korea	x	x		x
Nigeria				x
Iran		x		
Iraq		x		
Senegal	b	b		
EC			x	
Indonesia	x			

Sources: Jabara (1982) and USDA (1986).

a: The majority of rice trade is through private exporters. Exporters are required to register with recognized trade associations and comply with Department of Foreign Trade regulations.

b: Parastatal monopoly on rice imports abolished effective December 1986.

A list of countries relying primarily on state marketing agencies to fulfill the role of importer and exporter is provided in Table 4. The objectives and behavior of these state actors may differ according to the country's position in the market. For example, Iran and Iraq are large and consistent importers; reliability and continuity of supply are important objectives. Therefore, it is not surprising that the Iranian and Iraqi government food agencies typically lock-in most of their rice imports through countertrade agreements with exporters. India, conversely, enters the market sporadically, usually in response to domestic production shortfalls or surpluses. Countries in this situation rarely rely on long-run contracts, preferring other modes of coordination that do not commit the state agency to a specified volume of imports before the domestic production situation is known. McCalla (1979) hypothesizes that the objective of India's state trading agency is to minimize the cost of domestic grain shortfalls.

Multinational Grain Trading Firms

The six largest multinational grain traders (MTs: Cargill, Continental, Louis Dreyfus, Bunge, Mitsui/Cook, and Garnac) handle an unknown, but presumably large portion of world rice trade. The MTs deal heavily with state trading agencies. This is sometimes confined to the execution of logistical functions after state importers and exporters have negotiated a deal. However, the MTs often buy rice directly from the state agencies without having made prior sales arrangements. In this capacity as speculator or arbitrager, the MTs may stabilize prices both temporally and spatially, assuming that they act competitively.

It may be hypothesized that the objectives of the major MTs include increasing market volume, market share, and profits. The market environment that facilitates these objectives is more likely one of price instability rather than stability. Profits of the large private grain traders seem to move over time not with total volume traded, but rather with the degree of disruption and instability in the year's trading patterns (Caves 1979, Gilmore 1982). Such an environment enables multinationals to put their superior market intelligence to work and capture the rents resulting from market disturbances. However, large volumes are not unimportant; they promote size economies in two ways. First, the MTs make only a few cents on each ton of grain handled; therefore, profits in the industry require large volumes. Second, the MTs' potential to maximize their objectives depends on having large, diverse positions to draw from quickly to exploit temporary arbitrage opportunities (Peterson 1988). For these reasons, the grain traders appear to resist programs that reduce traded volume, such as U.S. acreage reduction programs.

The six largest MTs have the following general characteristics: they are diversified, have vast global market intelligence systems, and cross-subsidize operations (Schmitz *et al.* 1981). In addition, all of the major MTs have a maze of affiliates and subsidiaries. Inter-affiliate sales, which appear to account for a large portion of MT sales (40 percent for Cargill, Inc. from 1970-75), provide several informational advantages, especially for grains traded on futures markets. For example, the Commodity Futures Trading Commission reporting rules do not require foreign firms to fully identify or report their futures positions, as they do of U.S. firms (Gilmore 1982). This allows a MT with foreign subsidiaries to temporarily conceal important market information.[8] Also, because importing subsidiaries generally serve as agents and do not take legal possession of the grain, neither the ultimate purchaser's identity nor the final destination of the shipment need be declared. This provides a camouflage for trade flows and conceals the identity of the ultimate buyer. While this may not greatly affect price instability ex post, it certainly introduces uncertainty into the market. In 1974 for example, President Ford, concerned that the USSR might destabilize the wheat market by buying on a scale comparable to 1972, invoked a moratorium because it could not be established with certainty what Soviet buying intentions or existing contracts were, since foreign subsidiaries served as intermediaries (Gilmore 1982).

MTs may have a cost-procurement advantage over state exporters or farmer cooperatives in the international marketing of grain since they can buy grain from many sources of supply to meet export commitments (multiple sourcing). For example, an MT can buy grain not only from U.S. or Thai exporters but also from the Pakistani or Burmese Marketing Boards. The MTs generally do not operate on the basis of individual sales, but rather on net positions, reflecting their expectations of future market conditions (Peterson 1988). They are constantly acquiring physical supplies of grains and making sales, thus the operation resembles a pipeline (Conklin 1982). This has given rise to the use of "optional-origin contracts," which allow the seller to contract with an importer without specifying the grain's origin. The MT may also procure grain from various sources in excess of actual requirements, and then cancel the less attractive contracts before the time of final sale. This allows the trader to juggle different purchases in several countries to fill an identical order (Gilmore 1982). Peterson (1988) states that the flexibility of these contracts often allows the MT to pass along cost-savings to the foreign buyer. Aside from price-hedging opportunities, optional-origin contracts protect the MT and buyer from restrictive national agricultural policies such as embargoes, which might otherwise cut the foreign buyer off from a supply of grain already under contract.

Schmitz *et al.* (1981) argue that "when the large companies shop around for the best deal themselves, their actions do not necessarily always benefit the producers in the country in which the parent company is located (or in any particular country for that matter)" (p. 41). However, such behavior would tend to improve market integration, and bring lower prices to importers as

[8] Export sales reports are released to the public by the USDA with a lag of 7 to 14 days after an MT grain sale occurs. Studies by Conklin (1982) and the GAO (1985) have concluded that "...the full adjustment of prices to export sales information does not occur until the sales report is released..." (p. vii). Therefore, a large trader may possess information that the market as a whole does not learn about until one to two weeks later.

long as the industry is competitive. If it is not, the MT may extract rents from both producers and importing consumers, especially if export and import elasticities are low.

Emerging evidence suggests that world grain market instability creates higher marketing margins between f.o.b and c.i.f. ports (Binkley 1983). The major functions performed by the MTs – transport, storage, processing, and handling – typically involve high fixed investments. This suggests that adjustments to varying trade volumes are made with difficulty and higher per unit costs. Some sources contend that this has created second-round effects on market structure. Bulk Systems International (1980) reports that because of the "erratic nature of the grain trade," the development of efficient, low-cost port facilities "has proceeded at a far slower pace than with other large volume major bulk commodities." Moreover, large transport vessels, which provide lower operating costs, are less prevalent in the grain trade than in commodities such as coal and iron ore, whose trade volumes are more stable than grain (Binkley 1983).

Cooperatives

In the United States, cooperatives account for roughly 40 percent of off-farm grain sales; the proportion of this which is rice is unknown. As grain moves through the marketing channel into export position, it is increasingly controlled by the large multinational grain traders. The cooperatives control less than 20 percent of the grain moved to U.S. export ports, and account for only 7.5 percent of U.S. sales to foreign buyers. Thus, although cooperatives are active near the beginning of the marketing chain, they turn over about 70 percent of their potential export volume to other grain traders (Schmitz *et al.* 1981). However, several large U.S. milling cooperatives procure rough rice from their producer members, mill it, and retain a relatively high proportion of the milled product for direct sale to importers.

The reasons why farmer cooperatives do not play a large role in the international grain marketing are numerous. Thurston *et al.* (1976) provide the following reasons: (1) lack of experience and expertise; (2) lack of access to cooperatively-owned export facilities; (3) less risk in indirect sales to multinationals; (4) economies of size favoring the large multinational traders; (5) lack of multiple sourcing and commodity diversification; (6) relatively inferior market intelligence; and (7) fear of the unknown. Cooperatives' small role in international grain marketing is in part due to the rapid change in the structure of the U.S. grain marketing system. Traditionally, when the bulk of harvested grain was consumed domestically, the cooperatives were geared toward handling, distribution, and marketing at the local level. Over the past thirty years, however, the end use composition of US grain has changed significantly. U.S. wheat and rice exports have risen dramatically, especially since the early 1970s. Some observers state that cooperatives have not positioned themselves well for the increased internationalization of grain marketing (Gilmore 1982).

Major risks, uncertainties, and information costs appear to be better absorbed by the size of the large multinational traders. For example, Caves (1977-78) argues that the characteristics of information as an input create scale economies in coordination and risk-bearing. Information procurement has a fixed cost that can be spread over numerous transactions, and information about trading locations is subject to increasing returns in the trading possibilities that it reveals. There are also economies of scale in storage and transshipment facilities at particular locations, and in pooling the risks associated with price and exchange rate variability, uncertain government policies, and legal idiosyncracies of importing countries. Large, diversified investment portfolios allow the larger firms to appreciably reduce the variance of returns. Moreover, the perishability of information creates scale economies in the maintenance of a continuous and extensive trading presence to exploit transitory trading opportunities (Caves 1977-78). Not surprisingly, therefore, the ratio of multinational to cooperative grain volume traded is larger in international trade – where information and risk-bearing costs are high – than in intra-national grain trade.

Finally, most cooperatives are national organizations and cannot draw supplies from different countries to capture the cheapest possible source. Even domestically, the regional cooperatives view their function as selling their members' grain rather than exploiting profitable trading opportunities wherever they arise (Caves 1977-78). A notable exception has been the Farmers Export Company, which had speculated aggressively and extensively on grain markets during the early 1980s. It unfortunately incurred sizable financial losses in the process (Rowan 1981). Gilmore (1982) notes the potential of cooperatives to overcome these traditional barriers to participation in international grain markets by combining operations with multinational-type firms. The joint venture between Toepfer and European and American cooperatives has provided the latter with an assured market outlet, expanded export marketing capacity, a valuable market information network, and overseas administrative and marketing infrastructure with which to conduct trade.

In summary, a diverse set of actors are involved in the movement of grain within domestic boundaries, from farm to export ports, and from import ports to consumers. Whether these are primarily public or private actors varies by country. However, the international exchange of grain is dominated by state trading agencies and multinational trading firms. The physical transfer (as opposed to ownership) of grain is almost always carried out by a small group of large private traders. The degree of market power exercised by this group is hotly contested (Conklin 1982, GAO 1985, Caves 1977-78, Schmitz 1986, Gilmore 1982, Morgan 1979). Although numerous studies have pointed out the theoretically important effects of market power on instability and trade patterns (Binkley 1983, Schmitz *et al.* 1981, McCalla 1979), relatively little information is available to draw reliable conclusions concerning whether market power indeed exists.[9]

Coordination Mechanisms and Marketing Institutions

The relationship between a marketing firm's inputs and outputs and more generally the productivity and stability of the international grain system, is a function of the institutional organization of the system. This section contrasts the methods of coordination between actors in the international wheat and rice markets, and how risks and uncertainties in these systems are shaped by alternative methods of coordination.

Open Market Coordination

International grain transactions between importers and exporters generally takes place in one of three types of markets: the open market, the public tender market, and the private tender market (Schmitz *et al*. 1981). Rotterdam, Hamburg, and London are examples of open markets, in which there is a continuous two-way flow of offers and bids, often through brokers. As mentioned previously, brokerage fees appear much higher in rice trade than for wheat because of the greater search costs involved in matching sellers with buyers wanting particular varieties and qualities that are poorly standardized. In public tender markets, the buyer, often a state importer, issues tenders ahead of the requested offering date. Private tenders are less formal; the buyer, either a public or private actor, invites a few selected exporters to make offers.

The terms of grain export sales are specified in legal contracts that include the quantity, quality, shipping period, destination, delivery terms (generally f.o.b. or c.i.f.), payment terms, and price. In both wheat and rice contracts, price is almost always denominated in U.S. dollars, whether the United States is involved in the deal or not (Peterson 1988). Rice prices are usually determined by flat price or by reference to some benchmark price for a certain grade, such as the Thai f.o.b. Bangkok price. Flat pricing fixes the price at which the future delivery will take place. Buyers under flat pricing are often state trading agencies that are more concerned with locking in a supply of grain at a known price, and less concerned with potentially paying a higher price than would be necessary, as would be the case if cash prices fell prior to delivery. In the wheat market, the existence of viable futures markets has allowed the development of basis pricing. Basis pricing specifies some agreed upon amount over a particular futures price, and allows the

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[9] However, the market power hypothesis has the burden of answering several questions, such as why the c.i.f. Rotterdam price of U.S. wheat over the past three decades has averaged only about 10 cents per ton higher than the f.o.b. U.S. Gulf price, instead of the oligopoly outcome, which would be that grain traders raise the c.i.f. price to the EC threshold price and capture the variable levy.

importer to choose, sometime prior to the delivery date, the date for the calculation of the relevant futures price. Basis pricing, which allows participants to partially guard against price risk, is used by more sophisticated private and state buyers, such as the Japan Food Agency (Harrison 1988). However, basis pricing requires reference to a futures price. Because rice futures trading is poorly developed, very little rice trade is basis-priced. Other types of formula pricing are possible based on a spot price modified by inflation and exchange rate movements.

Vertical Integration

Vertical integration is pervasive in the international wheat and rice marketing systems. Cargill, for example, is a principle buyer of grain from farmers, a "fobber" (*i.e.*, a grain handler responsible for moving the crop from production region to port), an importer and exporter, a processor, a livestock and poultry farmer, a transporter, a speculator, hedger and Futures Commission Merchant on the commodity exchanges, and a borrower and lender of commercial credit (Gilmore 1982). Vertical integration in the international marketing of grain has developed, at least in part, to reduce the potentially great transactions costs and uncertainties of trading across national boundaries with different currencies, languages, units of measure, commercial codes of ethics, *etc.* (Peterson 1988).

While vertical integration is not unique to the multinational traders (cooperatives and state traders also combine vertical stages within their operations), MT vertical integration is of a unique sort. While MTs have operations at each stage in the marketing chain, each stage tends to pursue its most advantageous opportunities whether or not that entails internal coordination within the firm's various stages (Peterson 1988). For example, an MT's shipping fleet may find it more profitable at a particular point in time to haul iron ore or some other commodity than transport its own wheat to fulfill a contract. This is quite different from most cooperatives or state traders, which, as stated above, tend to provide services mainly for other stages of their firms' operations.

Long Run Agreements

Grain contracts lasting for more than a year in duration are categorized as long term. They are often of an ongoing nature, such as the multi-year wheat trade understandings between government agencies of the U.S. and those of the USSR, Poland, and Israel. Perhaps surprisingly, long run agreements are relatively more important in the world wheat market than in the rice market. Long run wheat agreements comprised about 25 percent of total wheat trade in the 1980s. By contrast, only 6-10 percent of the rice trade was coordinated through long run contracts (Slayton 1984).

The rationale behind long-run agreements is clear. From the perspective of grain-dependent importers, a continuous pipeline of wheat or rice, especially during tight world market conditions, may be crucial for political stability. Governments in this positions prefer a secure, long-term source of supply from reliable exporters rather than taking advantage of low prices offered in particular years by non-traditional exporters (Tolley *et al.* 1984). Many exporters, likewise, prefer to lock in stable trade volumes, which aid in the orderly structuring of domestic supply and price targets. Predictable import demand and price stability were major factors leading to the U.S.-Soviet Union grain agreements since 1976. Prior to that time, large but sporadic entry of the Soviet Union into the market caused considerable price instability, since its import plans were not revealed early enough to permit adjustment of production plans in exporting countries.

These concerns highlight that price, while important, is not the sole factor that links grain buyers with sellers. Other factors such as security and stability reduce the importance of price in the coordination task. The pricing arrangement in long-term contracts is often incidental to the contract; price is usually fixed according to prevailing spot market prices at the date of delivery. It is important to note that although long run contracting bypasses the open market in the allocation of grain, it nonetheless requires the existence of the open market to determine the pricing terms of the contract.

Although long-term agreements represent an institutional innovation by market actors to reduce their vulnerability to instability, uncertainty, and transactions costs, such agreements create side effects that increase uncertainty for others. As long-run contracting and conventional vertical integration become more important, the volume traded on the open market invariably declines, making it less able to absorb quantity variations in world trade. Consequently, the open market becomes more vulnerable to wide price swings caused by sporadic market entrants. This is often referred to as a thin market problem. If the open markets have been sufficiently thinned, the potential arises for poor resource allocation and volatile price movements that do not reflect underlying supply and demand conditions. Unfortunately, this would not only affect price discovery on the open markets, but all other forms of coordination that depend on open markets for price determination. This may be a problem particularly in the rice market because traded volume is low to begin with (only 4 percent of world rice production is traded internationally), grades are poorly standardized, prices in various markets and for various varieties may move independently of one another in the short-run, and because of the unstable trade volumes of several large rice traders.

In addition, while long-run contracts facilitate the security goals of consistent importing and exporting countries, they increase risks and transaction costs borne by others. Countries with occasional rice surpluses or deficits frequently have difficulty breaking into the market because major import and export centers are already locked into bilateral relationships. This raises search costs and uncertainty for these actors, and provides incentives for them to develop alternative forms of coordination that thin the market even further (NC-117 1979).

Spot and Futures Markets and Price Discovery

Price discovery is the process through which buyers and sellers "discover" the competitive prices that best represent the consensus of what traders think commodity prices ought to be in the future based on information available today. Broad dissemination and publication of exchange-generated prices can foster competition in establishing cash prices for commodities in localized markets as well as in related services such as storage, transportation and processing" (GAO 1985, p. 5). The reliability of the price actually "discovered" may be sensitive to the legal, informational, and broader institutional organization of the market.

A critical distinction between the organization of the rice and wheat market is that there are no reliable, widely used spot or futures markets for price discovery for the various types of rice. Although the f.o.b. Bangkok rice price quotes are often referred to as the world price for rice, it is important to note that these are posted prices set by the Thai Board of Trade, and are supposed to be the minimum price that private exporters must demand from their buyers, otherwise no export license will be issued (Siamwalla and Haykin 1983). Actual f.o.b. prices may diverge substantially from these weekly-posted prices, as exporters will illicitly raise or lower prices depending on prevailing supply and demand conditions. Therefore, the Bangkok posted prices may be of limited value for price discovery on a day-to-day basis. However, the Bangkok prices are more valuable in discerning annual shifts in international market conditions; Falcon and Monke (1979-80) conclude that they are fairly representative of longer run world supply and demand conditions.

In the other major rice exporting center, the United States, price discovery is also hampered by spot and futures market deficiencies. Reported spot prices are less specific than those for wheat: there is no daily or even weekly rough rice spot market price for a specific variety and grade. Weekly cash prices are reported for milled rice, but they are more indicative of private treaty arrangements dominated by several large rice millers on the buying side rather than spot prices discovered in a vibrant competitive market. In addition, these prices are usually expressed as a range, and often may not vary for several weeks at a time. In short, U.S. rice price determination is far from transparent, occurs mainly at the mill level, and, for several sub-markets, is dominated by several large mills and exporters that suppress or distort price information (Business Week, 1978, Caves 1979).

These spot market characteristics have also affected the viability of rice futures markets. For example, because there are no published spot market prices for a specific deliverable variety and grade of rough rice, no "basis" (*i.e.*, the difference between cash and futures price) can be determined on which to negotiate contracts. Basis analysis of the milled rice market (Gordon 1984) indicated that the basis often moved in the wrong direction, the correlation between cash and basis prices was relatively low compared with more heavily traded crops, and rice futures prices were often biased predictors of their delivery month values. These attributes reduce the ability of farmers to hedge rice on the futures market, and, not surprisingly, the milled rice futures market on the New Orleans Commodity Exchange closed in 1984.

By contrast, the U.S. wheat futures markets on the Chicago Board of Trade is used extensively both by U.S. and foreign actors, including a number of state traders. U.S. spot prices can be quoted daily for a deliverable variety and grade. It can be argued that the U.S. spot and futures markets form the central pricing point in the international wheat markets. In this sense, the information generated from these futures market are public goods; the additional use of the information, once discovered, adds little or nothing to cost, nor does added use interfere with its use by others (Schrader *et al.* 1986). For example, Canada and Australia peg their minimum foreign sales prices to the Chicago Wheat futures price. The EC variable levy could not function without a spot or futures price discovery process. In this way, those who do not participate in open market arrangements can benefit from the information generated from them without having to pay the costs.

Risk shifting is performed through hedging on the futures market, where actors who are unwilling to bear price risk can shift risk to those who are willing to assume it in return for potential profit.[10] However, the risk shifting potential of the futures market is primarily short-run in nature. Futures price quotes do not normally extend more than a year into the future, and thus the market cannot provide safeguards against severe inter-annual instability. Many investments (storage terminals, production equipment, ships, *etc.*) span across many years, and the potential for low or negative returns cannot be altered by the short-run hedging potential of futures markets. However, the intra-annual risk management afforded by futures markets is a very important asset to the wheat market.

Timely information is central to efficient marketing. The absence of viable spot and futures markets for rice to synchronize prices in other sub-markets has probably hampered allocational efficiency as well as making other forms of coordination (that rely on spot price information to establish a transaction price, such as contracting) more difficult, and subject to higher transactions costs. Traders are also exposed to larger profit/loss variability, which increases trading and storage risks, risk premia, and marketing margins, unless other viable contingency markets exist. Available data over the 1975-87 period indicate marketing margins between f.o.b and c.i.f. ports were much higher for selected rice trade routes than for those of wheat, which do not appear explainable on the basis of transport costs alone (Jayne 1989). Transaction costs are higher in rice markets than in wheat markets because of the need to search for buyers, sellers, and reliable price information in the absence of a centralized market (Siamwalla and Haykin 1983). Brokerage fees for rice appear to be about 5 to 10 percent of sales value, which is much higher than for wheat.

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[10] There is a longstanding debate, however, whether futures markets can provide efficient price discovery and insurance functions at the same time (see Houthakker 1959; Dusak 1973).

National Trade and Stockholding Patterns

Trade patterns in the rice market have been rapidly changing since the 1960s. Of the five major rice importers in the 1960s, only Indonesia remains among this set in the 1980s (Table 5). Major importing centers have shifted from south and east Asia to the Mideast and Africa. Prior to World War II, Asia accounted for 93 percent of rice exports and 75 percent of imports. This dropped to 60 and 39 percent by 1980 (Barker, Herdt, and Rose 1985). This is because of successful self-sufficiency drives in Asia after the experience of the early 1970s, changing tastes and preferences in Africa, and the stimulus of oil revenue in the Mideast on rice imports. Four of the five largest rice importers are now OPEC nations, suggesting a possible relationship between the price of oil and rice demand. There has been more continuity among rice exporters: Thailand, the United States, Pakistan, the Peoples Republic of China, and Burma have been the five major exporters since the 1960s. However, the rapid change in rice import patterns indicate a lack of deeply entrenched, durable trade relationships among the major actors.

By contrast, wheat trade patterns have remained relatively stable over the past three decades (Table 5). Over this period, 85 percent of the world's wheat exports have consistently been supplied by the United States, Canada, Australia, France and Argentina. Of the five largest wheat importers in the 1960s, four of them (the PRC, Egypt, Japan, and Brazil) remain among this set in the 1980s. The most important change in wheat trading patterns has been the transition of the Soviet Union to a major importer during the 1970s. This reflected a major shift in Soviet policy around 1970 to stimulate domestic livestock production and consumption, which consequently caused large surges in wheat and coarse grain imports. The central plan economies, namely China and the USSR, now account for 30 percent of the world's wheat imports. The Mideast and North African countries, while individually importing only moderate amounts, as a group now account for about 20 percent of all wheat imports.

Stock Levels

A major distinction between the world rice and wheat markets is the amount of stocks available to stabilize the market in response to production or demand shocks. From 1980-87, the average ratio of world stocks to world production was 29 percent in the wheat market compared with only 15 in the rice market. The major rice exporters especially hold much smaller stock levels relative to production than in the wheat market. High short run instability and the absence of viable risk-shifting institutions such as futures markets may partially account for the low level of stockholding in the rice market. Causality may not be unidirectional however. Larger stocks, accessible for trading in the world market without being subject to government restrictions, could reduce the responsiveness of price to crop forecasts. For instance, if stocks are low, impending production shortfalls in key areas may cause prices to be bid up higher in order to ration available supplies. But if stocks are large and "overhang the market," then world production variations may produce less price movement because actors know that there are large stocks available to dampen any price rise (Stein and Smith 1977).

Table 5. The Five Largest Importers and Exporters in the World Wheat and Rice Markets: 1960-87

1960-71		1972-79		1980-88	
------------- Numbers in parentheses are annual average trade volumes in thousand metric tons. -------------					
Wheat Exporters					
USA	(19117)	USA	(31131)	USA	(37716)
Canada	(11485)	Canada	(13560)	Canada	(19260)
Australia	(6937)	Australia	(8876)	France	(15030)
France	(3345)	France	(8328)	Australia	(12084)
Argentina	(2685)	Argentina	(3217)	Argentina	(5882)
Wheat Importers					
India	(4563)	China	(5942)	USSR	(18655)
China	(4353)	USSR	(5801)	China	(11176)
Japan	(3752)	Japan	(5546)	Egypt	(6133)
Brazil	(2164)	Egypt	(3970)	Japan	(5360)
Egypt	(2119)	Brazil	(3285)	Brazil	(3242)
Rice Exporters					
Thailand	(1490)	USA	(2090)	Thailand	(3846)
USA	(1440)	Thailand	(1822)	USA	(2328)
China	(1068)	China	(1437)	Pakistan	(1106)
Burma	(1030)	Pakistan	(790)	China	(622)
Pakistan	(132)	Burma	(458)	Burma	(569)
Rice Importers					
Indonesia	(716)	Indonesia	(1398)	Iran	(642)
Sri Lanka	(471)	Vietnam	(475)	Iraq	(501)
India	(444)	Iran	(354)	Indonesia	(487)
Vietnam	(411)	Sri Lanka	(330)	Nigeria	(467)
Malaysia	(366)	Bangladesh	(299)	Senegal	(340)

Table 6. Annual Average Stockholdings of Wheat and Rice: 1980-87

	WHEAT		RICE	
	(000 mt)	% of world stocks	(000 mt)	% of world stocks
U.S.A.	36,516	25.7	1,561	3.3
China	29,366	20.7	25,466	54.3
Soviet Union	16,712	11.8	na	na
EC-12	13,094	9.2	--	--
India	10,388	7.3	6,722	14.3
Canada	9,087	6.4	na	na
Indonesia	na	na	1,990	4.2
Japan	--	--	1,699	3.6
Australia	4,590	3.2	--	--
Turkey	4,444	3.1	--	--
		% of world production		% of world production
WORLD	141,848	28.9	46,885	15.4

Source: USDA 1988
na: information not available
--: less than 3 percent; all other countries holding less than 3 percent of world stocks on average are not reported.

The dominant wheat stockpilers during the 1980s have been the United States, China, the Soviet Union, and the EC-12. In the rice market, China has held over half the world's rice stocks since 1980 (Table 6). In average terms, this has been twice the volume of annual world rice trade, leaving China in a strong position to either stabilize or destabilize the market. However, given the budgetary costs of shielding such a huge domestic market from world price fluctuations (over a third of the world's rice production is consumed in China), the government would apparently have powerful incentives to stabilize the world market.

Short-Run Trade Volume Instability

The international rice trade is not very large relative to total world consumption or even compared to the domestic markets of several large actors.[11] Since 1980, the average annual volume traded is 4 percent of world consumption, as compared with 21 percent for wheat. Because international rice trade is a relatively small fraction of production, small percentage changes in domestic production or consumption can translate into large percentage changes in trade volumes and world prices. Regardless of whether government insulation policies contribute to the problem, a high level of instability in the world rice market can be deduced without reference to them.

In fact, the trade volumes of major actors in the world rice market have been much more unstable than those in the wheat market, as measured by the coefficient of variation of country net export regressions.[12] This is true when comparing instability between wheat and rice exporters, and especially when comparing wheat and rice importers. However, these results are not good indicators of the relative level of uncertainty and risk in these markets. For example, the implications for world price instability would be very different if net export fluctuations of major actors were caused by changes in domestic production rather than by changes in stock releases onto the world market reacting to world price movements. It is often stated that government insulation policies which treat the world market as a residual market have been a major cause of fluctuations in net exports and hence world price instability. The following section assesses the validity of these claims.

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[11] Despite a 50 percent increase since the mid-1960s, annual rice trade is still smaller than the annual production in Bangladesh.

[12] This is measured as the standard deviation of the dependent variable (computed by regressing net exports on a linear time trend and taking the standard deviation of the residuals), divided by the mean net export level).

3. GOVERNMENT INSULATION POLICIES AND WORLD MARKET INSTABILITY

Theoretical Rationale

A plethora of recent studies have concluded that mounting government insulation in agriculture is the major factor responsible for the growing instability in world prices (Johnson 1975, Shei and Thompson 1977, Zwart and Meilke 1979, Falcon and Monke 1979-80, Sarris and Freebairn 1983, Blandford and Schwartz 1983, Bigman 1985). The basic theoretical rationale behind this argument is presented in a two-region partial-equilibrium framework (McCalla and Josling 1985). Figure 1a shows domestic supply and demand curves for a commodity exporter (SX_o, DX_o) and an importer (SM_o, DM_o). The middle panel shows the resulting import demand and export supply curves under free trade, which are the sum of the domestic supply and demand slopes. Supply in both countries is determined by domestic price (which is equal to world price under free trade), weather, and other factors.

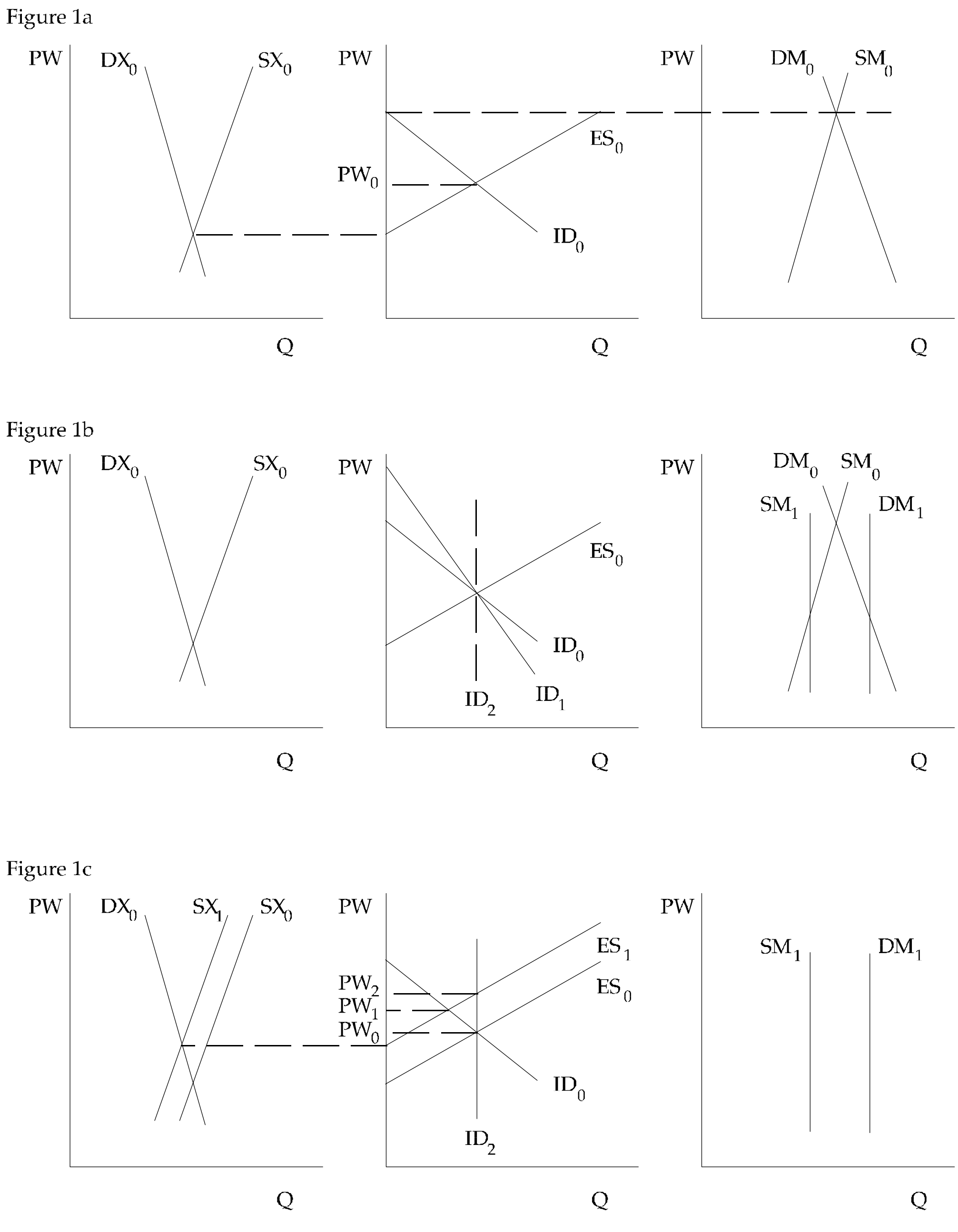

Figure 1. Theoretical Effect of Government Insulation Policy on World Price Instability

Now let the importing government introduce a producer price stabilization scheme (such as a variable levy or price support program), while allowing consumer prices to still be determined by world conditions. The domestic supply function (SM_1) becomes insensitive to world prices and is now affected by the policy-influenced domestic price (Figure 1b). As domestic supply becomes vertical relative to world price, the import demand function rotates to ID_1. If both the producer and consumer price were fixed, then both the domestic supply and demand curves would be vertical (SM_1, DM_1), and the import demand curve facing the exporter would be completely inelastic (ID_2). The importing government has made its import volume completely unrelated to the world price, implying a world price elasticity of import demand equal to zero.

Now introduce a weather-induced supply shock in the exporting country (Figure 1c). Domestic supply is reduced to SX_1, which reduces the supply of exports to ES_1. The supply shortfall in the exporting country raises world price to PW_2. In the absence of the price stabilization scheme in the importing country, a comparable supply shortfall would have raised the world price only to PW_1. This is because quantity supplied and demanded in the importing country would have been allowed to adjust to the changed world market conditions rather than being totally insulated from them. The more inelastic the import demand curves and export supply curves, the greater are changes in world price resulting from shocks in domestic markets. This is the general basis for the argument that government insulation policies increase world price instability.

Past Studies

A number of empirical studies have found support for the above theoretical framework. The general line of inquiry is to measure how national production and world price variations affect annual trade flows. Blandford (1983) defines these interactions between national and world markets as follows:

1. Transmission effect: "the degree to which short-term variability in supply and demand in a given national market is passed on to the world market through variations in the country's volume of trade."

2. Absorption effect: "the degree to which short-term variability originating in other countries, and reflected in the variation in world prices, is absorbed through quantitative adjustment in the national market and its volume of trade" (p. 383-4).

Blandford estimated these two effects on a national/regional basis for wheat and coarse grain using the following equation:

$$(NM - NM^{*})_t = a_0 + a_1(PROD - PROD^{*})_t + a_2(PW - PW^{*})_t$$

where NM is net imports of country i, PROD is domestic production of country i, PW is world price, and NM^{*}, $PROD^{*}$, and PW^{*} are linear trend values of these variables. The extent to which domestic production instability is transmitted to the world market is measured by a_1. This transmission coefficient would have a value of -1 if all production instability were transmitted to the world market and a value of zero if none were. The absorption coefficient, a_2, measures the effect of world price deviations from trend on a country's net imports. A negative value would indicate a normal type of demand relationship, which would be stabilizing; the more negative (elastic) the response, the more the country absorbs world market instability. A zero value would indicate complete insulation with no import response to world price changes. This is considered destabilizing because a lack of trade adjustment forces prices to adjust comparatively more in order to reach an equilibrium.

Similar variants of this model have been used by Abbott (1979), Wilde *et al.* (1985), and Mitchell and Duncan (1987) to examine the wheat market, and by Siamwalla and Haykin (1983) and Falcon and Monke (1979-80) to examine the rice market. By and large, these studies have found that the absorption effect for most countries is quite low and often statistically insignificant. Only one country/region in Blandford's wheat study, the United States, showed a significant relationship between net exports and world price at the 10 percent level. Siamwalla and Haykin note that less than one-third of the 55 countries examined showed any trade responsiveness to world rice price. These results have often been used as evidence of government insulation policies that prevent trade flows from responding to world price, and therefore represent a major cause of the growing instability in world prices (Bigman 1985, Falcon and Monke 1979-80, Blandford and Schwartz 1983).

Reserving until later a discussion of the logic behind these conclusions, let us examine why econometric estimation of import demand and export supply elasticities may be so low or statistically insignificant. First, the Blandford, Siamwalla and Haykin, and Falcon and Monke studies estimated net export responsiveness to world prices for all countries using the nominal US dollar value of wheat and rice (No. 2 dark northern spring, f.o.b. U.S. gulf; and 5% broken, f.o.b. Bangkok) without accounting for exchange rate fluctuations between the dollar and a country's currency, or for the country's rate of inflation. According to standard trade theory, a country's net export responsiveness to world prices would be affected by these variables, and the observed lack of responsiveness to world prices may be partially due to the exclusion of these relevant variables from the models rather than from insulation policies *per se*.

In addition, these studies have estimated net exports as a linear function of world price. Evidence from other sources indicate that trade volumes may be related to prices in a non-linear fashion (Hillman, Johnson and Gray 1975, Peck and Gray 1980, Abbott 1988). For example, import demand may be relatively inelastic when prices are high (due to pipeline demand) and relatively elastic when prices are low (due to increased use of the commodity as a feed grain). Misspecified functional form may in some cases account for the observed lack of trade responsiveness to world prices.

A third potential complication concerns matching the annual world price to the relevant marketing period for each particular country. Harvest and marketing calendars vary greatly from country to country. Use of one annual price series, such as an average of January to December monthly prices, in all of the country equations will be out of sync with many countries' marketing periods and will therefore be inappropriate price data to estimate some countries' trade elasticities. Annual price data generated from monthly data that match with a particular country's marketing year is more appropriate.

Fourth, net exports in any year are simply annual production minus consumption minus the change in national endstocks. Therefore, a model of trade instability should include those factors that cause instability in domestic consumption, production, and stocks.

While it may be true that government insulation policies do not contribute to the stability of world grain markets, these four factors may in part account for the low and/or statistically insignificant trade elasticities observed in world rice and wheat markets. The remainder of this section incorporates these considerations into a related model, and examines the implications of government insulation policies on the transmission and absorption of instability onto/from these markets.

The Model

It is identically true that in any given year,

(1) $NX_t = (PROD_t) - (CONS_t) - (END_t - END_{t-1})$

where NX, PROD, CONS, and END are net exports, domestic production, consumption, and endstocks, in per capita terms. The time relationship between these annual variables is as follows:

$Planting_t$ $Harvest_t$ $Planting_{t+1}$ $Harvest_{t+1}$
==============================================*=========*=
($production_t$) A (--------------------------------- marketing $year_t$ ----------------------------)B

This study regards the relevant annual period as the marketing year, which begins at point A on the time path and ends at point B. Within the marketing $year_t$ occurs $consumption_t$, stock $changes_t$, and net $exports_t$. At point A, or just prior to it, production has already occurred and is hence exogenous. Although production is obviously affected by some set of explanatory variables, it is reasonable here to view production as exogenous since a major purpose of the analysis is to measure the extent to which governments have responded to annual fluctuations in production (which occur before the start of the marketing period and are then known), by venting these fluctuations onto world markets through trade. Identity (1) highlights the fact that variations in domestic production, once they occur, must be counteracted by an equal adjustment in consumption, stocks, net exports or some combination of the three. The magnitude of the transmission and absorption effect for a particular country depends on how such adjustments are made.

The treatment of production as exogenous, while valid for examining short run government responses to weather- and disease-induced supply fluctuations, is not capable of measuring the dynamic effects of price policy on production operating through producer price expectations. It is necessary, therefore, to stress that this longer-run source of government-induced instability is not captured in the model.

Next, national consumption and endstock equations are formulated in per capita terms:

(2) $CON_t = a_0 + a_1(PD_t) + a_2(GNP_t)$

(3) $END_t = b_0 + b_1(PD_t) + b_2(PD^*_{t+1}) + b_3(R_t)$

where PD is domestic price, PD^*_{t+1} is expected domestic price in the next marketing year, GNP is real per capita income, and R is nominal interest rate. Equations (2) and (3) represent standard consumption and stock demand equations, and can be traced to consumer utility maximization and theories of temporal arbitrage. Under the proposition that price expectations are formed adaptively through the process

(4) $PD^*_{t+1} = PD^*_t + \delta(PD_t - PD^*_t)$

equation (3) reduces to

(3b) $END_t = c_0 + c_1(PD_t) + c_2(PD_{t-1}) + c_3(R_t) + c_4(R_{t-1}) + c_5(END_{t-1})$

where $c_0 = \delta b_0$; $c_1 = b_1 + b_2\delta$; $c_2 = b_1(\delta\text{-}1)$; $c_3 = b_3$; $c_4 = b_3(\delta\text{-}1)$; $c_5 = 1\text{-}\delta$.[12]

Domestic and world prices may be linked by a government price determination equation such as

(5) $PD_t = d_0 + d_1(PW_t)$.

This equation is similar to "price linkage" equations in Abbott (1979), Zwart and Meilke (1979), Skold and Meyers (1987), and Bolling (1988) that consider domestic price to be some policy-induced function of world price. The parameters d_0 and d_1 can be viewed as the net impact of a combination of instruments which are used to establish a domestic price that reflects the pricing objective of the government. The model may represent many alternative types of policies. For example, if $d_0 = 0$ and $d_1 = 1$, government allows variations in world price to freely affect domestic prices. Conversely, if $d_1 = 0$, domestic prices are totally insulated from world price movements.

However, there are both theoretical and empirical grounds for believing that domestic and world prices may be related in a non-linear fashion (Lattimore 1974, Skold and Meyers 1987). For example, governments' ability to moderate consumer price increases may be weakened as world prices climb progressively higher. Governments' capacity to affect PD is also influenced by beginning stocks and production. A low level of beginning stocks may impede governments' ability to maintain prices at desired levels if world prices rise. Production levels may also affect PD, especially where import and export parity prices diverge substantially due to geographical location or poor transport infrastructure. In such cases, local production, beginning stocks, and government policy determine PD in the range between import and export parity prices. Therefore, a more reasonable variant of equation (5) might be[13]:

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[12]For derivation, see Appendix 5.

[13] Several potential explanatory variables, such as foreign exchange earnings, are not used here. While it is frequently held that foreign exchange limits the ability of poorer countries to import grain, this argument breaks down in many cases. Adequate grain imports are often so important for political reasons that when foreign exchange earnings drop, governments may reduce imports of other goods (raw materials, spare parts, *etc.*) to maintain grain imports (Scobie

(5b) PDt = d0 + d1(PWt) + d2(PW2$_t$) + d_3(PROD$_t$) + d_4(END$_{t-1}$).

Substituting equation (5b) into (2) and (3b) yields

(6) CONt = $a_0 + a_1[d_0 + d_1(PW_t) + d_2(PW^2{}_t) + d_3(PROD_t) + d_4(END_{t-1})] + a_2(GNP_t)$

(7) ENDt = $c_0 + c_1[d_0 + d_1(PW_t) + {}_d2(PW^2{}_t) + d_3(PROD_t) + d_4(END_{t-1})] +$

$c2[d_0 + d_1(PW_{t-1}) + d_2(PW^2{}_{t-1}) + d_3(PROD_{t-1}) + d_4(END_{t-2})] +$

$c_3(R_t) + c_4(R_{t-1}) + c5(END_{t-1})$.

These equations show that coefficient d_1 (*i.e.*, the degree to which government policies allow world price variations to affect domestic price) will influence the responsiveness of consumption and stocks to changes in world price. The closer d_1 is to unity, the closer consumption and endstock responsiveness to world price will resemble that under free trade. Moreover, the closer d_1 is to unity, the closer the net effect of production changes on consumption and endstocks will be to that under free trade.

Substituting equations (6) and (7) into (1) gives the following reduced-form equation:

(8) $NX_t = ß_0 + ß_1(PW_t) + ß_2(PW_{t-1}) + ß_3(PROD_t) + ß_4(PROD_{t-1})$

$+ ß_5(GNP_t) + ß_6(R_t) + ß_7(R_{t-1}) + ß_8(END_{t-1})$

$+ ß_9(END_{t-2}) + ß_{10}(PW^2{}_t) + ß_{11}(PW^2{}_{t-1})$

where $ß_0 = -(c_0 + c_1d_0 + c_2d_0 + a_1d_0 + a_0)$

$ß_1 = -(c_1d_1 + a_1d_1)$

$ß_2 = -c_2d_1$

$ß_3 = 1 - c_1d_3 - a_1d_3$

$ß_4 = -c_2d_3$

$ß_5 = -a_2$

$ß_6 = -c_3$

$ß_7 = -c_4$

1983). As a result, foreign exchange as an explanatory variable cannot avoid measuring the substitutability of grain for other imports. This is largely supported by Wilde *et al.* (1985), who showed that net wheat imports were sensitive to foreign exchange earnings in only 2 of 19 low- or middle-income countries at the 5 percent level.

$ß_8 = 1 - a_1d_4 - c_5 - c_1d_4$
$ß9 = - c_2d_4$
$ß_{10}= - (c_1d_2 + a_1d_2)$
$ß_{11}= - c_2d_2.$

Equation (8) is the reduced-form equation to be estimated. It consists of six component parts:

1. A net export identity (equation 1),
2. Domestic consumption (equation 2),
3. Domestic endstock demand (equation 3),
4. Adaptive price expectations process (equation 4),
5. Exogenous annual domestic production and beginning stocks,
6. World-to-domestic price transmission equation (equation 5b).

The reduced-form specification represents the effects of exogenous variables on trade through their influence on consumption and changes in endstocks. Past as well as current changes in production and world price alter the time path of endstocks and hence net exports in a dynamic process. It is clear from the structural definitions that the transmission and absorption effects (*i.e.*, the coefficients on $ß_3$ and $ß_1$, respectively) are influenced by both domestic price elasticities and the degree to which government policies allow variations in world price to freely affect domestic prices.

Equation (8) was estimated for 18 countries and regions in the wheat market, and for 22 countries/regions in the rice market. In each case, a restricted model without the quadratic price terms was also estimated. The non-linearity hypothesis was then subjected to an F-test. PW^2_t and PW^2_{t-1} are included or excluded from the model based on this criterion. The "world price" used for wheat is No. 2, Hard Red Winter, f.o.b. U.S. Gulf; for rice, it is 5 % broken, milled f.o.b Bangkok.[14] The derivation and sources of all data are presented in Table 7.

[14] There may be some question whether the world rice price is better approximated by the Thai price, or the price of a prominent U.S. mill port, due to the potential effect of U.S. rice programs on the world market. However, rice price analysis by Brorsen, Grant and Chavas (1983) indicates that the Thai price appears to have a stronger influence on U.S. prices than the other way around.

Several problems with the model must be considered. The structural parameters in equations (2)

Table 7. Variable Definition and Data Sources

VARIABLE	DEFINITION	SOURCE
NX	per capita net exports (kgs); values are negative for importers	A,K (1960-87)
PROD	per capita production (kg)	A,K (1960-87)
END	per capita endstocks (kg)	A,K (1960-87)
pw	f.o.b. Bangkok, milled 5% brokens	B (1960-62) C (1963-86); E (1987)
ER	national currency units per U.S. dollar, annual average	F (1960-84) G ((1985-87)
DFL	national deflator index (1980=100)	C (1960-85) G (1986-87)
PW	(pw*ER/DFL)*100	derived
GNP	real per capita gross national income (1980=100)	H,K (1960-83) G,K (1984-87)
R	interest rates (3-month discount window borrowings, U.S. commercial paper)	I (1960-87)
PD	real domestic retail price per metric ton	J (1960-82)

Sources:

(A) U.S. Department of Agriculture, 1988. Production, Stocks, and Disappearance Database. Commodity Economics Division, Economic Research Service, Washington, DC: Economic Research Service.

(B) Food and Agriculture Organization of the United Nations (various issues). "FAO Bulletin of Monthly Statistics," Rome: FAO.

(C) International Monetary Fund, 1986. "International Financial Statistics, Supplement on Price Statistics," Washington, D.C: IMF.

(D) U.S. Department of Agriculture various issues. "Wheat Situation and Outlook Report," Washington, D.C: Economic Research Service.

(E) U.S. Department of Agriculture various issues. "Rice Situation and Outlook Report," Washington, D.C: Economic Research Service.

(F) International Monetary Fund, 1985. "International Financial Statistics, Supplement on Exchange Rates," Washington, D.C: IMF.

(G) International Monetary Fund, various issues. "International Financial Statistics," Washington, D.C: IMF.

(H) International Monetary Fund, 1984. "International Financial Statistics, Supplement on Output Statistics," Washington, D.C: IMF.

(I) Board of Governors of the Federal Reserve System various issues. "Federal Reserve Bulletin," Washington, D.C: Board of Governors of the Federal Reserve System.

(J) International Rice Research Institute, 1986. "World Rice Statistics," Manilla, Philippines.

(K) Urban, F. and P. Rose, (1988). "World Population by Country and Region, 1950-86, and Projection to 2050," Staff Report AGES 880308, Washington, D.C: U.S. Department of Agriculture.

and (3b) cannot be recovered from estimation of (8) due to underidentification. However, where domestic price data are available, equation (5b) can be estimated to draw inferences about the degree to which national absorption and transmission effects might change in a transition to free trade. This is explained further in Section 3.

Second, the government policy coefficients in equation (5b) may not be stable. Whenever the underlying policy changes, the coefficients will change as well (Abbott 1979). The appropriate sample period is therefore a period under which government policy is relatively consistent. This problem is, of course, not unique to trade issues.

A third potential problem arises when a country's net exports are large relative to the world market. In such a case, the world price may no longer be considered exogenous, and estimation of equation (8) would present an identification problem. However, a dominant firm oligopoly model of world grain trade (Mitchell and Duncan 1987) reports that only the United States has exerted any price leadership in the rice market. The report concludes that "the remaining major exporters in these markets have behaved in a manner consistent with a small-country exporter model in which their market demand is perceived to be perfectly elastic at the world price set by the dominant exporter" (p.20). To account for potential simultaneity between net trade and world price, this study uses an instrumental variables procedure for the United States, China, and Thailand in the rice market (Appendix 2).

Finally, the data used in estimation may be subject to measurement errors. Production and population data, for example, are in some cases little more than time trends altered by limited information (Abbott 1979). Parameter estimates must be interpreted accordingly.

To reiterate, the purpose of the model is threefold: to provide conceptual insights into the interactions between national and international markets, to allow inferences to be made concerning the extent to which particular countries transmit or absorb quantity instability onto/from world markets, and to evaluate the contention that government insulation policies contribute greatly to world market instability.

Interpretation of Results

The results of regression (8) are presented in several ways. The complete regression results are contained in Appendix 2. The more immediate focus of this study concerns the estimated transmission and absorption coefficients, which are presented in Tables 8 and 9.

The results suggest that, of the countries examined, one-third had trade volumes that were either moderately or highly responsive to world price. Seven of the 21 countries examined had trade elasticities that were significantly greater than 0.50 at the 90 percent level or above. Three of the major five exporters appeared to be moderately to highly sensitive to world price (Pakistan, China and the United States). This is in contrast to earlier studies (Falcon and Monke 1979-80, Siamwalla and Haykin 1983) which found a general lack of responsiveness

Table 8. Price Elasticity of Net Export Supply Estimates in the World Rice Trade

Exporters:	
Thailand	-.32
United States	.32**
China	.74**
Pakistan	1.07**f
Burma	.03
Importers:	
Iran	1.47**f
Iraq	.95**f
Indonesia	.11
Nigeria	.01
Brazil	2.43
Senegal	.03***f
EC-12	1.69***f
Korea	.35
India	.34
Japan	.10
Malaysia	.01
Vietnam	.55**f
Bangladesh	.02
Soviet Union	.91*
Mideast	.19f
Sub-Saharan Africa	.31**

Note: the elasticities are $d(NX)/d(PW) * \overline{PW}/\overline{NX}$, with PW and NX defined in Table 7 and evaluated at their mean levels over the estimation period. Negative signs indicate perverse results.

f: F-statistic on PW^2_t and PW^2_{t-1} significant at the 95 percent level, in all cases signifying that the trade elasticities become more elastic as PW_t falls.
***: Significant at the 99% level.
**: Significant at the 95% level.
*: Significant at the 90% level.

Table 9. Potential Trade Instability Resulting from National Production Variations: Rice (1960-87)

Country	Transmission Coefficient: $ß_3$ in Equation (8) (a)	Standard Deviation of Production Variations from Trend (000 tons) (b)	(a*b) (000 tons) (c)	(c) as % of Average Annual World Trade (d)
Exporters:				
Burma	.49***	776	380	4.13
Thailand	.36***	722	260	2.78
United States	.38	553	210	2.32
China	.01	4507	41	.41
Pakistan	.00	235	0	--
Importers:				
Indonesia	.45**	1196	538	5.79
Vietnam	.46***	770	354	3.82
Korea	.28	445	124	1.36
EC-12	1.25***	100	125	1.36
Japan	.13*	875	114	1.24
Nigeria	-1.04*	112	-116	1.18
Mideast	.92**	101	93	1.01
Bangladesh	-.15	462	-69	.75
Malaysia	.34**	154	52	.57
India	-.01	4197	-42	.46
Brazil	.07	506	35	.38
Iraq	.62**	52	32	.35
Sub-Saharan Africa	.19	121	23	.25
Iran	.24	68	16	.18
Soviet Union	-.09	114	-10	.11
Senegal	.23	21	5	.05

*** Significantly different from zero (two-tailed test) at the 99 percent level.
** Significant at the 95 percent level.
* Significant at the 90 percent level.

between the net exports of major actors and world price. As mentioned earlier, however, these studies have used the US dollar price of Thai 5% broken rice as the world price and have assumed a linear relationship between price and net exports. The results of this study indicate that when this price is adjusted by national exchange rate and domestic price indicators, and is allowed to affect trade behavior in a non-linear manner, many countries appear very price responsive (Table 8). Two points follow from this.

First, as suggested by the purchasing power parity theory, the relevant price series facing rice market actors is clearly the import or export price in the national currency relative to the domestic price level. The domestic price level is important because the rate of inflation may counteract or exacerbate exchange rate fluctuations in real domestic currency terms. Second, the results indicate that when world prices are low, countries such as Iran, Iraq, Pakistan, Vietnam, Senegal, and the EC-12 may be much more price responsive than in tight world market conditions, when minimum domestic rice supplies and pipeline stocks are critical.

As the major rice exporter, Thailand's lack of price responsiveness represents a potentially destabilizing element in the rice market. The lack of response is not surprising given the government's historical reliance on variable export taxes on rice. When world prices rose, the government tended to raise the export tax as well, with the objective of diverting potential exports to the domestic market in order to stabilize prices. The correlation between the f.o.b. Bangkok 5% broken price and the export tax was +.32 over the available data period (1967-82). Hence, the Thai government's variable export tax served to cut off potential export volume that otherwise could have moderated world price rises.[15] Fortunately, other major exporters – China, Pakistan, and the United States – responded significantly to world price, especially during surplus periods, despite heavy government involvement in their domestic markets.

The relatively stabilizing influence of China on the world market may have important implications for other countries where two or more grains are important in national consumption. Chinn (1981) and Timmer and Jones (1986) have noted the "calorie arbitrage" undertaken by China since the mid 1970s. When the wheat/rice price ratio rises, the government tends to reduce imports of wheat and compensate by rerouting potential exports of rice back into domestic markets. When the wheat/rice ratio falls, both rice exports and wheat imports are increased. In this way, China – with its heavily administered system – exerts a stabilizing effect on both the world wheat and rice markets.

Many of the countries examined vent over half of their production instability onto world markets. This is evident by examining the national transmission effects reported in column (a) of Table 9. The statistical strength of this coefficient for most countries examined indicates that short-run production variability is an important source of variation in national trade volumes.

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[15] Since 1986, Thai rice policy has undergone major reforms, including the suspension of the export tax. This may be expected to increase the future responsiveness of Thai rice exports to world price movements.

However, the degree to which this affects world market instability depends on the magnitude of national production fluctuations. For example, although Indonesia vents less than half of its production variation onto the world market, the sheer size of its production fluctuations can cause destabilizing swings in world import demand. The standard deviation of production deviations from trend, *i.e.*, ($PROD_t$ - $PROD^*_t$), (where $PROD^*_t$ is the linear trend value in year t) is reported for each country over the sample period in column (b). If normally distributed, the deviation from trend production would be less than its standard deviation approximately two out of three years. Ninety-five percent of the production fluctuations would be within two standard deviations. Even though (PROD - $PROD^*$) may not be normally distributed in all cases, this figure is a first approximation of the extent of expected production variability in a given year. The product of columns (a) and (b) thus provides a measure of potential trade instability resulting from production variability in national markets. With the normality caveat mentioned above, the figures in column (c) may be interpreted as the expected fluctuation in net exports resulting, *ceteris paribus*, from a domestic production variation of one standard deviation.

Not surprisingly, the largest producers tend to have large production variability. However, the degree to which such variability is absorbed by consumption and endstock adjustments varies greatly, and profoundly affects the extent to which production changes destabilize the international rice market. China and India have the greatest production variability of all countries (column b), yet they tend to transmit very little of their production variability into trade variability. Table 9 indicates that a production fluctuation of two standard deviations from trend would be expected to change Chinese imports by less than 100,000 tons, or 1 percent of annual trade in a normal year.

By contrast, the southeast Asian countries of Indonesia, Burma, Vietnam, and Thailand represent the four greatest transmitters of production instability onto the world market. A production fluctuation of two standard deviations from trend (which should occur once every 20 years, assuming a normal production distribution) would be expected to change Indonesian imports by about 1 million tons, or 10 percent of annual rice trade in a normal year.

Sources of Rice Production Instability

Although production variability coupled with a high transmission coefficient represents a major source of trade instability on world markets, what is the major source of the production variability? Production variability can be broken down into area and yield components. Yield fluctuations from trend in most cases reflect variable weather patterns, and are largely unrelated to policy shifts in the short run, although this is not always the case. On the other hand, year-to-year variation in area cultivated is more often attributable to changes in government policies that alter crop and input prices or place restrictions on resource allocation.

The sources of production instability are determined by decomposing the variance of annual percentage changes in production into area and yield components. Starting with the identity that production (PROD) equals the product of area (A) and yield (Y), which may reasonably be assumed functionally unrelated, the total derivative of production is:

$$d(PROD) = Y*d(A) + A*d(Y).$$

Dividing both sides of the equation by PROD yields:

$$d(PROD)/(PROD) = d(A)/A + d(Y)/Y.$$

Taking the variance of both sides gives:

$$\text{Variance } [d(PROD)/PROD] = \text{Variance } [d(A)/A] + \text{Variance } [d(Y)/Y] + 2*\text{Covariance } [d(A)/A, d(Y)/Y].$$

This formula is used to analyze the production, area, and yield variability of the major national actors in the world wheat trade. The method implicitly accounts for trend movements in the data. Hence, steadily rising yields or acreage are not counted as instability by this indicator (see Appendix 1 for further discussion of the properties of this measure).

Table 10. Sources of Production Variability in Major Rice Trading Countries

	% of Variance in Production from:		
	Var (AREA)	Var (YIELD)	Cov (AREA, YIELD)
Exporters:			
Thailand	39	45	16
U.S.A.	89	11	0
China	52	61	-13
Pakistan	30	45	25
Burma	21	58	21
Importers:			
India	4	71	25
Indonesi	53	27	19
Iran	44	93	-37
EC-12	15	89	- 4
Nigeria	48	72	-30
Senegal	23	72	5
Bangladesh	21	56	23
Vietnam	21	72	7
Japan	19	71	10
Korea	4	91	5
Brazil	52	45	3
Soviet Union	51	30	19
World:	24	46	30

Source: computed from data in USDA (1988).

The results indicate that yield instability accounts for the bulk of production instability among 13 of 17 major trading regions (Table 10). This is especially true throughout south and east

Asia, where the rice crop is greatly affected by the Asian monsoon. Parts of Thailand, Burma, China and southern India have highly variable rainfall and are prone to drought. Improved and more extensive irrigation will be required to appreciably reduce production instability in these areas (Barker *et al.* 1985). In other parts of China, Japan, Korea, Bangladesh, and southeast Asia, flooding and typhoons also create great yield variability.

Area instability has dominated in several countries, most notably Indonesia (the third largest importer) and the United States (the second largest exporter). Area instability in both of these countries appears highly related to policy- induced changes in production incentives facing farmers. In Indonesia, this has taken the form of wide annual variations in real input prices and production subsidies (International Rice Research Institute 1986). In the U.S., acreage reduction programs, fluctuating support prices, and recently, the use of commodity certificates to release stocks onto the market – all responses to changing world market conditions – have significantly affected the acreage devoted to U.S. rice production over the years. Changes in the variability of U.S. producer and milled rice prices have also created variability in rice area cultivated (Brorson, Chavas and Grant 1987, Grant *et al.* 1984). Therefore, policy-induced uncertainty, which manifests itself through annual domestic price variability, may exacerbate the instability of production and annual trade volume. An econometric simulation analysis by Mahama and Meyers (1985) indicates the removal of trade restrictions may result in less world price stability than expected, because such policy changes would increase the variability of domestic prices, which would in turn increase production and trade instability.

Conditions Necessary for Government Insulation to Affect World Price Instability

The conventional wisdom that government insulation policies exacerbate price instability in world markets are based on several combinations of the following assumptions:

1. The insulating country is large relative to the size of the international market, and, therefore, faces an upward (downward) sloping export supply (import demand) curve, rather than the perfectly elastic function faced by small trading actors.

2. If the insulating country in question is small, then its' production deviations from trend must be positively correlated with world production deviations from trend.

3. The proportion of domestic production variation vented onto world markets (*i.e.*, the transmission coefficient) is higher under government insulation than under non-insulation.

4. The net export supply elasticity under free trade (related to the sum of domestic supply and demand elasticities) must be appreciably greater than the country's net export supply elasticity under insulation, as estimated in equation (8).

These assumptions are examined in turn.

The first assumption requires that national trade variations caused by insulation policies are large enough to actually affect the world market. This immediately rules out all but a handful of countries in the rice trade. Even for four of the five major importers (Iran, Iraq, Nigeria, and Senegal), transmission of national production instability would appear to have a negligible effect on the world market. This is because national production deviations are small in these countries relative to the volume of world rice trade. For none of these countries would a national production deviation from trend of one standard deviation (column b in Table 9), when multiplied by the proportion of production variation transmitted abroad (column a), amount to more than 2.5 percent of average annual world trade over the period 1960-87 (column d). However, production fluctuations in Indonesia, the third largest importer, are large relative to the world market. About half of Indonesia's production fluctuations are transmitted onto the world market (as shown by the transmission coefficient for Indonesia in column a). A one standard deviation change in production from trend in Indonesia would be expected to amount to 5.7 percent of world rice trade over the period 1960-87.

Among exporters, expected trade variations resulting, *ceteris paribus*, from a domestic production variation of one standard deviation from trend are highest for Burma and Thailand (column c). In neither case, however, would such fluctuations amount to more than 4 percent of annual world rice trade over the period 1960-87. A production deviation of two standard deviations from trend would be expected to cause an 8 percent change in annual world trade, but such extreme fluctuations would be expected to occur with a probability of five percent, assuming that Thai and Burmese rice production around trend approximates a normal distribution.

Overall, the results suggest that in all but four countries examined in the rice market (Thailand, Burma, Vietnam, and Indonesia), production variations of two standard deviation from trend create less than a 5 percent change in mean world trade volume over the period 1960-87. The bulk of rice importers therefore face a rather elastic export supply function. The more elastic the export supply (import demand) curve facing an individual importer (exporter), the less a random fluctuation in its trade volume will affect the world price. With such a modification to the theoretical framework presented earlier in Figure 1 (representing the mechanisms by which government insulation is claimed to destabilize world prices), it becomes apparent that little world price instability can be attributed to the insulation policies of most rice trading countries.

The validity of assumption 2 – *i.e.*, that trade fluctuations of small countries, when aggregated, destabilize world prices – is related to the geographical concentration of world price production and is examined in Section 4.

Assumptions 3 and 4 are relevant only for the handful of large countries remaining. The extent to which government insulation policies of these countries destabilize the world market depends on the difference between the absorption and transmission effects under insulation compared with those under no trade restrictions. Reconstructing the functional relationships in equations (1), (2), (3b), and (5b) gives:

(9) NX_t = $PROD_t$ - CON_t [GNP_t, $PD_t(PW_t, PW^2_t, PROD_t, END_{t-1})$]

- END_t [R_t, END_{t-1}, R_{t-1} $PD_t(PW_t, PW^2_t, PROD_t, END_{t-1})$,

$PD_{t-1}(PW_{t-1}, PW^2_{t-1}, PROD_{t-1}, END_{t-1})$] + END_{t-1}.

Differentiating (9) with respect to PW_t yields:

(10) $d(NX_t)/d(PW_t) = -[d(CON_t)/d(PD_t) + d(END_t)/d(PD_t)] * d(PD_t)/d(PW_t)$.

This is the absorption effect under both insulation and non-insulation. The relationship has already been estimated under insulation and is equivalent to $ß_1 + 2*ß_{10}(PW_{t*})$ in equation (8).

Differentiating (9) with respect to $PROD_t$ gives the transmission effect under both insulation and non-insulation:

(11) $d(NX_t)/d(PROD_t) = 1 - [d(CON_t)/d(PD_t) + d(END_t)/d(PD_t)] * d(PD_t)/d(PROD_t)$.

This relationship has already been estimated under insulation, and is equivalent to $ß_3$ in equation (8). The issue now is to compute the transmission and absorption effects implied by free trade, and evaluate whether they are larger or smaller than those under insulation.

The Absorption Effect

As is apparent from equation (10), the responsiveness of net exports to world prices can be broken into two effects: the responsiveness of domestic consumption and stock demand to domestic price, and the responsiveness of domestic price to world price movements.

Concerning the second effect, recall that under free trade (and no transport costs), the coefficients in equation (5b)

$PD_t = d_0 + d_1(PW_t) + ...$

would reduce to d_0=0 and d_1=1, as PD_t would in fact equal PW_t. Therefore, under free trade, equation (10) reduces to

$d(NX_t)/d(PW_t)_{FT} = - [d(CON_t)/d(PD_t) + d(END_t)/d(PD_t)]$.

Assuming for the moment that the responsiveness of consumption and endstocks to domestic prices are the same under both insulation and free trade, the difference between net export price responsiveness under insulation and free trade hinges on the degree to which government dampens the transmission of world price movements to domestic markets (*i.e.*, the degree to which $d(PD_t)/d(PW_t)$ is less than one). Thus, the free trade-implied trade elasticity may be calculated by dividing equation (10) under insulation, which was previously estimated for each country in equation (8) and reported in elasticity form in Table 8, by the price transmission coefficient $d(PD_t)/d(PW_t)$ under insulation. This coefficient was estimated using OLS in equation (5b) for seven rice trading countries for which domestic price data were available. The resulting price transmission elasticities are presented in Table 11. Complete regression results are given in Appendix 3.

Table 11. Estimates of World-to-Domestic Price Transmission Elasticities for Selected Rice Trading Countries

Exporters:	
Thailand	.26***
United States	.83***
Pakistan	.45**f
Burma	.87**
Importers:	
Bangladesh	.68*
Indonesia	.07
Malaysia	.19***

Source: Domestic price data obtained from International Rice Research Institute (1986). All other data sources are listed in Table 7.

Note: Elasticities are $d(PD_t)/d(PW_t)*\overline{PW}/\overline{PD}$.
f: F-statistic on PW^2_t significant at the .95 level
***: significantly different from zero at the .99 level
**: significant at the .95 level
*: significant at the .90 level

The degree to which governments allowed world price fluctuations to affect domestic prices varied widely. Domestic prices in Burma and the United States were quite responsive to world price movements. In the United States, a 10 percent increase in world price generated a 8.3

percent increase in the domestic consumer price, calculated at the respective price means over the estimated period. The relationship between domestic and international rice prices was non-linear in the case of Pakistan. The government allowed domestic rice prices to rise by smaller amounts as world prices rose progressively higher, apparently to protect consumers from transitory food insecurity during tight world market conditions. Other countries, notably Indonesia, Malaysia, and Thailand, heavily insulated their domestic markets from world rice price movements. In Indonesia, for example, a 10 percent increase in the world price produced less than a one percent increase in domestic consumer prices on average.

Estimates of the absorption effect under free trade can now be computed by dividing both sides of equation (10) by the price transmission coefficients (represented in elasticity form in Table 11) for each country. This forces $d(PD_t)/d(PW_t)$ to be unity, as is implied under free trade. The free trade-implied elasticities are reported in Table 12, under three alternative estimates of consumption and stock responsiveness to domestic price. This is necessary because there are no data under free trade for any of the countries examined. Thus, it is unknown how a transition to free trade would affect consumption and stock demand responsiveness to domestic price, *i.e.*,

$d(CON_t)/d(PD_t) + d(END_t)/d(PD_t)$ in equation 10.

The three alternative scenarios are:

(1) no change in domestic price responsiveness under free trade and insulation, *i.e.*,

$$[ß_1 + 2*ß_{10}(PW_t)]* d(PW_t)/d(PD_t)$$

as estimated from equation 8;

(2) domestic price responsiveness under free trade is 25 percent higher than that measured under insulation, *i.e.*,

$$[ß_1 + 2*ß_{10}(PW_t)] *d(PW_t)/d(PD_t)*1.25;$$

(3) domestic price responsiveness under free trade is 50 percent higher than that measured under insulation, *i.e.*,

$$[ß_1 + 2*ß_{10}(PW_t)] *d(PW_t)/d(PD_t)*1.50).$$ [16]

[16] While each of these scenarios assume that the responsiveness of consumption and/or stocks to domestic price under free trade will be greater or equal to that under insulation, this is not necessarily the case. Government insulation policies designed to stabilize domestic prices must, to be successful, make stocks more responsive to price than if private actors alone performed this function. Therefore, the assumption that the domestic elasticities are equal or greater under free trade may upwardly bias the free trade-implied elasticities.

While the free trade-implied elasticities are often much larger in relative terms than those estimated under insulation, they are generally not much higher in absolute terms. The results indicate that only in Indonesia and Pakistan would the volume of trade be significantly more responsive to world prices under free trade than under current insulation policies. This is for two reasons. First, in several of the countries examined, government allowed over half of annual world price fluctuations to affect domestic market prices. This implies that either the

Table 12. Estimates of World Price Elasticity of Net Export Supply in World Rice Trade: Actual and Free-Trade Implied

Country	-----INSULATION----- Actual Estimates from Equation (8)	----------FREE TRADE---------- Sensitivity Analysis Scenario:		
		(1)	(2)	(3)
Exporters:				
Thailand	-.32	-1.60	-2.00	-2.40
United States	.32	.33	.41	.50
Pakistan	1.07	2.82	3.52	4.23
Burma	.03	.06	.07	.09
Importers:				
Bangladesh	.02	.03	.03	.05
Indonesia	.11	2.20	2.75	3.30
Malaysia	.01	.05	.06	.08

Sources: Domestic price data obtained from International Rice Research Institute (1986). All other data sources are listed in Table 7.

Sensitivity Analysis Scenarios:

(1) assumes that consumption and endstock response to domestic price is equal to that implied from estimation of equation 8, after adjusting for the effect of incomplete price transmission under insulation. Thus, the world price elasticity estimates in this column are derived by dividing each country's net export supply curve under insulation, estimated in equation 8, by the price transmission coefficient, $d(PD_t)/d(PW_t)$, as estimated in equation 5b. This effectively adjusts for the depressing effect of government insulation policies on a country's trade responsiveness to world price.

(2) assumes that consumption and endstock response to domestic price is 25 percent higher than that implied from equation 8.

(3) assumes that consumption and endstock response to domestic price is 50 percent higher than that implied from equation 8.

government policies were unsuccessful in meeting their objectives, or that they were not designed to remove all price variation, but rather to mitigate price movements outside of certain explicit or implicit ranges.

Second, and more importantly, even if domestic prices were quite divorced from world price movements, as in Malaysia, Bangladesh, and Thailand for example, there is no indication that the transition to freer trade would substantially increase net trade responsiveness (Table 12). This is because domestic consumption and stock responsiveness to domestic price may be quite low as well. Even assuming a 50 percent increase in the responsiveness of consumption and endstocks to domestic prices, these responses are too low to substantially increase the trade elasticities in most of the countries examined. In such cases, the effect of government insulation policies on net export responsiveness, although potentially large in proportional terms, may be quite small in absolute terms.

This was examined further by estimating the responsiveness of consumption and endstocks to domestic retail rice prices for the same seven rice trading countries for which domestic price data were available. The procedure involved two-stage least squares estimation using equations (2), (3b) and (5b).

In the first stage, equation (5b) is estimated; fitted values for domestic price are then used to derive domestic consumption and endstock demand elasticities in equations (2) and (3b). These estimates are compared with those of a similar study by Ito, Wailes, and Grant (1985), and are presented in Table 13. Complete regression results are contained in Appendix 4. The evidence indicates that rice price elasticities of consumption are very low. All of the estimates in both studies were below .50. This is not surprising since rice is a critical staple food with limited substitutes in most Asian countries.[17] These results are consistent with the survey of grain studies compiled by Scandizzo and Bruce (1980), which reveals that 14 of 16 estimates of rice and wheat demand elasticities are less than .50. Ongoing research suggests that low domestic supply and demand elasticities are frequently the result of multivaried production and marketing constraints, urbanization, weak processing techniques, and other factors common in developing areas, rather than an unwillingness to respond to price per se (Weber *et al.* 1988, Delgado 1988, Martin and Crawford 1988, Rogers and Lowdermilk 1988, Streeten 1987). Evidence of limited consumption responsiveness to domestic price suggests that even if most governments allowed domestic prices to move freely with world prices, national trade responsiveness to world prices would not greatly increase in absolute terms.

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[17] Even in areas where other staple grains offer consumption substitutes for rice, rice demand elasticities were still found to be very low in many cases. In parts of Sub-Saharan Africa for example, this appears to be the case because of lower fuel costs and ease of preparation for rice compared with potential coarse grain substitutes (Rogers and Lowdermilk 1988; Reardon 1988).

Table 13. Estimates of Domestic Price Elasticity of Consumption and Endstocks For Selected Rice Trading Countries

	DOMESTIC PRICE ELASTICITY OF:		
	------------CONSUMPTION------------		-----STOCKS-----
	This Study	Ito, Wailes, and Grant (1985)	This Study
Exporters:			
Thailand	+.14	.00	-.71
United States	-.09	-.18**	-5.60**
Pakistan	-.28	-.14	-1.54***
Burma	-.08*	-.02	na
Importers:			
India	--	.00	--
Bangladesh	-.01	-.03	-1.94
Indonesia	-.48**	-.05	-3.21
Japan	--	.00	--
S. Korea	--	-.17	--
Malaysia	+.03	na	-.23

Sources: Domestic price data obtained from IRRI (1986). All other data sources are listed in Table 7.

Note: Consumption elasticity: d(CON)/d(PD)*PD/CON

Endstock elasticity: d(END)/d(PD) * PD/END

***: Significant at the .99 level
** : Significant at the .95 level
* : Significant at the .90 level
na : Stock data not available

Stock demand estimates vary greatly among countries. Although they are quite high in some cases, reference to Table 6 reveals that most of the countries examined (the United States and Indonesia excluded) maintain small stock levels compared with the volume of world trade.

Thus, most rice trading countries have a limited ability to stabilize the world market through stock adjustments.

Transmission Effect

Equation (11) shows that the magnitude of the transmission effect under both insulation and free trade depends on (a) the responsiveness of consumption and endstocks to domestic price, and (b) the effect of production on domestic price. In the absence of trade restrictions or domestic price policies, world and domestic prices are equated (abstracting from transport costs). In the small-country case (*i.e.*, small in terms of production; the country may still be a major trader), changes in production cannot affect world price, and therefore equation (11) reduces to:

$$d(NX_t)/d(PROD_t) = 1.$$

The logic behind this result is demonstrated in Figure 2. The case of an exporter is presented, but the results apply equally to a large or small importer (in terms of trade volume); the main condition is that the country's production fluctuations are small relative to the world market. Because the time frame of the analysis is short-run, supply is considered unresponsive to current price, but again the results do not depend on this. Supply and demand (S_0, D_0) define the excess supply curve (ES_0). In the small-country case, the import demand curve is horizontal, and is equal to world price (ID_0=PW). Under free trade, the excess supply curve in conjunction with import demand determine the volume of exports (X_1-X_0). Now introduce a weather induced increase in supply (S_1). The excess supply curve shifts to ES_1, inducing exports of X_2-X_0. Because world price is not altered by the change in domestic production, the entire increase in production, X_2-X_1, is exported via trade, inferring $d(NX_t)/d(PROD_t)=1$.

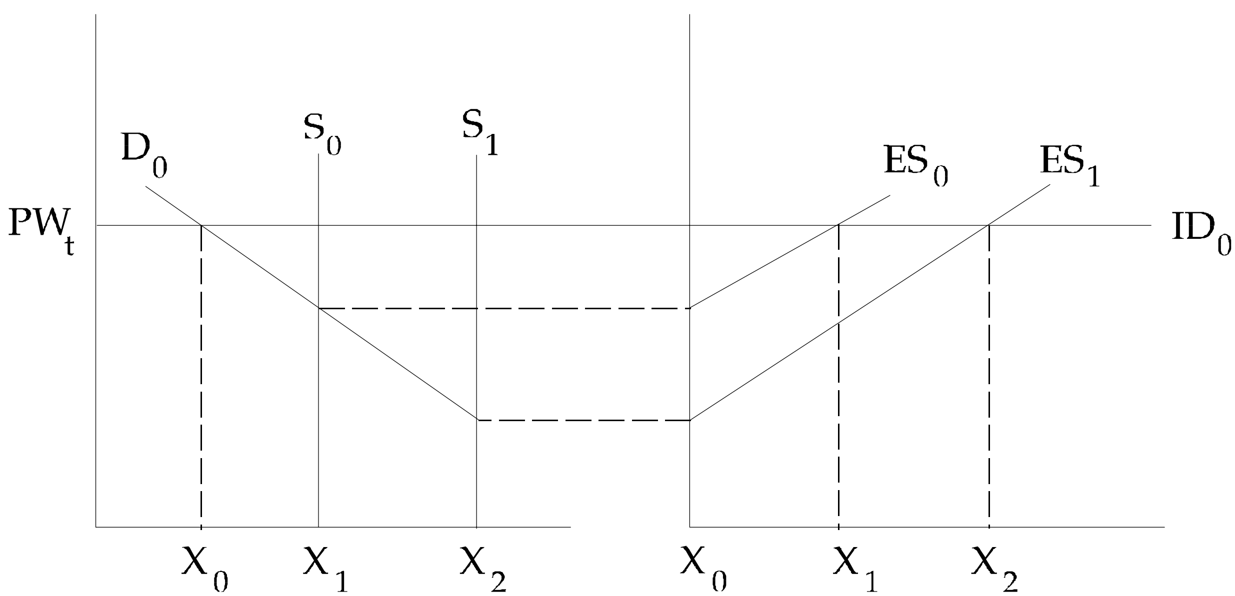

Figure 2. Transmission Effect under Free Trade for Small-Country Case

Note that this same logic extends to large actors in the world market, as long as they produce insufficient quantities domestically to alter world price through the transmission of production variability. This would include four of the largest five rice importers (Iran, Iraq, Senegal, and Nigeria). Table 9 indicates that these countries' potential trade instability resulting from a production shock of two standard deviations from trend would in no case amount to more than 2.6 percent of average annual world rice trade over the 1960-87 period.

To reiterate, the above theoretical model indicates that under free trade, national production fluctuations would be totally transmitted onto the world market (*i.e.*, $d(NX_t)/d(PROD_t) = 1$), given the condition that national production fluctuations do not affect world price for the country in question. The venting of production disturbances through trade is consistent with the classic gains from trade argument that goods migrate from surplus to deficit areas until the marginal revenue (cost) of selling (buying) an additional unit of grain abroad are the same as in the domestic market.

Perusal of Table 9 reveals that the vast majority of countries transmit less than all of their production variations onto world markets under present and past insulation policies. Therefore, the transition to freer trade by small and large trading nations may actually increase the transmission of instability onto world markets. This reveals the questionable logic underlying assertions often made that government insulation policies of major traders destabilize world markets through the venting of production variations.

The analysis thus far has not addressed the transmission effect for the small number of countries in which production variations may plausibly affect world price. This list would include Thailand, Indonesia, Burma, Vietnam, China, and the United States in the rice market, and the Soviet Union, United States, France, Argentina, and Canada in the wheat market. For exposition, the cases of Thailand, China, and the United States are analyzed for the rice market. The task is to discern the magnitude of $d(PW_t)/d(PROD_t)$ to draw inferences about the transmission effects of these large producers under free trade.

To do this, I employ the same model as before, consisting of:

1. A net export identity (equation 1),
2. Domestic consumption (equation 2),
3. Domestic endstock demand (equation 3),
4. Adaptive price expectations process (equation 4),
5. Exogenous annual domestic production and beginning stocks, and
6. World-to-domestic price transmission equation (5b, but modified to reflect the free trade case that PD=PW), to arrive at a free trade-implied net export equation for exporter i.

12) $NX_{it} = PROD_{it}$

$$- a_{i0} - a_{i1}(PW_t) - a_{i2}(GNP_{it})$$

$$- c_{i0} - c_{i1}(PW_t) - c_{i2}(PW_{t-1}) - c_{i3}(R_t) - c_{i4}(R_{t-1})$$

$$- c_{i5}(END_{it-1}) + END_{it-1}.$$

Equation (12) is identical to reduced form equation (8) except for the modification in (5b) that PD_t=PW_t under free trade. Then, a simple rest-of-world net import equation, representing the aggregation of equation (12) across all other rice trading countries yields the reduced-form equation

(13) $NM_{ROW,t} = \quad - PROD_{ROW,t}$

$$+ A_0 + A_1(PW_t) + A_2(GNP_{ROW,t}) + C_0$$

$$+ C_1(PW_t) + C_2(PW_{t-1}) + C_3(R_t) + C_4(R_{t-1})$$

$$+ C_5(END_{ROW,t-1}) - END_{ROW,t-1}$$

where each A and C coefficient represents the aggregate of the respective a_i and c_i coefficients across all other countries. Equation (13) is equivalent to the horizontal summation of all importer excess demand functions minus the summation of excess supplies of competing exporters. The equation can be simplified by letting the coefficients on PW_t, $A_1 + C_1$, equal a reduced-form coefficient δ_1, and letting all other variables and their coefficients be represented in vector form by $\delta_2(Z)$

(14) $NM_{ROW,t} = \delta_1(PW_t) + \delta_2(Z).$

Equating equations (12) and (14) and solving for PW_t gives

(15) $PW_t = \quad [PROD_{it} - a_0 - a_2(GNP_{it}) - c_0 - c_2(PW_{t-1}) - c_3(R_t)$

$$- c_4(R_{t-1}) - c_5(END_{t-1}) + \delta_2(Z)]/(a_1 + c_1 + \delta_1).$$

Differentiating PW_t with respect to $PROD_{it}$ yields:

(16) $d(PW_t)/d(PROD_{it}) = 1/(a_1 + c_1 + \delta_1) < 0$

where $a_1 = d(CON_{it})/d(PW_t) < 0$

$c_1 = d(END_{it})/d(PW_t) < 0$

$\delta_1 = d(NM_{ROWt})/d(PW_t) < 0.$

It is clear that the more price responsive domestic consumption, endstocks, and rest-of-world imports are to world price under free trade, the closer equation (16) is to zero, and, thus, the closer the transmission coefficient in equation (11) is to 1. It is often stated by proponents of trade liberalization that the transition to free trade would substantially increase the magnitude of world import and export elasticities. This analysis implies that such a transition would increase the transmission of domestic production variability of large-country actors in the world market.

To examine this further, I use empirical estimates of parameters δ_1 borrowed from the commodity trade literature. Most estimates of the short run elasticity of demand for US, Thai, and Chinese rice exports are in the range of -4 to -10 under existing insulation policies of importing countries (see Tyers and Anderson 1988). Under free trade and assumed price transmission elastiticies of unity, import demand elasticities facing these countries have been estimated to rise to the range of -27 to over -40 (Tyers and Anderson 1988).[18] For arguments sake however, let us choose the lowest rice import demand elasticity estimate found in the literature: -0.08 as estimated by Siamwalla and Haykin (1983). While this estimate applies to the situation of insulation policies in effect during the early 1980s, let us assume, again for arguments sake, that this elasticity would not increase under a transition to freer trade. Using the range of coefficients for $d(CON_{it})/d(PW_t)$ and $d(END_{it})/d(PW_t)$ as derived in Table 12, the free trade-implied transmission effects are calculated for Thailand, China, and the United States (Appendix 6). In no case were these transmission coefficients lower than those estimated from equation (8) for these countries under insulation policies. This result is more robust considering that an implausibly low import demand elasticity estimate was used in the calculation.

[18] Adjusting this range of elasticities into their respective coefficients (using mean world price and volume data over the 1960-87 period) to obtain δ_1 in equation (16), and using estimates of $a_1 + c_1$ from Table 12, the value of $d(PW_t)/d(PROD_{it})$ in equation (16) becomes effectively zero, implying a transmission effect of 1.

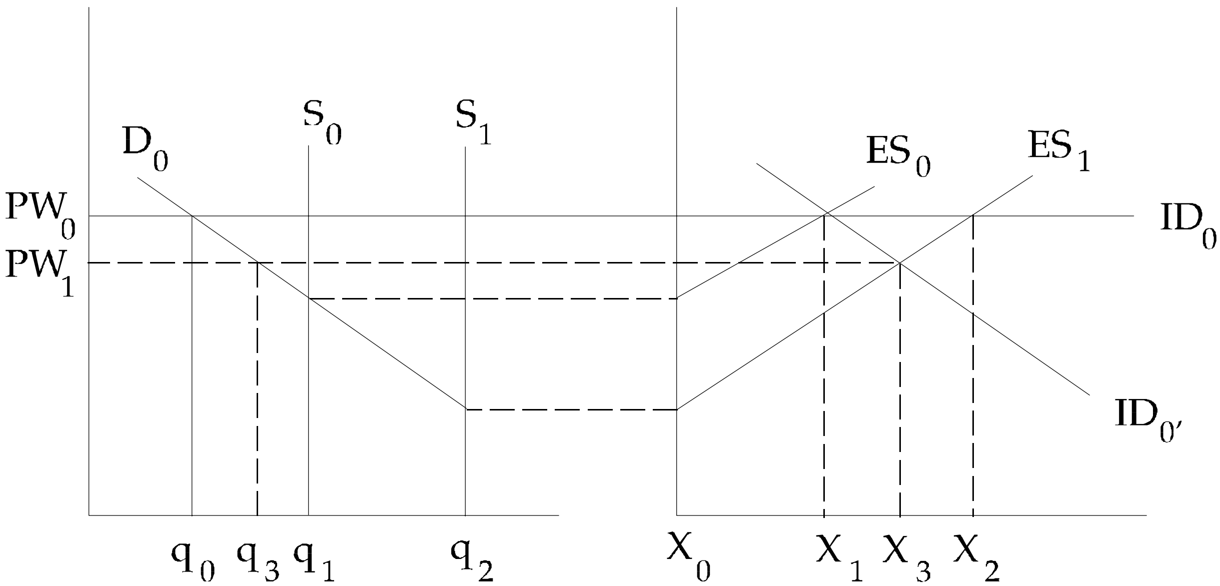

Figure 3. Transmission Effect under Free Trade for Large-Country Case

The logic behind this result is presented in Figure 3. It is the same as Figure 2, except a more inelastic import demand curve is drawn, reflecting the case of a large country exporter. Domestic supply and demand curves (S_0, D_0) determine excess supply curve ES_0, which in conjunction with import demand curve ID_0', determine the volume of net exports (X_1-X_0). Now let a production shock shift supply to S_1 and by q_2-q_1, exports increase by X_3-X_1 only (*i.e.*, (q_2-q_3)-(q_1-q_0) in the left hand side panel), implying that $d(NX_t)/d(PROD_t) < 1$. If the import demand curve becomes more elastic as an outcome of freer trade (*e.g.*, ID_0), a greater proportion of variations in production would be vented through trade, approaching one as the import demand curve approaches negative infinity (as in Figure 2).

Conclusions

Although it is often stated that government price stabilization policies which directly influence trade patterns introduce significant instability in the world market, the results of this analysis question such conventional wisdom. It is certainly true that many countries with such policies transmit part of their production instability onto world markets. It is also apparent that net trade elasticities of these countries are quite low in some cases. This is not in itself evidence that government insulation policies exacerbate world price instability. The issue is whether instability would be greater or lower with a transition to freer trade. The transmission and absorption effects are two prominent criteria for examining this issue. The conventional model presented at the beginning of this implies that free trade would increase countries' trade responsiveness to world price and thus their ability to absorb quantity shocks on the world market. In many cases, however, the magnitude of such improvements would be small in absolute terms. This is because most rice trading countries examined do not exhibit enough responsiveness to domestic prices even without trade restrictions to greatly affect these countries' responsiveness to world prices once such trade restrictions are eliminated. Therefore, low national trade elasticities can be deduced without reference to government insulation policies.

The net trade curves facing individual trading countries may become significantly more elastic if all countries liberalized trade. This would, however, bring mixed blessings. On the one hand, such a transition would increase the ability of the world market to absorb quantity variations from an individual trading nation. On the other hand, the magnitude of such quantity variations would appear to be much greater under free trade. The model suggests that as the import demand (export supply) function facing an individual exporter (importer) becomes more elastic, a greater proportion of its production instability will be transmitted abroad. Moreover, the variability of production itself may increase because domestic prices – the expected values of which affect production decisions – may themselves become more variable under free trade. This would occur as world market shocks are increasingly allowed to affect domestic prices.

4. ORGANIZATIONAL SOURCES OF INSTABILITY IN THE WORLD RICE MARKET

Instability and uncertainty are critically influenced by organizational aspects of a market, distinct from, or in addition to government insulation policies per se. In the case of world rice trade, these factors include (1) the lack of durable, reliable import markets; (2) the geographical concentration of world production; (3) self-sufficiency policies of traditional rice importers and the role of green revolution technology in achieving these ends; (4) the relationship between petroleum prices and rice import demand; and (5) the evolving substitutability between wheat and rice among major consuming countries.

The Reliability of Foreign Markets and Transaction Costs

A striking difference between the organization of world rice and wheat trade concerns the reliability of export and import markets. This is a crucial factor for all countries that depend on the world market. For exporters, reliable import markets represent a source of national revenue and a vent for surplus production which would otherwise need to be absorbed domestically, with potentially high internal disruption. For importers, reliable surplus-producing areas are necessary to meet domestic food requirements, broader national policy goals and, in some cases, political stability.

Figures 4 and 5 contrast the fragility of trade patterns in the rice market relative to the wheat market. Mean production to consumption ratios over the 1980-87 period are measured along the horizontal axis. The further a given country's ratio is from unity, the more likely it consistently appears on one side of the market, either as an exporter (if the ratio is greater than one) or an importer (if the ratio is less than one). The vertical axis shows each country's importance in the world market. The plot of wheat trading countries shows a relatively wide dispersion of most countries from one, but many actors in the rice market are concentrated near one, indicating that annual production variations may cause them to appear on either side of the market in any given year. This is indeed borne out by examining the trade data of a number of rice market actors. Korea, Vietnam, Indonesia, India, Brazil, and Japan have sporadically switched from importer to exporter (or vice versa) several times since the mid 1970s. Of these, Indonesia and Vietnam were identified in the previous section as potentially able to destabilize world market prices due to the magnitude of their domestic production variability and their willingness to transmit large portions of it onto world markets. In the wheat market, India and the Eastern European bloc (once) have entered the market as both importer and exporter since 1970.

Several points follow from this. First, the potential for several large import markets to evaporate in any given year presents great uncertainty for exporters in terms of venting their surpluses at a remunerative price. Because many importers have distinct preferences for

certain varieties or qualities of rice, the drying up of an import market may make it difficult for an exporter with a certain kind of rice to find another buyer without accepting a large discount. Second, the combination of large, unreliable markets, distinct tastes and preferences within these markets, and no clear price discovery process (as in the wheat market) creates high search costs for both buyers and sellers. This is exacerbated by the lack of internationally accepted grades and standards in the rice market. Consequently, it is not surprising that the rice market supports a number of large brokerage houses located in the United States, Europe, Singapore and Hong Kong, charging fees of 5 to 10 percent of sale. Such rates are "almost inconceivable in the wheat trade" (Siamwalla and Haykin 1983). While such agents perform needed services, they impose costs on market participants that would not have to be incurred if trade patterns were more reliable and if more widely accepted grades and price discovery mechanisms were successfully instituted.

Countries producing sporadic rice surpluses are even worse off. They frequently lack the milling facilities to ensure standardization and have insufficient exposure to the market to have acquired a reputation regarding quality (Siamwalla and Haykin 1983). Furthermore, a sizable proportion of rice import markets may already be committed in the form of government-to-government and long run contracts. Hence, search costs for sporadic exporters are generally high. Siamwalla and Haykin conclude that this situation characterizes the rice trade in general:

> The main problem with the rice market in our view is not instability in the sense generally understood, *i.e.*, exhibiting large fluctuations in prices, nor particularly that these fluctuations are the consequences of "thinness":...Rather the main problem lies in the fact that the transaction costs involved are very large. When a country enters the world market (either as exporter or importer), or even when it is staying put and buys or sells the same volume as before, it has to search for trading partners. There is no rice "supermarket" as there is in the United States for wheat (quoted in Barker, Herdt, with Rose 1985, p. 192).

Geographical Concentration of World Rice Production

Another aspect of the rice market exacerbates the above problem. In Section 3, it was concluded that the domestic markets of only a handful of countries, *ceteris paribus*, are large enough to potentially disrupt the world market through venting their production instability abroad. However, the geographical concentration of rice production adds a new dimension to this issue.

Eighty percent of the world's rice is produced in China, Thailand, Burma, Bangladesh, India, Indonesia, and Vietnam. Production in these countries is highly correlated due to the Asian monsoons. There are in fact three distinct monsoon patterns, but only two are relevant here: (1) the Indian monsoon, which controls air movements over India, Bangladesh, and parts of Burma and Thailand; and (2) the Malayan monsoon, which affects Indonesia, Burma, Thailand, Vietnam, and most of China. Correlation coefficients of production variations from trend from 1960-87 are strikingly high, as shown in Table 14.[19] Moreover, the correlation coefficient of production deviations from trend between the Asian exporter bloc (Thailand, China, and Burma) and importer bloc (Indonesia, Bangladesh, Vietnam and Malaysia) is .66.

Table 14. Correlation Coefficients of National Rice Production Deviations from Trend in Monsoon Asia

	Indian Monsoon Region				
	India	Bangladesh	Burma	Thailand	
India	--				
Bangladesh	.68	--			
Burma	.13	.42	--		
Thailand	.59	.40	.45	--	
	Malayan Monsoon Region				
	Thailand	Burma	Indonesia	China	Vietnam
Thailand	--				
Burma	.50	--			
Indonesia	.47	.34	--		
China	.27	.05	.60	--	
Vietnam	.34	.36	.67	.51	--

Source: USDA (1988).

[19] It is to be expected that production levels themselves will be correlated between countries as acreage and yields rise through time. More relevant for the examination of instability are unexpected variations in production, approximated here by the deviation from a linear time trend ($PROD_t - PROD^*_t$).

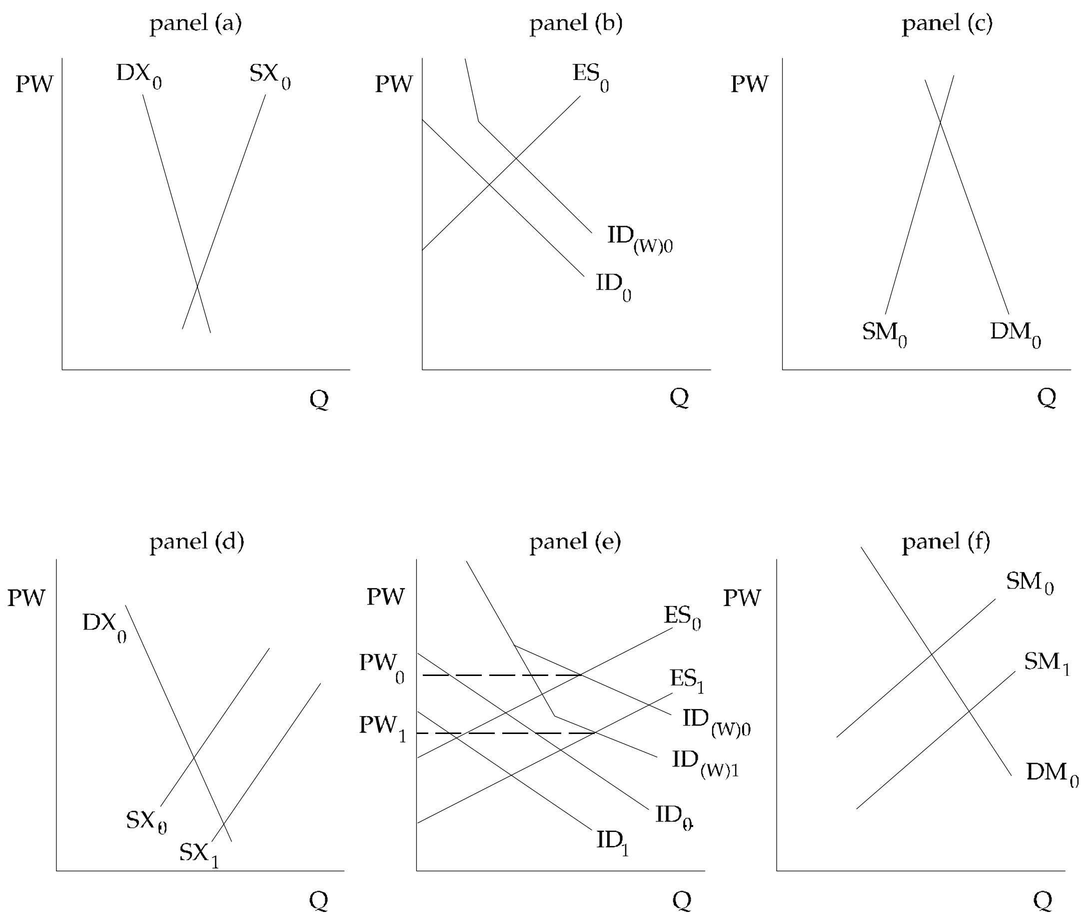

Figure 6. Heuristic Model Representing the Effects of Correlated Production in Asian Rice Importing and Exporting Countries on Price Instability

These results suggest that, within monsoon Asia, when a major exporter generates a surplus, there is a good probability that other major exporters and importers will have done the same. This puts pressure on domestic markets to absorb the production variation through consumption and stock adjustments, but as the econometric results in Section 3 indicate, part of the production variability is invariably transmitted onto the world market. As a result, net trade variations tend to occur in the same direction among these countries, causing wider price swings than would otherwise occur if world production were more geographically dispersed. This phenomenon is shown in Figure 6. Asian exporters' (*e.g.,* Thailand, Burma, China) aggregate supply and demand are represented in panel (a), while importers' aggregate supply and demand (*e.g.,* Indonesia, Bangladesh, Vietnam, and Malaysia) are shown in panel (c). Their export supply

(ES_0) and import demand curves (ID_0) are shown in panel (b). All other countries' net import demand is assumed fixed, which when added to ID_0, gives world import demand ($ID_{(W)0}$). If the monsoons bring favorable weather throughout south and southeast Asia, supply in both the importing and exporting regions may shift to SM_1 and SX_1 (panels d and f), causing movements in the Asian ES and ID curves (and thus $ID_{(W)}$) that reinforce rather than offset movements in world price away from its normal level (PW_0-PW_1 in panel e).

In the wheat market, production is more geographically dispersed. The five major exporters (USA, Canada, France, Australia, and Argentina) are dispersed over four continents, and the largest wheat importers (Soviet Union, China, Egypt, Japan, and Brazil) are equally dispersed geographically. The correlation coefficient between production deviations from trend among these wheat importer and exporter blocs was -0.34 between 1970 and 1987. This means that when the major importers as a group experienced production shortfalls and a corresponding increase in import demand, it was probable that the major wheat exporters had produced a better-than-average harvest to compensate, and vice versa. Therefore, the argument that government insulation policies have exacerbated world wheat price instability when their effects are aggregated across countries is very tenuous, because the transmission effects of exporters and importers have tended to wash out in any given year.

Green Revolution Technology and Self-Sufficiency Policies

Available evidence suggests that, on the whole, the introduction of new rice technology has increased year-to-year fluctuations in production (Barker, Gabler, and Winkelmann 1981, Mehra 1981, Hazell 1982). Much has been written on this, and it is not examined here. Instead, the following examines a much greater source of market instability generated indirectly by the advent of new rice production technology in the past several decades.

World food shortages in the early 1970s raised the specter of mass starvation in many developing countries that hitherto had relied greatly on the world market to relieve domestic production shortfalls. These events set in motion self-sufficiency policies among many developing countries. Such policies, however, and the green revolution technology that operationalized them, created very different outcomes for world rice and wheat trade. In the case of wheat, the new technologies were widely applicable to the climates of traditional exporters as well as importers, and therefore did little to change the direction or stability of wheat trade. Advances in rice production technology, however, generally favored the major rice importing regions. This was because the new technology performed best in irrigated areas with good water control rather than in the major river deltas, the traditional source for export rice (Barker, Herdt, with Rose 1985). As a result, the major beneficiaries have been traditional import markets such as Indonesia, Korea, Malaysia, Sri Lanka, and India, as well as several exporters (China and Pakistan). Yet the longstanding export centers of Thailand and Burma produce rice largely under recessional flooding with limited water control, and thus had been unable to use the new technology to its full potential. This technology bias toward traditional importers has produced both direct and indirect effects on the volume and stability of rice trading patterns:

> When the technology proved successful, the importing countries instigated rice programs designed to promote self-sufficiency, the ultimate security against an unstable market. The exporters, on the other hand, saw little to be gained from promoting the new technology (which initially performed relatively poorly in their environment) or increasing production, since many of the traditional importers appeared to be moving toward self-sufficiency. Thailand, for example, was more concerned with maintaining stable domestic prices than with promoting production for exports (Barker, Herdt, with Rose 1985, p. 195).

Hence, the Asian beneficiaries of the new rice technology have inadvertently generated much uncertainty in the rice market, especially in the long-term. In the short run, large countries such as Indonesia and Vietnam have transmitted a moderate to high proportion of their production variability into trade variability. These countries are also among the group that moves from importer to sporadic exporter and back in an unpredictable way. The growing self-sufficiency among once-large importers such as India, Indonesia, Korea, and Sri Lanka has, *ceteris paribus*, depressed world import demand and prices over the long run. While this has been largely offset by soaring demand in the Middle East and Africa, self-sufficiency policies have been undertaken in many of these countries as well. It is uncertain where and what the world demand for rice will be 10-15 years in the future, and this uncertainty may well affect the rate of production investments in traditional exporting countries. The long run uncertainty associated with the combination of new rice production technology (which has altered the traditional structure of comparative advantage) and self-sufficiency policies, may produce very regrettable consequences should world prices rise sharply again in the future. This could arise if incomes rise rapidly (particularly in India and China[20]), while potentially productive investments in exporting countries are shunned today because of the risks and costs of surplus production under uncertain future world demand.

[20] Because China and India consume one-third and one-sixth of the world's rice production respectively, shifts in their demand relative to supply can create substantial reverberations on the world food system. Timmer and Jones (1986) note that national income levels in China are at a point where food and feed grain demand typically rise very sharply with additional increases in income. Since China's per capita meat consumption is among the lowest in the world, rising incomes may cause very large increases in world feed grain demand, and this would probably have spillover effects in the rice and wheat markets.

Petroleum Prices and Rice Import Demand

Since the late 1970s, OPEC countries have increasingly dominated rice import demand. In fact the leading four importers during the 1980s are Iran, Iraq, Indonesia, and Nigeria, with Malaysia, Saudi Arabia, and the Soviet Union not far behind. Rice consumption in these countries may be affected by petroleum revenue because it commonly accounts for over 90 percent of national export revenue. This suggests a possible relationship between the world demand for rice and the price of petroleum.[21]

To examine this relationship, the real price of petroleum was added to the list of regressors in structural equation (3) in the previous section. The variable thus appears in the estimated trade equation (8), and was subjected to an F-test. Countries examined were Iran, Iraq, Indonesia, Nigeria, and the Middle East region. In the case of Nigeria, the petroleum price variable was multiplied by a dummy variable equaling zero until 1975 to account for the period in which Nigeria obtained little or no oil revenue. The F-tests showed a significant relationship between the real price of petroleum and net imports at the 5 percent level in the cases of Iran, Nigeria, and the Middle East region. This is not surprising since both Iran and Nigeria, which earn over 90 percent of their export revenue from oil, have engaged in extensive countertrade agreements involving the exchange of oil for rice and other grains. Rising oil prices, *ceteris paribus*, enable them to afford greater food imports. The real petroleum price elasticities of rice import demand were calculated as .87, 1.93, and .41 for Iran, Nigeria, and the Middle East region. Collectively, these countries have accounted for 22 percent of annual rice imports since 1980.

These results suggest that rice market instability is affected not only by production fluctuations, government policy, and their interaction, but also by important demand-side shocks originating from outside the rice market. This phenomenon is not as pronounced in the wheat market because world wheat import demand is not dominated by oil exporting countries as it is in the rice market (see Table 5).

Wheat-Rice Interrelationships[22]

Wheat imports have increased substantially in almost all rice-importing countries of Asia. Among five countries which have implemented policies designed to achieve rice self-sufficiency (Indonesia, Korea, Malaysia, Sri Lanka, and the Philippines), the ratio of rice imports to wheat imports has switched from 2/1 to 1/2 over the past two decades. Wheat production has also increased dramatically in China, India, Pakistan, and Bangladesh.

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[21] Ideally, petroleum revenue would be better, but this data was unavailable; petroleum price (f.o.b. Ras Tunuras, Saudi light crude) was used as a proxy.

[22] This section draws mainly from Barker, Herdt, with Rose (1985).

Factors driving this surge in Asian wheat imports include (1) urbanization; (2) market incentives and policies of developed country wheat exporters; and (3) the long run decline in wheat prices relative to rice prices since World War II (Cimmyt 1983, Barker, Herdt, with Rose 1985).

There are at least three major reasons for the decline of wheat-rice price ratios. First, world wheat production has been growing faster than rice production (approximately 3.0 vs. 2.5 percent per year). Wheat production has increased rapidly especially in China, India, Bangladesh (where rice is the primary staple food in most areas), and Pakistan. These increases are largely the result of production technology advances that occurred earlier in the higher-income areas. The second reason for the decline of wheat-rice price ratios is that populations in the main rice consuming areas of the world have been growing more rapidly than in the main wheat-consuming areas (2.2 vs 1.4 percent per year). Third, the income elasticities among rice consumers appear higher than among wheat consumers (Barker, Herdt, with Rose 1985).

The increasing substitutability between wheat and rice in food import requirements may promote stability in both world markets. For example, China, which has been observed to engage in a "wheat-rice calorie arbitrage" can increase rice exports and scale back wheat imports when world wheat prices rise relative to rice, and vice versa (Chinn 1981, Timmer and Jones 1986). This behavior, which promotes trade responsiveness to world prices and promotes world price stability, is made possible by some degree of substitutability in consumption between rice and wheat, at least at the national level. With wheat making rapid inroads into consumption patterns in a number of traditional rice-consuming countries, price instability originating in one market is more likely to be moderated by substitution behavior in the other market.

5. CONCLUSIONS AND POLICY IMPLICATIONS

This concluding section is divided into four parts. First, the major findings of the study are summarized. Next, the feedback effects of instability on the organization and performance of the rice market are discussed. The third section discusses the policy implications of these results, and examines the advantages and drawbacks of several alternative mechanisms to reduce the level of instability in world rice markets. Areas for further research are discussed in the final section.

Summary

World rice prices since 1960 have been significantly more unstable than those of other traded agricultural commodities such as wheat, corn, soybeans, or even petroleum. This is true in both annual and quarterly terms, using several alternative measures of instability. Prices in these markets have become substantially more volatile since the early 1970s, although they have stabilized somewhat during the last five years.

Much of the increased world price instability since the 1970s has been attributed to government insulation policies that sever the link between domestic and international prices; the logic and empirical evidence behind these conclusions are tenuous. It is not valid to examine net export responsiveness to production and world price variations, and simply conclude that a high transmission effect and/or a low absorption effect are evidence that government insulation policies aggravate world price instability. Rather, such conclusions require the following conditions: (1) the country in question must be large enough for its production and trade variations to affect the world market (alternatively, such variations must be positively correlated with aggregate world production variations); (2) the transmission effect under insulation must be greater than it would be under free trade; and (3) the absorption effect under free trade must be larger than it is under insulation. The following summarizes the empirical results of this study and assesses whether these conditions are met in world rice markets.

Condition (1): Only a handful of countries in the rice and wheat markets exhibit sufficient production variability and a propensity to transmit this instability abroad to appreciably destabilize the world market. Given the empirical history of national production deviations from trend, and the proportion of such deviations that are transmitted abroad, only several countries (the United States, Soviet Union, EC-12, and Argentina in the wheat market; Burma, Thailand, Indonesia, and Vietnam in the rice market) behave in ways that would alter world trade volumes by more than 5 percent, even during extreme years when production varies by two standard deviations from trend.

The effects of government insulation policies may be magnified if national production fluctuations are correlated. This is because such production variations aggregated across countries may be large enough to seriously affect both world import demand and export supply. This was found to be true in the rice market because of the geographical concentration of world rice production. More than 80 percent of the world's rice is produced in a narrow swath of south and southeast Asia. The correlation coefficient of production deviations from trend between the 3 largest Asian rice exporters (Thailand, Burma, and China) and 4 major Asian importers (Indonesia, Bangladesh, Vietnam, and Malaysia) was .66 between 1970 and 1987. This means that poor harvests among these blocs (which account for over 60 percent of world rice production) tend to occur at the same time, putting greater pressures on the world market to cope with simultaneously rising import demand and falling export supplies (and vice versa in years of surplus). The geographical concentration of rice production appears to be a major source of price instability in the world rice market, and partially explains why world rice prices are more unstable than other traded agricultural commodities. Insulation policies may exacerbate this source of instability.

In the world wheat market, national production variations of major actors are much less correlated. The five major exporters are dispersed over four continents, and the largest wheat importers are equally dispersed geographically. The correlation coefficient between production deviations from trend in the wheat importer and exporter blocs was -0.34 between 1970 and 1987. This means that when the major importers as a group experienced production shortfalls and a corresponding increase in import demand, it was probable that the major wheat exporters had produced a better than average harvest, and vice versa. Therefore, the argument that government insulation polices exacerbate world wheat price instability when their effects are aggregated across countries is very tenuous, because the transmission effects of exporters and importers tend to wash out in any given year. In marked contrast to the rice market, the negative covariance between production deviations of wheat importers and exporters has had a stabilizing influence on world wheat prices.

Condition (2): Fluctuations in trade volumes resulting from production variability do not infer that government insulation policies are the cause. Under "free trade," production variations are partially and invariably transmitted onto foreign markets as goods migrate from surplus to deficit areas. As noted by Bigman (1985), production instability itself influences trade flows under free trade in addition to the classical elements of comparative advantage. Therefore, the instability-related issue is whether the transmission of production instability is greater under government insulation than under free trade.

The analysis in Section 3 suggests that, contrary to the conventional wisdom, a greater proportion of national production variations would be transmitted onto foreign markets under free trade than under insulation. This is because freer trade, as argued by its proponents, would make the net trade functions facing large trading countries more elastic (a result of liberalized trade by the rest of the world). While such a transition would increase the ability of the world market to absorb quantity variations from an individual trading nation, it would also increase the magnitude of such quantity variations. The model suggests that as the import demand (export supply) function facing an individual exporter (importer) becomes more elastic, a greater proportion of its production instability will be transmitted abroad. Moreover, the variability of production itself may increase because domestic prices – the expected values of which affect production decisions – may themselves become more variable under free trade. This would occur as world market shocks are increasingly allowed to affect domestic prices. Therefore, more elastic trade functions – often used as the basis for the argument that freer trade would stabilize world prices – would have countervailing effects on price stability.

Condition (3): Low trade responsiveness to world price, exhibited by many countries, does not imply that government insulation policies are the cause, or that the removal of such policies would significantly improve such responsiveness. This is because the short-run responsiveness of national production and demand to domestic price -- which would determine trade elasticities under free trade -- are often very low in any case. In many Asian countries, there are few substitutes in consumption for rice. Moreover, interrelated production, marketing, and information constraints impede producers' ability to respond to current price signals, especially where physical and institutional infrastructure are weak. Therefore, government insulation policies, by partially severing the link between domestic and international prices, may greatly dampen world price responsiveness in proportional terms, but potentially very little in absolute terms. For example, although Malaysia's price responsiveness would be five times higher under free trade than under present insulation policies (from .01 to .05), the change in absolute terms is still very low.

If government insulation policies have been overemphasized as a source of instability in the world rice market, an explanation is still required for the high degree of volatility in this market. The major factors include (1) the relationship between world rice demand and petroleum prices; (2) the lack of durable, reliable import markets in the rice trade; (3) self-sufficiency policies of traditional rice importers and the role of green revolution technology in achieving these ends; and (4) the geographical concentration of world rice production.

Rice import demand appears highly linked to petroleum prices. This is because four of the major five rice importers are oil exporting countries. Rice imports of Nigeria, Iran, and the Middle East bloc are quite sensitive to oil prices. Therefore, rice market instability is affected not just by production fluctuations, government policy, and their interaction, but also by important demand-side shocks originating from outside the rice market.

A major distinction between the world rice and wheat markets is the amount of stocks available to stabilize the market in response to production and demand shocks. Between 1980-87, the average ratio of world stocks to world production was 29 percent in the wheat market compared with only 15 percent in the rice market. The difference is partially attributable to the diametrically opposing price policies of major wheat and rice producing countries. Stock accumulation has been a direct side effect of government programs in the United States and the EC, where producer prices in the 1980s have been higher than commonly used world price indicators. By contrast, major rice producing countries such as Thailand, Burma, Pakistan, Indonesia, and India have consistently taxed rice farmers and subsidized consumers; such a policy environment is not conducive to the accumulation of large stocks. None of these countries have held stocks which amount to more than 12 percent of production during the 1980s.

The greater proportion of wheat held in storage may mitigate upward price swings during shortage conditions better than in the rice market. Evidence elsewhere suggests that the responsiveness of prices to production forecasts are influenced by the size of available stocks (Gardner 1975). If stocks are low, impending production shortfalls in key areas may cause prices to be bid up higher in order to ration available supplies. But if stocks are large and "overhang the market", then world production variations may produce less price movement, because actors know that there are large stocks available to dampen any price rise (Stein and Smith 1977).

As mentioned above, the geographical concentration of production is a paramount cause of price instability in the world rice market as it leads to positively correlated production variations in major rice importing and exporting countries. Yield variation appears to be more important than area variation as a source of rice production fluctuations in most producing countries. This is especially true in most of the southern and south-east Asian countries affected by the Asian monsoons.

In the United States, on the other hand, area variability has been more important than yield variability as a source of production instability, for both rice and wheat. This appears to be due to periodic changes in U.S. commodity programs that greatly influence domestic production incentives. An important purpose of these policy changes has been to realign domestic prices with world market conditions; their success has been limited when examining annual U.S. production and world price movements. Econometric evidence presented elsewhere indicates that U.S. rice and wheat production have responded to lagged prices, but not current prices (Tyers and Anderson 1988, Zwart and Meilke 1979). Therefore, production changes in year t may have a destabilizing influence if current world market conditions are very different from the preceding year. U.S. rice production and annual f.o.b. Bangkok rice prices moved in the opposite direction five times during the volatile 1970s and three times during the 1980s. U.S. wheat production and annual world wheat prices moved in opposite directions six times during the 1970s. This has put added pressure on U.S. stocks to adjust in order to reduce the transmission of production variations onto the world market.

The organization of the rice market has a profound effect on the level of world price uncertainty. First, the world rice market is very fragmented and borders on being a misnomer. In the short-term, prices of indica and japonica varieties in various sub-markets frequently move independently of one another because of limited substitutability in consumption among the different varieties and qualities. Matching buyers with sellers of a particular type of rice is more difficult than in the wheat market because (1) grades are inadequately standardized, (2) reliable price information about a particular market may be difficult and costly to obtain, especially in the short run, and (3) the rice market lacks an established trading forum in which buyers and sellers can interact with low search costs. This has created high transactions costs of international rice trading. Partial evidence of this includes the high brokerage fees charged by trading houses mentioned earlier.

Transactions costs are also raised by unreliable and unstable trade patterns that characterize the rice trade. A number of large actors, including Indonesia, Korea, India, Brazil, and Japan, may appear as either importer or exporter in any given year. This is because such countries are now near or at self-sufficiency. Therefore, relatively small changes in domestic supply or demand can cause these countries to enter the world market as either importer or exporter. This has impeded the development of reliable long-run trade patterns, contributing to the uncertainty faced by major rice traders.

Marked shifts in import markets are due to increased emphasis on self-sufficiency, new production technologies that generally favored traditional importing regions, a rising preference for rice as a staple foodgrain in African countries, the rise of petroleum revenues in large food-deficit countries to finance rice imports, and increased inroads made by wheat in consumption patterns in major rice consuming countries.

While it is clear that these factors related to market organization have influenced the level of instability in the rice market, the causal flow is not one-way. The following section examines potential effects of instability on the institutional organization and performance of the rice market.

Instability and Market Organization

The evolving structure of the rice trade is both a cause and an outcome of world market instability. Since at least World War II, world rice trade as a proportion of world production has been extremely low compared with the wheat market. Comparable variations in the volume of trade therefore cause larger shocks in the rice market. This is particularly significant considering the geographical concentration of rice production in monsoon Asia. Therefore, a strong prima facie case can be made that the rise of government insulation policies for rice are a response to, as much as a cause of, inherent instability in the world rice market. Insulation policies may be very rational and understandable responses to an unreliable world market, although they may generate secondary effects which even further destabilize the world market.

World market instability has also been a major motivation behind the self-sufficiency drives of numerous importers since the early 1970s. Operationalized by the green revolution rice production technologies, countries such as India, Indonesia, Korea, and Sri Lanka have approached self-sufficiency (*i.e.*, production levels that match consumption in an average year), making the world market even more thinly traded. Due to the success of these policies in many countries, a structure of the world rice market has emerged in which numerous countries float in and out of the world market as trade flows are dominated by random and temporary aberrations in domestic supply and demand. This situation has created high search costs, greater price variability and market thinness, each of which reinforce the others.

Thin markets are often viewed as transitory phenomena in which various factors cause participants to shift exchange from the spot market to alternative forms of coordination such as vertical integration or long run contracts (NC-117 1978). However, Siamwalla and Haykin (1983) argue that thinness in the world rice market is a steady state. Because of many countries' unreliable and sporadic participation in the rice trade, long-term agreements are not viable alternatives. Because trade channels are not established ruts, and widely-quoted spot prices are unavailable, transactions costs are high (in terms of both time spent identifying and negotiating a contract, and brokerage fees or marketing margins). These factors tend to further steer governments away from reliance on the world market. Siamwalla and Haykin (1983) conclude:

> The participants in the world rice market – importers and exporters alike – are in an n-country version of the prisoner's dilemma game. 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 (p. 63).

In the long run, this gridlock may be relieved somewhat. A new set of actors in the Middle East and Africa may, for the foreseeable future, provide the stability on the import side of the market that is required for the development of long-run bilateral agreements with major exporters such as Thailand, Pakistan, and the United States. This could reduce search costs substantially and provide a more stable trading environment for regular participants. Yet such a development would be hazardous to sporadic traders who may have great difficulty obtaining or selling grain in an evaporated spot market.

Another consequence of the unstable, thin, and fragmented nature of the rice market may be the failure of a viable internationally-accepted rice futures market to develop. Viable futures markets have always depended on sufficient volume to avoid the risk of price manipulation by large actors (Houthakker 1959). But this presents a critical trade-off in the fragmented rice market. On the one hand, greater volume to lubricate the market may be achieved by standardizing price differentials between different varieties and grades of rice, and by increasing the number of delivery points. This would make more contracts fungible and make the futures market more attractive to speculators. However, the market's value to hedgers depends on the correlation between the futures price and the spot price realized when the futures contract matures, and that correlation is reduced as less substitutable contracts are made interchangeable (Caves 1978). As mentioned earlier, monthly spot prices among various sub-markets and varieties do not always move together (Falcon and Monke 1979-80). The unpredictable and perverse basis movements in rice futures observed on the New Orleans Commodity Exchange during the early 1980s (Gordon 1984) may partially be due to contract standardization problems, which was an outgrowth of market thinness, fragmentation, and uncertainty.

The failure of viable rice futures markets to develop has also been linked with (1) U.S. domestic prices being set above the world price for prolonged periods which dampened price variability needed to foster hedging and speculation; (2) the lack of "offshore" rice stocks that are immediately accessible for trading in the world market without the possibility of intervention by any government (Siamwalla and Haykin 1983); and (3) Thailand's historic lack of interest in the development of a rice futures market on its soil. Thailand, because of its major exporter position, has frequently been identified as a promising location for a futures market. Rice is cheaper closer to its origin and therefore requires less investment. Also, as rice exports are more concentrated than imports, major stockholdings in a prominent export market would make it easier to rechannel them to various countries as shortfalls develop (Siamwalla and Haykin 1983). Although Thailand's rice policies have historically been geared toward domestic market stability, major changes since 1986 may make Thailand a more attractive candidate for an active rice spot and futures market. The abolition of the Thai variable export tax on rice in 1986, the reduction in direct government rice procurement, and greater incentives for private storage (Konjing 1988) may make trading on a Thai market more attractive to foreign traders. Problems with grade and contract standardization would still need to be overcome. The recent changes in Thai rice policy may also create greater demand for risk-hedging and transaction cost-reducing mechanisms. Such conditions in the major trade center of southeast Asia may foster the development of a major world spot and futures market, similar to the roles that Chicago and Kansas City play in the international wheat trade. However, the policies of other major actors in the rice market, primarily the United States, may influence the development of such a central market. The proclivity of the U.S. to heavily subsidize its rice exports in order to relieve domestic surpluses has already affected Thai perceptions concerning the profitability of sustained future investments in rice production, exporting, and marketing infrastructure (Siamwalla 1989). The prospects of engaging in a export market-share war with the United States and its greater treasury resources has already prompted a reallocation of private and public investment toward other higher-valued agricultural exports. Such trends would be deleterious to world rice market stability if they hampered the development of forward markets and risk-transfer mechanisms to facilitate coordination in world rice trade.

Policy Implications and Alternative Mechanisms to Reduce World Market Instability

This analysis suggests a shift in the focus of policy work on instability in international grain markets away from government price stabilization policies per se, and toward other structural and organizational features of these markets that exacerbate instability.

A belief underlying many analyses of market performance is that much of the instability and lack of coordination within a market are due to government policies that interfere with the smooth functioning of private market forces. This analysis indicates that, while such policies may have negative side effects in some cases, there are other inherent features of the rice market, unrelated to government policy per se, that generate serious coordination problems. Efforts to stabilize the market by moving toward freer trade will not address the fundamental sources – mainly structural and chronic – of the instability in the rice market: (1) the geographic concentration of world production in an area of unstable weather; (2) very low consumption responsiveness to domestic prices, which would therefore prevent national trade sensitivity to world prices from rising much under free trade; (3) the fragmented nature of the rice market, characterized by numerous, poorly standardized varieties and qualities of limited substitutability in consumption; and (4) a persistently thin market where reliable price information is difficult and costly to obtain, and where the development of alternative coordination mechanisms to reduce trade uncertainties are thwarted due to many actors' tendency to sporadically and unpredictably float in and out of the market.

The institutional development of the world wheat trade contributes to the stability of this market relative to rice. Various grades and varieties of wheat are well standardized. Price information is readily available for both current and futures quotes. These prices appear to be fairly accurate indicators of prevailing supply and demand conditions in the short run. In the long run, endemic temporal coordination problems persist. Production decisions are made with incomplete knowledge of the aggregate impact of the simultaneous decisions of producers in other regions. There are no private institutions by which producers, arbitragers, consumers, and governments can assess the aggregate decisions being made by others and then modify their decisions through a series of interactions that would equilibrate expected and actual prices over the long run (Marion and Rhodes 1986). Governments have circumvented (but not solved) this problem by instituting support prices, consumer floor prices, variable levies, *etc.* These policies appear to be more a response to existing instability than the root cause of it. Unfortunately, successive moves to self-sufficiency and domestic market insulation may produce second-round effects on the organization of the market that further destabilize it in a vicious cycle.

In light of the interactive relationship between instability and government policy responses, perhaps more progress can be made toward the stabilization and coordination of world grain markets by addressing several key root causes. Given the geographic concentration of world rice production, an internationally-financed reserve with trigger prices at which to purchase and sell would moderate the extreme fluctuations that characterize the rice market. Such a scheme may largely pay for itself given a sufficiently wide price band to cover transport and storage costs, and given a pricing structure that anticipates shifts in medium- to long-term supply and demand conditions rather than basing the price band on past price trends. Such an international reserve could also be used to keep sporadic importers and exporters out of the market; by providing incentives for these countries to unload sporadic surpluses to the reserve, or purchase occasional imports from the reserve, potential dislocations to the world market could be avoided or at least reduced. The transactions costs involved would also be reduced since the reserve would represent a ready buyer and seller for sporadic market participants when a great deal of trade between major importers and exporters is already tied up in bilateral contracts.

In addition, efforts to standardize grades and varieties across national markets may reduce the fragmentation and transaction costs currently associated with rice trading. Lack of reliable price and trade information raises transaction costs, and is a symptom of weak spot markets that impede price discovery. In the U.S., these problems are exacerbated by the concentration of the rice marketing industry, which is composed of several large cooperatives/millers and multinationals that have strong incentives not to disseminate price information. Policy changes to promote greater entry and participation in grain marketing – both in the United States and globally – may facilitate the generation and dissemination of much needed price information in the rice market.

Policies designed to reduce the instability of international grain markets must confront the need for national production variations (which are inevitable for the foreseeable future) to be counteracted by some combination of adjustments in consumption, stockholdings, or trade. These three forms of adjustment connote three broad types of alternative policies.

Greater adjustment in consumption and/or stocks would result from movement toward free trade (reduction in trade barriers). This is the approach being stressed by U.S. proponents of the GATT. To the extent that large stockholdings are discouraged in developing countries (as they frequently are by international donors for reasons related to structural adjustment and debt reduction), production variations would increasingly be borne by consumption variations – politically risky in many developing countries. Proponents of freer trade must also consider the incidence of consumption adjustments to world price changes. It is widely acknowledged that growing affluence reduces consumers' short-run elasticity of grain demand in the form of both grain and livestock products (Blandford 1983). It is highly likely that a freer-trade solution would force low-income consumers in developing countries to bear the adjustment burden because they lack the purchasing power to sustain normal consumption levels during adverse fluctuations in national and international supply and demand. Policy analyses that focus on efficiency – usually in a static context – often ignore the potential dislocations and losses in productivity that result from political instability. The disruptions caused by food policy reforms in Jordan (1989), Zambia (1987), the Sudan (1985), and Tunisia (1983) demonstrate that trade liberalization is not always "low-cost". At the same time, it is clear that many resource-strapped governments in developing countries have been incapable of controlling food prices. Their attempts to do so have often resulted in a different but equally severe set of disruptions to market participants.

Greater adjustments in trade (in response to production shortfalls) characterize approaches such as the International Monetary Fund's "food financing facility" scheme. This approach provides countries in need with additional funds to purchase imports in response to domestic production shortfalls. The approach increases the transmission of production instability onto world market through trade. This would cause little effect on the world market if the country were small, but represents a potentially destabilizing policy if implemented in countries with large populations. In such a case, the IMF insurance approach would force consumption variations to take place in other, probably poor, countries that cannot receive IMF-type funds or cannot afford to insulate their consumers from world price shocks. This approach also cannot ensure that import deliveries arrive in time to alleviate supply shortfalls in many inland countries with poor transport networks. These countries would have to carry larger working stocks to last until imports could arrive.

Greater stock adjustment in response to production variations are characterized by most buffer stock schemes and the world wheat stockholding agreements considered during the 1970s. While this approach can stabilize domestic markets without transmitting production instability abroad, it is expensive and beyond the capabilities of many resource-strapped low-income countries.

Areas for Further Research

This analysis is largely short run in scope, in that it considers the effect of government insulation on year-to-year fluctuations in prices and quantities. A longer-term time frame may provide additional and potentially contradictory insights into this issue. For example, a transition to free trade could, over the long run, bring such non-marginal changes in the incidence of world production, that the whole world wheat or rice system could be organized quite differently than it is now. Japan and Korea, for instance, would be large importers of rice; the EC would be a much larger wheat import market; and wheat stocks in the United States would likely be lower than current levels, perhaps altering its role as the stabilizer of the world wheat market. The effect of such non-marginal changes was beyond the scope of this research but is clearly relevant for longer-run coordination and planning within an interdependent world grain system.

Such a proposed analysis would entail far more than deducing the structure of comparative advantage (and implications for stability) after accounting for current levels of national protection. Present patterns of comparative advantage are the product of past policy decisions (which directly influence factor productivity, demand, resource endowments, exchange rates, and other factors commonly taken as given by standard trade theory). Therefore, the particular distribution of world rice production based on efficiency criteria is policy- and time-dependent;

so, then, is the resulting level of instability in the world system. The appropriate pattern of investment in world grain production depends on how static or dynamic one wants to view comparative advantage.

A potentially more tractable extension of this research would be to make world price endogenous to the analysis of absorption and transmission effects. A shortcoming of this analysis is its partial equilibrium orientation; world prices and stock levels, consumption, and trade, aggregated across countries, were not simultaneously determined. Although this is not crucial for the majority of actors in the world wheat and rice markets (that are "small"), it certainly is important for the major players, whose transmission and absorption effects may be determined simultaneously with world price.

A third extension of this research pertains to the behavioral interactions between state trading agencies and the large international grain traders. The reliability and stability of prices "discovered" in prominent spot and futures markets are greatly influenced by the coordinating mechanisms of the large private traders. Information on these firms' operating practices is very scarce, and the limited information that is available may have researchers looking at the wrong questions, considering that the direction of inquiry is influenced by constraints on available data. There may be very high payoffs to additional descriptive research that further clarifies the operating procedures of the international grain traders, their responses to various types of government insulation policies, and their influence on the organization and stability of world grain markets.

APPENDICES

APPENDIX 1

THE VARIANCE OF ANNUAL PERCENTAGE CHANGE MEASURE OF INSTABILITY

Because each indicator of instability is sensitive to particular movements in a data set and insensitive to others, a brief description is given of the measure commonly used in this study to measure instability: the variance of annual percentage changes.

Computationally, the indicator is

$$\mathrm{VAR}\ \{ \sum_{t-1}^{n} [(\ln(x_t) - \ln(x_{t-1}))*100]\}$$

where x is the price or quantity variable in question. The indicator is dimensionless, and so can be used to compare data from different commodities.

The variance of annual percentage changes effectively detrends the data series in question. Thus, if the series increased by a constant percentage each year, then there would be a zero variance. The assumption behind this measure is that market participants can readily adjust to constant percentage changes each year, but they will have difficulties if period to period changes are highly variable (Dalziell 1985). This indicator may or may not accurately represent uncertainty (this is examined further in Part II). This is because there is no a priori information to assess whether market actors anticipate the trend or other variations in a particular data series.

Among the indicator's drawbacks are: (1) it gives excessive weight to outliers and hence to data errors; (2) the detrending process gives greater weight to the endpoints in the data series; ans (3) it assumes that agents know the long term trend in the data (Dalziell 1985).

APPENDIX 2

INSTRUMENTAL VARIABLE REGRESSION RESULTS FOR DEFLATED WORLD RICE PRICE IN DOMESTIC CURRENCY FOR USE IN EQUATION (8) FOR "LARGE COUNTRY" CASES

List of Instruments for Estimation of Deflated World Price in Domestic Currency (PW)

Country	Constant	PW_{t-1}	PW_{t-2}	PW_{t-3}	WORLD END_{t-1}	WORLD $PROD_{t-1}$
UNITED STATES	1529	.75	-.50	.09	25.2	-25.6
(1961-87)	(3.33)	(3.80)	(-2.12)	(0.43)	(1.74)	(-2.93)
	R^2 = .67					
	DW =1.81					
	F = 7.6					
THAILAND	21615	.99	-.74	.26	254.6	-336.9
(1961-87)	(2.58)	(4.82)	(-2.94)	(1.24)	(0.95)	(-2.14)
	R^2 = .70					
	DW = 2.05					
	F = 8.7					
CHINA	4.66	.82	-.54	.18	.21	-.06
(1961-86)	(0.78)	(3.44)	(-1.98)	(0.69)	(0.96)	(-0.45)
	R^2 = .49					
	DW =2.07					
	F = 3.3					

Parentheses contain t-statistics
For definition and derivation of variables, see Table 7.

OLS REGRESSION RESULTS FOR EQUATION (8): RICE

Dependent Variable: Per capita net rice exports (kilograms)

Country	United States (1963-87)	Thailand (1963-86)	China (1963-85	Bangladesh (1974-86)	Pakistan (1962-87)
Constant	.97	-29.4	-2.17	57.2	-37.8
	(0.29)	(-0.58)	(-1.21)	(0.61)	(-1.93)
$PROD_t$	.38	.36	.01	-.15	-.01
	(2.81)	(3.16)	(0.46)	(-0.66)	(-0.02)
$PROD_{t-1}$	.03	.17	.04	-.34	.42
	(0.23)	(1.45)	(1.57)	(-1.45)	(1.60)
PW_t	.008	-.002	.19	.0008	.005
	(3.50)	(-1.62)	(2.04)	(1.11)	(2.92)
PW_{t-1}	-.000	-.002	.05	.0006	.001
	(-.02)	(-1.52)	(0.51)	(0.90)	(0.56)
GNP_t	-9.03	4.01	1.87	7.88	20.2
	(-0.81)	(0.47)	(0.12)	(0.23)	(2.09)
R_t	0.34	-.83	.12	-.70	-.86
	(2.59)	(-0.62)	(2.12)	(-1.18)	(-1.81)
R_{t-1}	-0.40	2.08	-.17	.16	.38
	(-2.89)	(1.49)	(-2.38)	(0.27)	(0.93)
END_{t-1}	0.55	-.35	-.10	1.14	.05
	(2.42)	(-0.97)	(-2.51)	(1.76)	(0.09)
END_{t-2}	-0.02	-.30	-.02	-.54	-.25
	(-0.18)	(-0.92)	(-0.55)	(-1.16)	(-0.44)
PW^2_t	--	--	--	---	.0000003
					(-2.64)
PW^2_{t-1}	--	--	--	---	.0000001
					(-1.18)
R^2	.81	.88	.77	.81	.83
DW	1.96	1.90	2.31	2.66	1.78
F	7.05	11.43	4.88	1.45	6.03

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.

Dependent Variable: Per capita net rice exports (kilograms)

	Indonesia (1971-84)	EC-12 (1962-87)	Brazil (1964-86)	Soviet Union (1962-86)	Nigeria (1962-87)
Constant	-.24 (-1.41)	-1.78 (-1.58)	-4.98 (-0.45)	-.63 (-0.61)	6.56 (1.97)
$PROD_t$	.45 (2.68)	1.25 (6.82)	.07 (0.56)	-.09 (-0.19)	-1.04 (-3.20)
$PROD_{t-1}$	.02 (0.08)	-.27 (-1.60)	.02 (0.14)	.01 (0.01)	.61 (1.13)
PW_t	.0003 (0.22)	.008 (2.28)	.004 (0.36)	.002 (1.79)	.001 (0.33)
PW_{t-1}	-.001 (-0.99)	-.01 (-3.83)	.01 (1.04)	-.001 (-1.13)	.0003 (0.08)
GNP_t	-62.56 (-1.56)	-15.5 (-4.08)	-8.26 (-1.18)	na	-.11 (-0.93)
R_t	-.41 (-0.54)	.03 (0.66)	.08 (0.19)	-.29 (-2.55)	-.33 (-0.80)
R_{t-1}	0.52 (0.53)	0.06 (1.50)	-.20 (-0.50)	.02 (0.18)	.30 (0.86)
END_{t-1}	.60 (0.65)	1.06 (2.75)	.43 (1.62)	na	-.03 (-0.05)
END_{t-2}	-.04 (-0.07)	1.15 (2.64)	.20 (0.85)	na	.88 (1.51)
PW2t	--	-.000007 (-2.20)	--	----	
PW2t-1	--	.000009 (4.25)	--	----	
R^2	.93	.86	.59	.51	.77
DW	2.72	.92	1.51	1.53	2.01
F	6.21	8.13	1.89	2.51	5.15

Parentheses contain t-statistics. For variable definition and derivation, see Table 7. GNP for EC-12, approximated by unweighted average of GNPs of Germany, France, Italy, and the U.K.
na: data not available

Dependent Variable: Per capita net rice exports (kilograms)

Country	Japan (1962-87)	India (1962-87)	Korea (1962-86)	Burma (1962-86)	Senegal (1962-87)
Constant	-55.0	-8.86	19.62	19.08	-118.9
	(-2.75)	(-4.19)	(0.49)	(0.49)	(-3.36)
$PROD_t$	0.13	-.02	.28	.49	.23
	(1.77)	(-0.89)	(1.55)	(3.24)	(0.48)
$PROD_{t-1}$	.19	.02	-.30	.10	.25
	(1.34)	(0.97)	(-1.57)	(0.54)	(0.64)
PW_t	.00004	.02	.001	.04	-.03
	(0.02)	(0.75)	(0.45)	(0.30)	(-3.31)
PW_{t-1}	-.0001	.01	-.001	-.38	-.01
	(-0.07)	(1.15)	(-0.43)	(-0.50)	(-1.00)
GNP_t	23.05	52.6	-10.20	-30.76	4.24
	(3.50)	(3.55)	(-1.32)	(-2.37)	(2.70)
R_t	.12	.07	-2.34	-1.89	-.62
	(0.36)	(0.90)	(-1.77)	(-0.89)	(-0.83)
R_{t-1}	.11	-.12	-1.25	-.86	1.00
	(0.32)	(-1.34)	(-0.86)	(-0.45)	(1.25)
END_{t-1}	-.04	-.01	.51	na	na
	(-0.38)	(-0.21)	(1.50)		
END_{t-2}	.04	.11	.70	na	na
	(2.19)	(2.36)	(1.64)		
PW2t	--	--	--	--	.00002
					(4.78)
PW2t-1	--	--	--	--	.000005
					(1.41)
R^2	.85	.82	.73	.64	.77
DW	2.04	1.60	2.33	.96	2.01
F	9.99	7.84	4.45	4.41	9.15

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.
na: data not available

Dependent Variable: Per capita net rice exports (kilograms)						
Country	Iran (1962-84)	Iraq (1962-87)	Malaysia (1962-86)	Mideast (1962-86)	Sub-Saharan Africa (1962-87)	Vietnam (1962-86)
Constant	-3.47 (-1.61)	-43.77 (-5.33)	-85.50 (-4.43)	-10.03 (-2.68)	-2.41 (-0.48)	-149.4 (-5.21)
$PROD_t$	.24 (0.56)	.62 (2.23)	.34 (1.85)	.92 (2.24)	.19 (0.40)	.45 (2.98)
$PROD_{t-1}$	.33 (1.33)	.35 (1.32)	.18 (1.11)	.56 (2.14)	.25 (0.64)	.17 (1.22)
PW_t	.07 (3.01)	.08 (2.31)	.001 (0.07)	.008 (0.92)	.002 (2.18)	.09 (2.20)
PW_{t-1}	-.05 (-1.69)	.03 (1.01)	-.007 (-0.40)	-.02 (-2.77)	-.01 (-1.45)	.0006 (0.05)
GNP_t	-0.97 (-0.54)	na	na	-.50 (-2.86)	na	na
R_t	-.47 (-1.28)	-2.60 (-3.35)	1.10 (1.00)	-.11 (-0.57)	-.12 (-1.26)	-.18 (-0.18)
R_{t-1}	-.32 (-0.97)	.99 (1.14)	-0.62 (-0.48)	.06 (0.42)	-.01 (-0.10)	2.22 (2.36)
END_{t-1}	-.08 (-0.23)	1.29 (1.19)	-.06 (-0.22)	1.08 (2.30)	-1.16 (-1.72)	na
END_{t-2}	-.35 (-0.83)	.54 (0.47)	.07 (0.23)	-.87 (-1.84)	-0.85 (-1.05)	na
PW2t	--	-.00004 (-1.95)	--	-.000006 (-0.82)	--	-.00009 (-3.00)
PW2t-1	--	-.00003 (-1.53)	--	-.00002 (-2.61)	-.00001 (-0.37)	
R^2	.85	.92	.72	.97	.84	.74
DW	2.51	1.94	1.56	2.44	1.83	1.75
F	13.85	16.02	4.30	50.33	13.82	5.60

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.
GNP data for Mideast approximated by a time trend
na: data not available

APPENDIX 3

REGRESSION RESULTS OF DOMESTIC PRICE EQUATION (5b) FOR SEVEN MAJOR RICE TRADING COUNTRIES

Dependent Variable: Deflated domestic consumer rice price (PD)

Country	United States (1963-87)	Thailand (1962-86)	Bangladesh (1974-82)	Pakistan (1974-86)
Constant	159.4 (1.86)	3411 (1.44)	-7495 (-0.52)	2211 (1.42)
PW_t	.96 (9.21)	.20 (3.58)	.73 (2.01)	.64 (2.49)
$PROD_t$	-5.04 (1.27)	5.19 (0.61)	58.27 (0.68)	14.8 (0.56)
END_{t-1}	2.14 (0.35)	.33 (-1.62)	158.8 (0.60)	-169.5 (-1.99)
PW^2_t	--	--	--	-.00004 (-2.03)
R^2	.89	.41	.47	.68
DW	1.13	1.31	1.98	1.42
F	50.07	4.82	1.45	9.19

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.

Dependent Variable: Deflated domestic consumer rice price (PD)			
Country	Indonesia (1971-82)	Malaysia (1971-82)	Burma (1961-82)
Constant	3613 (3.50)	414.4 (1.94)	3334 (2.54)
PW_t	.05 (0.94)	.21 (3.20)	.53 (2.19)
$PROD_t$	-12.31 (-1.26)	6.68 (3.58)	-16.08 (-2.67)
END_{t-1}	-29.05 (-0.80)	-6.99 (-2.11)	na
PW^2_t	--	--	--
R^2	.68	.89	.39
DW	1.83	1.59	1.77
F	5.58	22.39	6.00

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.

APPENDIX 4

REGRESSION RESULTS OF NATIONAL CONSUMPTION EQUATION (2) FOR SEVEN MAJOR RICE TRADING COUNTRIES

Dependent Variable: National per capita consumption in kilograms (CON)

Country	United States (1963-86)	Thailand (1962-86)	Bangladesh (1974-82)	Pakistan (1974-86)
Constant	-1.27	174.9	-7495	2211
	(-0.72)	(3.83)	(-0.52)	(1.42)
PD_t	-.001	.004	.73	.64
	(-1.11)	(0.65)	(2.01)	(2.49)
GNP_t	22.4	-11.77	58.27	14.8
	(6.15)	(-1.57)	(0.68)	(0.56)
R^2	.72	.15	.47	.68
DW	1.38	1.70	1.98	1.42
F	26.14	1.83	1.45	9.19

Parentheses contain t-statistics
[#]Cochrane-Orcutt correction for serial correlation
For variable definition and derivation, see Table 7.

Dependent Variable: National per capita consumption (kilograms)			
Country	Indonesia (1971-82)	Malaysia[#] (1971-82)	Burma[#] (1961-82)
Constant	163.7 (4.72)	173.9 (5.18)	6.70 (0.12)
PD_t	-.08 (-2.69)	.003 (0.18)	-.01 (-1.81)
GNP_t	98.97 (6.63)	-3.40 (-3.78)	71.86 (3.85)
PD^2_t	.00002 (2.53)	--	--
R^2	.97	.86	.82
DW	2.39	2.02	1.92
F	82.23	16.13	28.00

Parentheses contain t-statistics
[#]Cochrane-Orcutt correction for serial correlation
For variable definition and derivation, see Table 7.

REGRESSION RESULTS OF NATIONAL ENDSTOCK DEMAND EQUATION (3b) FOR SEVEN MAJOR RICE TRADING COUNTRIES

Dependent variable: National per capita endstocks in kilograms (END)

Country	United States (1963-87)	Thailand (1962-86)	Bangladesh (1974-82)	Pakistan (1974-86)
Constant	.66	-26.63	10.91	17.45
	(0.13)	(-1.35)	(1.04)	(3.66)
PD_t	-.05	-.003	-.001	-.003
	(-2.96)	(-1.06)	(-1.35)	(-2.94)
PD_{t-1}	.05	.009	-.0001	.0001
	(2.73)	(3.16)	(-0.16)	(0.17)
R_t	-.13	.63	.17	.12
	(-0.64)	(0.71)	(0.52)	(0.71)
R_{t-1}	.28	-.65	.24	-.26
	(1.30)	(-0.77)	(0.66)	(-1.47)
END_{t-1}	.63	.50	-.52	-.18
	(3.29)	(3.13)	(-1.14)	(-0.62)
PD^2_t	.00004	--	--	--
	(2.78)			
PD^2_{t-1}	-.00003	--	--	--
	(-2.55)			
R^2	.86	.53	.57	.72
DW	1.89	1.76	2.61	2.22
F	12.48	4.22	0.79	8.17

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.

Dependent variable: National per capita endstocks in kilograms (END)		
Country	Indonesia (1971-82)	Malaysia (1971-82)
Constant	22.96	4.68
	(1.77)	(0.16)
PD_t	-.01	-.003
	(-1.83)	(-0.20)
PD_{t-1}	.001	.004
	(0.48)	(0.19)
R_t	.64	1.35
	(3.14)	(1.32)
R_{t-1}	.42	-.64
	(1.21)	(-0.64)
END_{t-1}	-.83	.36
	(-1.99)	(0.99)
PD^2_t	--	--
PD^2_{t-1}	--	--
R^2	.91	.48
DW	2.40	2.01
F	12.81	1.12

Parentheses contain t-statistics
For variable definition and derivation, see Table 7.

APPENDIX 5
DERIVATION OF EQUATION (3B) FROM EQUATIONS (3) AND (4)

Starting with:

(3) $END_t = b_o + b_1(PD_t) + b_2(PD^*_{t+1}) + b_3(R_t)$

and

(4) $PD^*_{t+1} = PD^*_t + \delta(PD_t - PD^*_t)$

arrange (3) in first-difference form:

(A1) $END_t - END_{t-1} = b_1(PD_t - PD_{t-1}) + b_2(PD^*_{t+1} - PD^*_t) + b_3(R_t - R_{t-1})$.

Next, subtract PD^*_t from both sides of equation (4) and substitute into equation (A1), giving

(A2) $END_t - END_{t-1} = b_1(PD_t - PD_{t-1}) + b_2[\delta(PDt - PD^*_t)] + b_3(R_t - R_{t-1})$.

Rearranging equation (3) and lagging all variables one year yields

(A3) $PD^*_t = [END_{t-1} - b_0 - b_1(PD_{t-1}) - b_3(R_{t-1})] / b_2$.

By substituting (A3) into (A2) and solving for END_t, one obtains the reduced-form equation (3b) used in the study:

(3b) $END_t = c_0 + c_1(PD_t) + c_2(PD_{t-1}) + c_3(R_t) + c_4(R_{t-1}) + c_5(END_{t-1})$

where the reduced-form c_i coefficients are defined in terms of structural parameters on page 57.

APPENDIX 6

FREE TRADE-IMPLIED TRANSMISSION COEFFICIENTS OF MAJOR RICE PRODUCING COUNTRIES UNDER ALTERNATIVE ESTIMATES OF IMPORT DEMAND ELASTICITIES

The purpose of this appendix is to show the method and calculations underlying the assertion made in the main body of this report that the free trade-implied transmission coefficients for several large-country rice traders (the United States, Thailand, and China) may be much larger than those estimated under insulation via equation (8). Calculations are performed assuming the most inelastic estimates of world rice demand elasticity found by this author in the literature (-0.08, in Siamwalla and Haykin 1983). Furthermore, I do not consider that the transition to free trade may increase the import demand elasticity facing exporter i. As shown in the main body, more elastic import demand figures would imply higher transmission coefficients.

As indicated by equation (11), the transmission effect under free trade is

(A11) $d(NX_t)/d(PROD_{it}) =$

$$1 - [d(CON_{it})/d(PW_t) + d(END_{it})/d(PW_t)] * d(PW_t)/d(PROD_{it})$$

where (as shown in equation 13),

(A13) $d(PW_t)/d(PROD_{it}) =$

$$1 / [\ d(CON_{it})/d(PW_t) + d(END_{it})/d(PW_t) + d(NM_{row,t})/d(PW_t)].$$

Using mean values of annual rice trade and deflated world rice price in $US, the import demand estimate of -0.08 implies that a one dollar increase in the world price would reduce world import demand by 2,554 metric tons. Using mean exchange rate and relative deflator information, the change in world import demand resulting from a 1 Thai bhat and 1 Chinese yuan change in the world price is 151 and 1,737 metric tons respectively. These values are used for the coefficient δ_1 in equation (13).

The procedure for estimating net export responsiveness to a change in local currency (coefficients a_1 plus c_1 in equation (12)) are described in Table 12. The same range of estimates are used for sensitivity analysis (*i.e.*, scenario (1) uses the national consumption and endstock responsiveness to domestic prices as estimated from equation (8); scenarios (2) and (3) raise these estimates by 25 and 50 percent).[23] These estimates are then changed from per capita to total volume terms. For the United States, the three alternative estimates for the increase in export supply resulting from a one dollar rise in the world rice price are 1,605, 2,006, and 2,408 metric tons). Similarly, a one bhat rise in world price is estimated to increase Thai exports by 0, 123, and 246 metric tons for the three alternative scenarios. For China, these figures are 1,666, 2,105, and 2,543 metric tons.

Using the figures presented above, the transmission effects can be calculated using equations (A11) and (A13). The transmission coefficients are presented for each country under each alternative scenario below (where enx is net export elasticity figures discussed above).

Country	Alternative Net Export Supply Elasticity Scenarios		
	(1)	(2)	(3)
United States	given enx = .33	given enx = .41	given enx = .50
	dNX/dPROD = .61	dNX/dPROD = .56	dNX/dPROD = .51
Thailand	given enx = .00	given enx = .50	given enx = 1.0
	dNX/dPROD = 1.0	dNX/dPROD = .55	dNX/dPROD = .38
China	given enx = .74	given enx = .95	given enx = 1.15
	dNX/dPROD = .51	dNX/dPROD = .45	dNX/dPROD = .40

As can be seen by comparing these estimates with those in Table 9, the free trade-implied transmission effects (given the range of net export and import elasticities examined) are in all cases larger than those measured under insulation, for each of the countries analyzed.

[23] Thailand's trade elasticity as estimated in equation (8) was negative. The range of net export elasticities used here (under the assumption of free trade) are zero, +.50, and +1.00.

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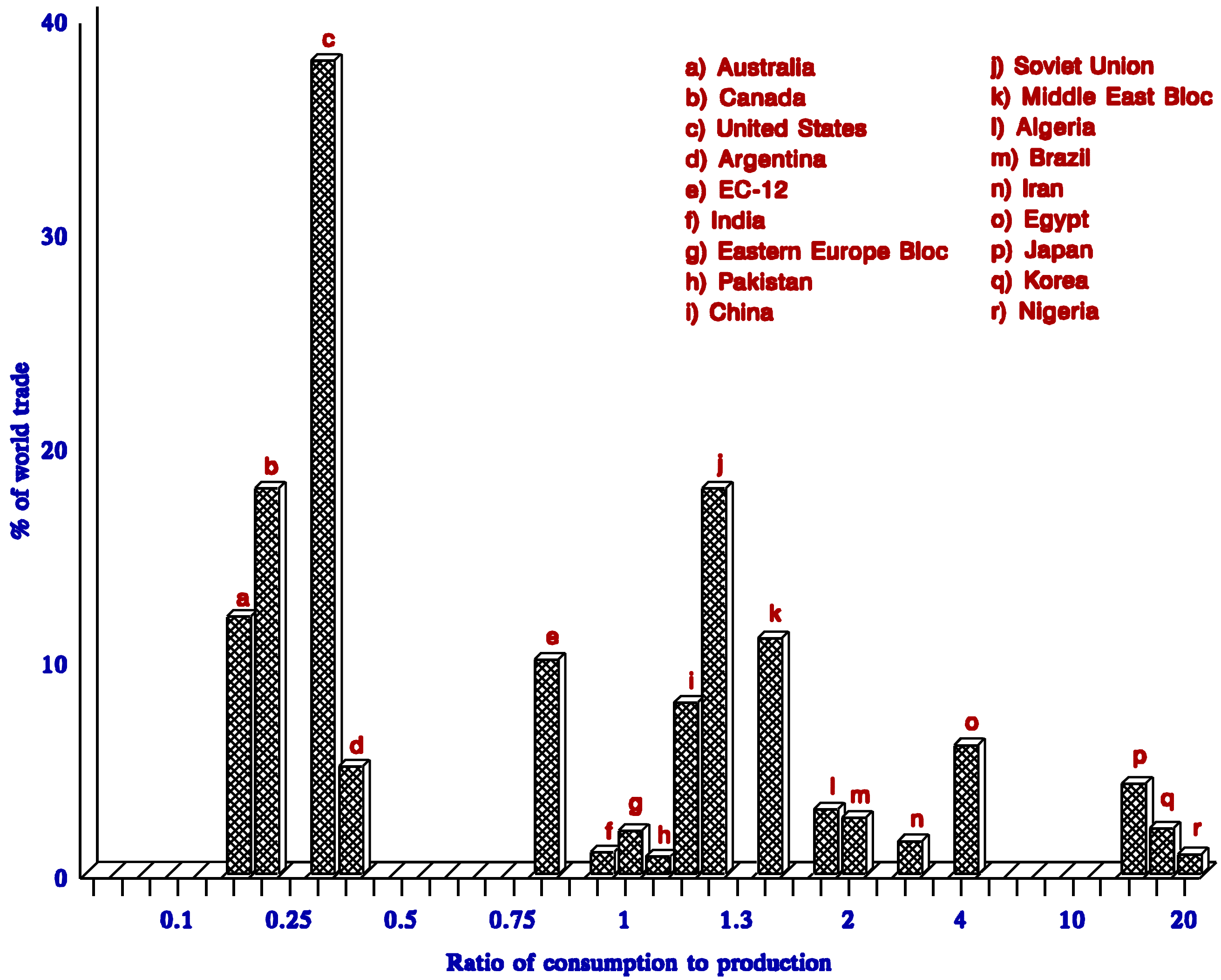
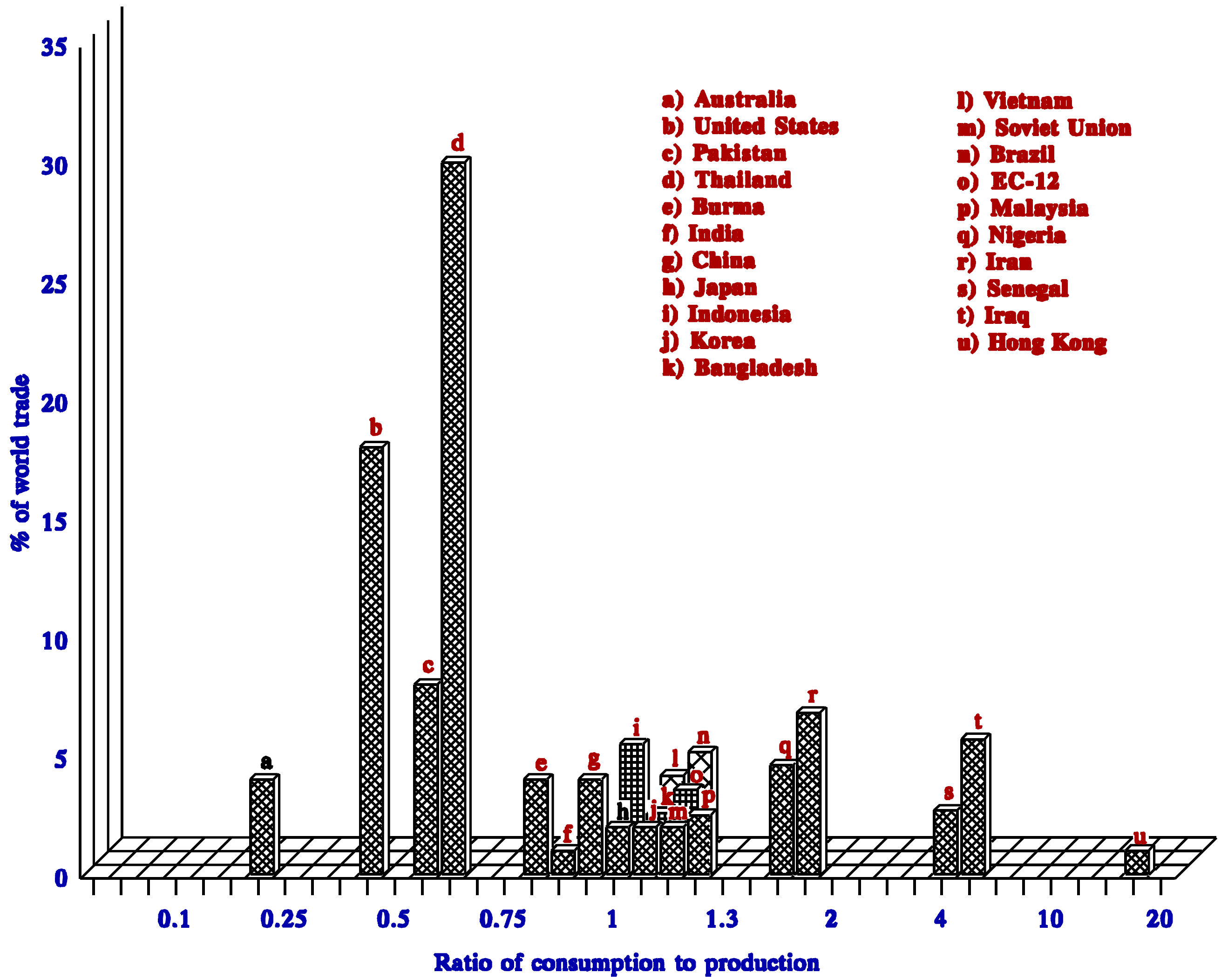


Source: USDA 1988.

Figure 4. Distribution of National Consumption to Production Ratios, Wheat: 1980-87



Source: USDA 1988.

Figure 5. Distribution of National Consumption to Production Ratios, Rice: 1980-87