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Impact of changes in ocean freight rates on United States rice exports

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IMPACT OF CHANGES IN OCEAN FREIGHT RATES ON
UNITED STATES RICE EXPORTS

By

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The direction and magnitude of the future world rice market is of vital consideration for the rice industries of both exporting and importing countries. Many studies have analyzed the international rice trade; however, there has been no published research that attempted to examine the effects of ocean freight rates on international rice trade.

The major objective of this study was to analyze the effects of ocean freight rates on the flows, supplies, demands, and prices of world rice shipments. A reactive programming model, within a spatial equilibrium analysis framework, was developed to obtain equilibrium level estimates of the variables mentioned above, to investigate the competitive position of major rice exporting countries, and to evaluate the effects of ocean freight rates in four different scenarios.

The 1990 calendar year was used as the base year for the analysis. Optimum shipping patterns of rice exports from the U.S. to world markets in 1990 was obtained to compare with models of the four different mentioned scenarios.

The results show that the competitive position of the U.S. rice industry would be reduced from its actual level in the world rice market under some trade conditions. That is, the U.S. rice industry would lose its export volumes under an optimum minimum cost trade market structure, while the position of U.S. competitors, such as China, Vietnam, and Thailand, would improve significantly. Also, the U.S. cargo preference policies did little to affect the world rice trade market structure.

Likewise, the results indicated that even when ocean freight rates have an important influence on the international rice trade, its effect is significantly different in each exporting country. China would be the most sensitive country to changes in ocean freight rates, not only in terms of its level of exports, but also in terms of the configuration of its rice trade pattern. Vietnam and Thailand rice exports and trade patterns also would respond significantly to changes in ocean freight rates, while the response of the U.S., in the same terms, could be considered relatively minor.

Changes in ocean freight rates are not recommended policies to enhance the competitive position of the U.S. rice industry. Other issues of policy, such as support to rice production and exports, and price policy, could be considered as more influential mechanisms to help the U.S. rice industry.

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CHAPTER I

INTRODUCTION

Rice is one of the world's most important cereals for human consumption. In the densely populated countries of Asia, especially Bangladesh, China, India, Indonesia, Iran, Japan, Korea, Pakistan, and Sri Lanka, rice is the most important staple food. As much as 80 percent of the daily caloric intake of people in these Asiatic countries is derived from rice (Luh, 1991).

Approximately 91 percent of the world's rice was also produced in Asia in 1989, and China alone harvested almost 35 percent of the global crop (Zhang, 1990b). However, despite the importance of rice as a staple food for a third of the world's population, the volume traded is relatively small (Chang and Luh, 1991).

Among the non-Asian rice producers the most important are Brazil and the United States (U.S.). Although the U.S. is tenth in world rice production, it is second to Thailand in world rice exports (U.S.D.A., 1991). As such, this grain is important for the U.S. in terms of its participation in the agricultural world trade.

Exporting is a major activity for the U.S. rice industry; however, as rice production has expanded in the U.S. and in other major producing countries, U.S. rice exports have diminished in the world market during recent years (U.S.D.A., 1992). Transportation cost is one of the reasons for this decline in U.S. rice exports. As it is shown in this study, transportation costs affect the competitive position of the U.S. rice industry in the international rice market.

Nature of the Problem

Over the years, numerous efforts have been made to analyze the international grain trade. Generally, it is believed that the level and magnitude of the trade of grain and other commodities are influenced by supply and demand. Some academicians argue, however, that international trade of commodities depends not only on demand and supply conditions, but also on so called "trade resistance" factors, which can reduce or nullify comparative advantages.

These trade-resistance factors include transportation costs, trade arrangements, tariffs and quotas, non-quantitative barriers, and political considerations. Analysis of these factors, along with demand and supply conditions could provide a better understanding of trade flow patterns of a particular commodity (Pinar, 1983).

Most studies concerning comparative analyses of "trade resistance" factors are primarily related to the study of effects of tariffs and other barriers on international trade, with remarkably little attention to transportation costs and freight rates profiles of individual countries[1], and their influence on international trade flows.

Ocean freight rates represent an important influence on the direction and type of traded products. Without the analysis of ocean freight rates, it is difficult to formulate intelligent trade policies, since the effects of tariffs and quotas can be confounded with those due to transportation. Total effective protection (tariffs, quotas, and transportation costs) may differ greatly from effective tariff and quota protection. Failure to include the influence of transportation costs in the calculations may seriously bias any result leading to policy action (Sampson and Yeats, 1978). The importance of transportation costs was pointed out by Mundell (1952), who found that transportation costs depend basically on the distances between countries, and if the distances were sufficiently large, the opportunity for trade gains would be eliminated.

To a certain extent, transportation costs are not controllable by policy makers, and are essentially administered issues. Obtaining an optimum flow among the exporting and importing countries can reduce transportation costs, because buyers and sellers are free to choose markets based on free market trade.

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[1] Ocean freight rates are defined as the costs of transferring commodities from an exporting country to an importing country. Ocean freight rate and ocean transportation costs are interchangeable terms in this study.

The review of literature reveals that no studies exist concerning the specific effect of ocean freight rate changes on the optimum flows of rice in international trade. Some studies have been conducted to evaluate the effect of trade liberalization on international rice trade (Chaitip, 1989, Angel and Rosson, 1991; Haley, 1991; Cramer et al., 1993), or the specific effect of some other "trade-resistance" factors (Yoon, 1988; Grant and Williams, 1990).

Objectives

1. To describe international trade flow of U.S. and major world exporting countries for rice.

2. To describe the volume of rice shipped and rates charged by different terms of shipping, distance, size of shipment, and flag of registry.

3. To estimate optimum distribution of rice, from U.S. and major competing countries, to importing countries, by maximizing market net prices.

4. To analyze the impact of changes in different levels of ocean freight rates on rice trade, equilibrium prices, and the potential for social and monetary gain from optimum flows.

Importance of This Study

Rice is an important commodity for the commercial balance of agricultural products of the U.S. Therefore, maintaining low ocean transportation costs for this product, will enable the U.S. to be more competitive in international markets by lowering prices of its exports.

This study offers information about how alternative levels of ocean freight rates affect rice exports, which will be useful for rice producers, carriers, and exporters in order for them to make appropriate decisions on rice production, transportation, and marketing. U.S. policy-makers can also use the information provided by this study to help develop suitable domestic programs and international trade policies to improve the U.S. competitive position in the world rice markets through production adjustments.

Review of Literature

Even though the influence of ocean transportation costs has been theoretically recognized by many academicians since the early 1950's (Wolfe, 1959; Moneta, 1959; Mundell, 1952), the empirical analysis of ocean transportation costs in international trade has been relatively limited. Main reasons probably are: (i) the presumption that transportation costs are very small or absent in international trade[2], and (ii) the lack of available data considering this variable.

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[2] For many years, zero transportation cost was one of the main assumptions of the modern theory of international trade (Chacholiodes, 1990).

Some empirical studies have evaluated the importance of ocean transportation costs as a main factor explaining the direction, magnitude, and benefits of trade flows, as well as the types of commodities exchanged internationally. For instance, Finger and Yeats (1976) demonstrated, for the U.S., that the effective protection due to international transportation costs were at least as high as that due to tariffs. Moreover, they showed that freight rates had increased at a faster pace than productivity during the 1960's, deserving special attention as a main non-tariff barrier in the international trade of commodities.

Sampson and Yeats (1977, 1978) also showed that trade barriers of international trade, imposed by transportation costs exceeded barriers due to tariffs for the Australian and the United Kingdom exports to the U.S. markets. They studied large groups of agricultural and non-agricultural commodities, concluding that nations may gain much more from trade expansion with policies aimed at reducing transportation barriers than from any other policy aimed at tariff reduction or elimination.

Geraci and Prewo (1976) used a cross-section of aggregate bilateral flows among 18 countries to estimate the elasticity of exports with respect to transportation costs. The authors found that the U.S. elasticity was -1.57; the highest elasticity was reported for Australia (-2.75), and the general average elasticity was -1.15. This study pointed out the existence of a significant impact of transportation costs over the direction and level of aggregate bilateral trade flows.

Studies considering transportation costs of specific commodities or groups of commodities also have emphasized the importance of this variable on international and interregional trade, as well as the major determinants of ocean freight rates. For example Davis (1968) developed a transportation model to determine a least-cost shipping pattern for U.S. grain exports. In the model, the author used the data developed on the cost per ton of shipping grain for three bulk grain vessel sizes from U.S. ports of origin to specific ports of destination. The resulting transportation model indicated that the law requiring 50 percent of government sponsored shipments to be carried on U.S. flag vessels[3] cost $200 million dollars per year in added transportation costs.

Likewise, Sharp and McDonald (1971) determined the impact of ocean vessel size on the transportation costs of U.S. exports of grain to seven foreign demand regions, and the associated impact of vessel size upon the US export grain facility requirements. They concluded that such a system must incorporate the utilization of large-scale, low-per-unit-cost vessels which would enable the U.S. to

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[3] The Cargo Preference Act is a U.S. law which mandates that a given percentage of the volume of commodities financed by the U.S. Government be shipped on U.S. flag vessels.

maintain a competitive position in the world trade of grains by minimizing transfer costs.

Harrer (1979) pointed out that shipping rates of agricultural commodities are basically a nonlinear decreasing function of distance. Other important variables explaining ocean freight rates are size of shipment, volume of trade, and seasonality. He also used a spatial equilibrium trade model to analyze effects of reductions in shipping rates on agricultural trade, concluding that while decreasing shipping rates for certain exporters does increase export receipts for the exporters, the percentage increases in export receipts are not large.

Binkley and Harrer (1981) concluded that the U.S. and Canada dominate the international trade of grains, based not only on production efficiencies, but also on transportation advantages. These transportation advantages come from their location with respect to the major markets and their relatively efficient ports. They also concluded that ship size and trade volume are of approximately equal importance as distance in determining ocean freight rates for grains, and that the role of transportation costs in trade analysis should not be ignored.

Joerger (1984) found that ocean transportation costs account for about 37 percent of the total transportation costs of the spring wheat marketing system. In general, decreases in U.S. ocean freight rates led to increases in the wheat prices of the different U.S. export ports analyzed. Likewise, when ocean freight rates increase, the U.S. export price decreases and the price in the importing country increases. It was estimated that importing countries absorbed about two-thirds of increases in ocean rates.

It was also reported by Joerger (1984) that the shipment patterns from the U.S. ports to foreign importing regions remained unchanged when ocean freight rates at the individual ports were altered. However, the volume shipped from each port was affected to a limited extent. In fact, generally a 10 percent change in ocean rates led to a one to two percent change in trade volume.

Pinar (1983), using a transportation model, analyzed the effects of ocean transportation costs and tariff barriers on the flows of international cotton shipments. This study showed that ocean transportation costs were important factors influencing the competitive position of the countries in the world market. A comparison of the optimum model with existing flows indicated that there would have been more than 25 million dollars of net savings associated with optimum flows. Among the exporting countries, the U.S. would have had the largest net gain, followed by Pakistan and Turkey. Of the importing countries, Taiwan, India, and Italy would have realized the largest net gain with optimum flow.

Yoon (1987) used a spatial equilibrium model to analyze the competitive position of the Southern U.S. rice industry in the international market. He found that the competitive position of the Southern U.S. rice industry was relatively low in the world rice market. In contrast, Thailand, China, and Burma would have relatively high competitive positions under the trade conditions evaluated in his analysis. Results also indicate that the U.S. cargo preference policies did little to affect the world rice trade market structure. Yoon stated that the industry should continue to encourage the creation of more rice export and domestic policies that reduce production and processing costs, in order to enhance the competitive position of the U.S. rice industry.

Zhang (1990a) showed that U.S. transportation costs for rice was primarily influenced by three factors: geographical distance, ship size, and ship flag. Specifically, as distance increased, shipping rates increased proportionally. Likewise, larger ships have lower unit cost per ton than smaller ships. Also, of three flags used in the models, shipping cost for U.S. flag ships was substantially higher than that for other ships. Liberian-flag ships were selected to be most frequently used for the shipments.

Hagen et al.(1991) suggested that ocean freight rates were quite volatile, and would have a very significant negative impact on California cotton export competitiveness.

In fact, they reported that 10 percent of increased ocean freight rates had an average effect of a 6.9 percent decrease in cotton sales. The median percent reported was 2.0. They also found that cotton exporters believe their industry would best be served with the deregulation of ocean freight rates, and the elimination of shipping surchargers.

Finally, Goodwin (1992) emphasized the importance of transportation costs when he evaluated the law of one price (LOP)[4], for prices in five international wheat markets. Under this law, efficient arbitrage and trade activities should ensure that individual wheat prices in spatially separated markets are linked through a common long-run equilibrium. His results indicated that the LOP failed as a long-run equilibrium relationship when transportation costs were ignored. However, when wheat prices were adjusted for freight rates, the LOP was fully supported.

Organization of Following Chapters

The rest of the dissertation is organized into the four following chapters. The second chapter presents background information related to the world rice situation in terms of consumption, production and trade, as well as the analysis of different characteristics of rice terms of shipping.

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[4] The law of one price (LOP), an important component of international trade models, asserts that efficient trade and arbitrage activities will ensure that prices in spatially separated markets, once adjusted for exchange rates and transportation costs, will be equalized.

Chapter three develops the theoretical framework concerning the development of spatial equilibrium analysis for international trade. The reactive programming model is presented, along with its major assumptions, and its underlying implications. This chapter also presents data requirements and a detailed explanation of the development of information used to run the model.

Chapter four analyzes the results generated by the spatial equilibrium model to satisfy objectives 3 and 4. In a first scenario, the optimum volumes of trade, world trade prices, and international flow patterns are compared with the actual trade data of 1990. This chapter also relates to the sensitivity analysis of the optimum model, in which three additional scenarios are evaluated: (i) the effects of the cargo preference policies, (ii) the effects of individual changes in ocean freight rates of four major rice exporting countries, and (iii) the effects of simultaneous changes in all ocean freight rates.

Summary, conclusions, limitations, and suggested areas for further research are presented in the fifth chapter.

CHAPTER II

BACKGROUND INFORMATION

The purpose of this chapter is to provide background information for the analysis of transportation costs. The information includes the situation of the rice international market, in terms of consumption, production, imports, and exports, with special emphasis on the U.S. rice industry. Types of vessels, types of flag, terms of shipment, and U.S. cargo preference policies are also provided in order to better examine transportation costs of rice in world markets.

U.S. Rice Consumption, Production, and Trade

Rice is one of the major food grains in the world. Over a third of the world's population, predominantly in Asia, depends on rice as a primary dietary staple. Per capita annual consumption of rice in Asia is around 100 kilograms (Kg.), compared with three to four Kg. per person in the Western world (Ito et al., 1989; Huang et al., 1991). Even though the per capita consumption of rice has been decreasing in recent years throughout some countries in Asia, rice has been increasing in importance in terms of its total consumption (Table 1). It has been estimated that by the year 2000, rice will be the chief source of energy for

Table 1. World Consumption of Milled Rice for Selected Countries and Regions, Selected Periods

Country	1965-69	1970-74	1975-79	1980-84	1985-90
	.................(1,000,000 M.T.)...................				
China	63.53	74.44	86.54	104.71	122.39
India	36.53	42.50	46.56	54.16	63.76
Indonesia	11.46	14.85	18.01	23.53	27.45
Bangladesh	11.30	11.21	12.91	14.42	16.11
Japan	11.36	11.58	10.32	10.38	9.80
Thailand	6.03	7.73	7.79	8.10	8.47
Burma	4.18	4.67	5.52	8.53	6.93
South Korea	3.90	4.51	5.62	5.44	5.61
Pakistan	1.58	1.85	2.07	2.19	2.11
U.S.	1.20	1.36	1.55	2.02	2.51
E.C.12	1.08	1.17	1.36	1.38	1.52
World	186.07	218.39	245.95	292.32	325.63
	.... (%).......................				
China	34.1	34.1	35.2	35.8	37.6
India	19.6	19.5	18.9	18.5	19.6
Indonesia	6.2	6.8	7.3	8.0	8.4
Bangladesh	6.1	5.1	5.2	4.9	4.9
Japan	6.1	5.3	4.2	3.6	3.0
Thailand	3.2	3.5	3.2	2.8	2.6
Burma	2.2	2.1	2.2	2.9	2.1
South Korea	2.1	2.1	2.3	1.9	1.7
Pakistan	0.9	0.8	0.8	0.8	0.6
U.S.	0.6	0.6	0.6	0.7	0.8
E.C.12	0.5	0.5	0.6	0.5	0.5

Source: Zhang, 1990b; U.S.D.A., 1991.

about 40 percent of the World's people, thereby surpassing wheat (Chang and Luh, 1991).

Rice is also an important crop, second only to wheat, in terms of total cereal production. In 1989, rice and wheat together occupied over one-quarter of the arable land in the world (Wisner and Wang, 1990). In recent years Thailand, Bangladesh, China, India, and Indonesia have been the largest world rice producers, accounting for about 75 percent of total world production. Brazil and the U.S. are the largest non-Asian rice-producing areas, and account for 2.1, and 1.4 percent, respectively, of the total world rice production (Table 2).

It is also important to note that the five largest rice producers (China, India, Indonesia, Bangladesh and Thailand) are also among the largest consumers, accounting for more than 70 percent of all rice consumption (Table 1). Other major rice-consuming countries include Vietnam, Japan, Burma, and Brazil. Because such a large percentage of rice is consumed and produced in the same countries, only a small amount of the total world rice production enters international trade. Thus, the world market in rice is characterized to be relatively small. In 1989, for example, only about 15 million tons, equivalent to less than five percent of the total rice world production, was traded, as compared to 18.6 percent for wheat and 12 per cent for coarse grain (Wisner and Wang, 1990).

Table 2. World Rough Rice Production Statistics for Selected Countries and Regions, 1965-1991

Year	1965-69	1970-74	1975-79	1980-84	1985-91
	................(1,000,000 M.T.)................				
Bangladesh	16.1	16.5	18.5	20.7	24.3
Brazil	6.6	6.3	7.7	8.8	10.1
China	96.4	119.9	135.5	161.6	175.5
India	53.6	53.6	62.5	71.9	99.9
Indonesia	15.0	20.6	24.2	33.9	42.0
Pakistan	2.6	3.5	4.4	5.0	4.8
Thailand	12.3	13.7	15.5	18.3	19.4
South Korea	4.7	5.1	5.8	7.7	7.9
Japan	17.7	15.6	16.0	13.2	13.5
Australia	0.2	0.3	0.5	0.7	0.8
U.S.	4.1	4.2	5.5	6.5	6.6
E.C.12	1.6	1.8	1.8	1.8	2.1
Others	44.7	61.4	71.5	81.5	77.6
Total	275.6	322.5	369.4	431.6	484.5
	....................(%)......................				
Bangladesh	5.8	5.1	5.0	4.8	5.0
Brazil	2.4	2.0	2.1	2.0	2.1
China	35.0	37.2	36.7	37.4	36.2
India	19.5	16.6	16.9	16.7	20.6
Indonesia	5.4	6.4	6.6	7.9	8.7
Pakistan	2.6	1.1	1.2	1.2	1.0
Thailand	0.9	4.2	4.2	4.2	4.0
South Korea	1.7	1.6	1.6	1.8	1.6
Japan	6.4	4.8	4.3	3.1	2.8
Australia	0.1	0.1	0.1	0.2	0.2
U.S.	1.5	1.3	1.5	1.5	1.4
E.C.12	0.6	0.6	0.5	0.4	0.4
Others	18.1	19.0	19.3	18.8	16.0
Total	100.0	100.0	100.0	100.0	100.0

Source: I.R.R.I., 1987; U.S.D.A., 1992.

The U.S., tenth in the world in rice production, is second, after Thailand, in world rice exports. Between 1985 and 1991 the U.S. exports averaged more than 2.3 million metric tons, equivalent to 36 percent of its total rice production, and to 18.8 percent of the total world rice exports (Table 3). For the same years, Thailand led in rice exports with almost 4.5 million M.T., which accounted for 35.6 percent of the total world rice exported. Other major rice exporters were Pakistan, China, Vietnam, and the E.C. (basically Italy and Spain).

The U.S. share of world rice exports has decreased in recent years, going from an average of 22.6 percent of the total rice exported during 1975-1979, to an average of 18.8 percent in 1985-1991. U.S. rice export destinations are relatively diversified, going to the Middle East, Africa, and other countries like Canada, Mexico, and Brazil (Table 4). For instance, the three largest importers of the U.S. rice in 1991 were Saudi Arabia (11.1 percent), Brazil (8.2 percent), and Canada (6.8 percent).

It should also be mentioned that the "small market" problem of rice world trade is compounded by the fact that 45 percent of Asian production is not irrigated and relies completely on the Asian monsoons[5] (Cramer et al., 1991).

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[5] The Asiatic monsoon is a wind system that influences the climatic region and reverses direction seasonally in India and Southern Asia. It is commonly marked by heavy rains (Webster's New International Dictionary of English, 1986).

Table 3. World Milled Rice Exports Statistics for Selected Countries and Regions, 1965-1991

Year	1965-69	1970-74	1975-79	1980-84	1985-91
	....................1,000 M.T.				
Burma	779.2	462.8	505.0	721.4	419.0
China	1544.2	2513.6	1544.8	1064.2	717.6
India	5.6	23.4	118.6	489.0	364.3
Pakistan	310.8	449.6	809.4	1090.4	1003.0
Thailand	1397.2	1332.2	2042.4	3539.8	4499.3
Vietnam	10.7	1.4	9.2	60.6	655.1
Australia	86.4	140.4	233.0	397.0	402.3
U.S.	1713.0	1722.6	2222.8	2650.6	2372.9
E.C.12	319.2	520.6	745.6	972.2	1042.3
<u>Total</u>	7962.0	9066.4	9812.2	12480.6	12640.7
	......................(%)......................				
Burma	9.8	5.1	5.1	5.8	3.3
China	19.4	27.7	15.7	8.5	5.7
India	0.0	0.1	0.2	3.9	2.9
Pakistan	3.9	5.0	8.2	8.7	7.9
Thailand	17.5	14.7	20.8	28.4	35.6
Vietnam	0.1	0.0	0.1	0.5	5.2
Australia	1.0	1.5	2.4	3.2	3.2
U.S.	21.5	19.0	22.6	21.2	18.8
E.C.12	4.0	5.7	7.6	7.8	8.2

Source: I.R.R.I., 1987; U.S.D.A., 1992.

Table 4. Top Ten U.S. Rice Export Markets, Selected Years

	1991		1990		1989	
Rank	Country	% of Total Exports[1]	Country	% of Total Exports[1]	Country	% of Total Exports[1]
		(%)		(%)		(%)
1	Saudi Arabia	11.1	Iraq	12.1	Iraq	18.8
2	Brazil	8.2	Saudi Arabia	9.5	Saudi Arabia	8.7
3	Canada	6.8	Mexico	7.5	Belgium-Luxemb.	6.3
4	Haiti	6.1	Peru	6.3	Turkey	4.4
5	Turkey	5.7	Canada	5.4	Spain	4.4
6	South Africa	4.9	Turkey	5.3	Mexico	3.8
7	Switzerland	4.1	Haiti	4.3	Canada	3.5
8	Liberia	3.9	South Africa	4.1	Switzerland	3.2
9	Netherlands	3.5	Belgium-Luxemb.	4.1	Haiti	3.1
10	Mexico	3.5	Jordan	3.7	South Africa	3.1
	Sub-total	57.8		62.4		58.1

[1] Percent calculated as proportion of total value of U.S. rice exports.

Source: U.S.D.A., 1992.

The resulting variability in production contributes to substantial instability in world rice prices. Furthermore, in order to stabilize domestic prices and prevent rice shortages, rice-consuming countries have many trade restrictions and domestic policies that distort trade. Over half the world rice is transacted between government agencies rather than on a commercial basis, amounting to 7.2 million metric tons in 1989 (Childs and Lin, 1989), implying that rice markets are strongly influenced by political as well as economic factors.

Rice Transportation Vessels

Rice is exported on three general types of ships: cargo liners, tanker vessels and tramp steamers. Cargo liners are ships traveling a fixed route according to a predetermined schedule and rates. Liner owners usually sell space on a vessel by the freight-ton to a number of different shippers at predetermined rates. Two types of rate schedules are used by liners: class tariffs and commodity tariffs. Under a class tariff, products are carried at a rate determined for each specific class of service. Under a commodity tariff, each good carried is given a separate rate (Zhang, 1990a).

Cargo liner competition is usually limited by arrangements covering freight rates charged. The largest and most prominent liner companies are increasingly engaged in cargo transportation between inland locations in which ships serve only as links in an overall transport system.

Shipments of rice on liners have been significant in past years. During the 1980's, cargo liners accounted for 22.2 percent to 45 percent of U.S. rice exports (U.S. Department of Commerce, 1986). The U.S. liner fleet has maintained a relatively large share of U.S. rice export trade despite effective foreign-flag competition. This result is partly due to successful productivity improvements by major operators and to federal subsidies that have helped to maintain U.S. liner fleet's cargo share position (U.S. Congress, 1983).

Tanker vessels usually handle large tonnages of single commodities by operating one or a fleet of ships especially designed for one cargo. Size and capacity range from the ultra large crude carriers of over half a million metric tons to the small coastal tanker. Tankers can, therefore, take advantage of economies of size. However, the advantage of tankers is minimized and may even be offset by too much turnaround time in loading and discharging. Most ports importing rice have an insufficient unloading capacity to take advantage of tankers (Zhang, 1990a).

For U.S. rice exports, tankers are the least important vessels used among all the types of ships. The largest amount of rice export carried by tankers in the 1980's was four percent. The U.S. flag tanker fleet is small and is attracting little business in the severely over-tonnaged international markets. Due to the lack of opportunities in the world market, much of the U.S. subsidized fleet has taken advantage of a provision allowing tankers to enter the domestic trade (Wood and Johnson, 1989).

The last type of ship, tramp steamers, are ocean carriers employed worldwide, but not over a fixed trade route, or under a regular scheduled service. Bulk agricultural commodities, such as grains and fertilizers, are their most important cargoes. Rates are determined by negotiations between the shipper and the carrier, with a shipbroker usually serving as an intermediary. The agreement is usually called a charter party[6]. Tramp owners charter their vessel to shippers either on a voyage basis, in which case the contract is usually for one voyage and a particular commodity, or on a time basis where the contract is for a specific time period.

Tramps are indeed one of the most important transportation means for carrying rice exports from the U.S. to international markets. Tramp vessels accounted for 72 percent of rice exports from the U.S. Southern region in 1981, and 77.7 percent during 1986 (U.S. Department of Commerce, 1986).

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[6] A charter is a contracted arrangement based on the mutual commercial interests of a charterer, who requires a vessel to meet his transportation needs, and a owner who places his vessel at the disposal of the charterer.

Flag of Registry

All vessels are registered in a nation and are owned by an individual or company incorporated in the nation of registry. All vessels are under the jurisdiction of the maritime authority of the nation of registry and are bound by its laws and regulations. All shipping firms operating under a given registry face similar cost structures. Cost inequalities among vessels with different flags are basically the result of their respective maritime policies which apply equally to all companies of a given flag (Wood and Johnson, 1989).

The most common policies associated with flag of registry are policies regarding the place where shipments can be purchased, who may work on these ships, and how these ships are taxed and regulated. Most countries involved in international sea transport apply similar policies for the first two. However, differences exist among countries concerning taxation and regulation.

Some countries known as "convenience" countries, allow easy registration with minimum taxes and regulations, and they are "open" to accept easily the registration of shipowners regardless a nationality. Major countries that currently permit "open" registries are Liberia, Panama, Cyprus, Singapore, and Somalia.

Open registry has been most attractive to U.S. shipowners because U.S. maritime policies prevent the U.S.

shipping industry from being competitive in international shipping. In fact, U.S. flag ship costs are substantially higher than foreign-flag costs for both ship acquisition and operation, due to higher construction cost, as well as operational costs associated with higher wage rates of the crew, costs of storage and supplies, repairs, and insurance (Zhang, 1990a).

For instance, unlike shipowners in other maritime countries, those in the U.S. are, with a few exceptions, required to purchase their capital equipment within the U.S. This requirement raises costs tremendously. Similarly, with minor exceptions, U.S. shipowners have employed only U.S. citizens as seamen, and the wages of U.S. seamen are by far the highest in the world. Thus, the only way the U.S. fleet continues to survive is through government subsidization.

Government subsidies are basically of two forms: operating differential subsidies, and construction operational subsidies. These subsidies represent distortions of competition in international shipping markets and the cost of these subsidies to U.S. taxpayers is becoming increasingly large. In addition to direct subsidies, the U.S. government provides indirect protection for its shipping industry. For instance, through cabotage laws, foreign flagships are prohibited from carrying domestic cargoes. Through cargo preference laws, certain cargoes are mandated to move on U.S. flagships. The cargo preference laws are discussed in more detail in the next section.

The number of shipments, total tonnage, and average rate charged per M.T. for different flagships reported in a sample of the main world ports surveyed by the Chartering Annual, is presented in Table 5. Note that the rates charged for the shipping of rice generally range between U.S.$ 25 and U.S.$ 55 per M.T. for foreign flagships, and that the rates for U.S. flagships are notably higher than this range. Shipments on U.S. flagships comprised 43.9 percent of the total number of shipments in the present sample. The higher percentage of U.S. flagship found is probably due to better reporting of U.S. shipments, since Maritime Research Incorporated is physically located in the U.S., and/or the fact that cargo preference laws would have more impact on shipments of agricultural commodities than on shipments of waterborne commerce in general (Harrer, 1979). Shipments on open registry flagships, of which Cyprus, Greece, Jamaica, and Panama are the most important in terms of the number of shipments, comprised 25.3 percent of the total number of rice shipments reported.

The U.S. Cargo Preference Policies

The practice of restricting certain cargoes to U.S. flags began with the 1904 law requiring that all military cargoes be moved in U.S. bottoms. In 1948, the U.S.

Table 5. Number of Shipments, Total Tonnage, and Mean Rate Charged per M.T., for Rice Cargoes on the Major Flagships of the World, 1990-1991

Flag of Registry	Percent of Shipments	Total Tonn. Shipped	Average Rate Charged
	(%)	(M.T.)	($/M.T.)
U.S.	43.9	324,868	83.9
Cyprus	9.3	68,499	36.8
Greece	8.9	66,185	44.5
Jamaica	3.4	25,470	25.4
Panama	3.7	27,720	62.7
Liberia	2.2	15,400	54.8
Mauritius	5.0	36,948	51.4
Steamer	10.1	74,900	43.5
Others	13.5	99,891	50.7
Total	100.0	739,881	

Source: Source: Maritime Research Inc., Chartering Annual 1990 and Chartering Annual 1991.

Congress passed the first cargo preference provision for aid cargoes. This practice continued on an ad hoc or annual basis until 1954, when Public Law 664 made it permanent. This Law required that 50 percent of all United States Government-sponsored shipments be moved on U.S. flagships (Harrer, 1979).

The U.S. Food Security Act of 1985 changed the cargo preferences law in the sense that it mandated a gradual increase in the share of particular exports, mostly food aid, that must be shipped on U.S. flag vessels (Tweeten, 1992). The cargo preference requirements do not apply to certain commercial agricultural export programs such as export credit, credit guarantees, blended credit, and export enhancement programs (Glaser, 1986). In 1986 and 1987, the law required that 60 percent and 70 percent food aid exports be shipped on U.S. flag vessels, respectively. And, in 1988 and thereafter, at least 75 percent of such exports must have been shipped on U.S. flag vessels. The U.S. Food and Agricultural Act of 1990 confirmed the 75 percent U.S. flag shipping requirement (U.S. Congress, 1990).

Cargo preference laws are applied in most of the countries[7], and have served as a type of quota in that they restrict foreign competition in rice and other commodities

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[7] Either unilaterally or multilaterally, more than 60 percent of countries reporting assistance to their merchant fleet (U.S. Department of Transportation, 1988) had cargo preferences policies in support of their own flag vessels.

markets, reduce the supply of shipping services, and thus maintain rates at levels high enough to allow flag operators to stay in business. The importance of these cargo preference policies is significant for the U.S. maritime industry. It has been documented, for example, that revenue from the carriage of preference cargoes totaled more than one billion dollars for all U.S. operators during 1980. Liner operators received 16 percent of all revenues under the programs (U.S. Congress, 1983)

Size of Shipment

The average shipment size of rice for the three main origin regions, for years 1990-1991, is presented in Table 6. Notice that there are marked differences in terms of average shipment size between the rice shipments originated in the main rice exporting areas (Thailand, Pakistan, and the U.S.), and other shipments. There is also a difference between the average shipment size of U.S. flag and Non-U.S. flag vessels originating in the United States. The average shipment size of U.S. flag vessels was 10,479.6 metric tons of rice, whereas it was just 6,863.8 metric tons for Non-U.S. flag vessels.

Similarly, it can be seen in Table 6 that the average rate per M.T.(adjusted by distance), charged by vessels whose origin point is located in the U.S. is notably higher than those charged by vessels that depart from

Table 6. Mean Shipment Size of Rice for Major Origin Area, 1990-1991

Origin Area	Average Shipment Size	Average Rate Shipments	Number of Shipments
	(M.T.)	($/M.T./d)[1]	(No.)
Thailand	9738.0	0.97	10
Pakistan	9528.8	0.85	8
U.S.	8671.7	2.65	62
U.S. Flag	10479.6	3.39	31
Non-U.S. Flag	6863.8	1.92	31
Others	5367.0	1.80	10
Average	8499.2	1.49	

[1] ($/M.T./d) means dollars per M.T. adjusted by distance (100 maritime miles).

Source: Maritime Research Inc., Chartering Annual 1990 and Chartering Annual 1991.

Thailand, Pakistan, and other places. The freight rates charged for rice cargoes from Pakistan and Thailand are particularly low.

The differences between the mean rate of U.S. flag vessels and Non-U.S. flag vessels are also important (3.39 versus 1.92 dollars per M.T. per 100 miles), and help to explain the higher ocean freight rates when U.S. cargo preference policies are applied.

Terms of Shipping

One of the most important specifications in a ship charter is the term of shipping. It is concerned with the responsibilities for loading and unloading a ship's cargo. These responsibilities, in general, are covered under four types of terms: free-in-and-out, free discharge, gross terms, and berth terms. When free-in-and-out terms are specified in a ship charter, the charterer[8] is responsible for the loading and the unloading of the cargo. If free discharge is specified, the charterer pays for the unloading of the ship, and the owner of the ship is responsible for the loading, whereas in the gross terms case, the shipowner is responsible for both, the loading and the unloading of the ship. Berth terms means that the contract of carriage

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[8] The charterer is a person or company who hires a ship from a shipowner for a period of time or who reserves the entire cargo space of a ship for the carriage of goods from a port or ports of loading to a port or ports of discharge.

is subject to the customs and conditions of the ports of loading and discharging (U.S.D.A., 1988).

Loading and unloading costs are usually included in the shipping rate charged per unit of weight, so these rates will vary according to the terms under which a cargo is shipped. Then, a higher rate per M.T. should be charged when the owner is responsible for loading and unloading costs and a corresponding lower rate should be charged when the charterer is responsible for taking care of all or part of these costs.

Table 7 reports the number of shipments, average rate charged per metric ton, and average size of shipment by type of shipment terms. Note that most rice was shipped under free-in-and out terms, and free discharge terms. Some cargoes were sent under berth terms arrangements. Four shipments, out of the total sample of 89 observations, were sent under liner terms, which is a specific case of gross term agreement, in which loading and unloading expenses are paid by the shipowner (U.S.D.A., 1988).

It appears that, in general, shippers from the U.S. prefer to be responsible just for the unloading of the rice cargo, leaving the responsibility of loading to the shipowners. For Non-U.S. shippers the trend is the opposite; they would rather assume the responsibility for loading and unloading a ship than incur an increase in shipping rates by letting shipowners assume all or part of

Table 7. Number of Shipments, Mean Rate, and Mean Size of Shipments by Terms of Shipment, 1990-1991

Terms of Shipment	Percent of Total Shipments	U.S. Shipments with ...	Average Shipment Size	Average Rate
	(%)	(%)	(M.T.)	($/M.T./d)[1]
Free-in-and-out	36.7	21.0	9592.1	0.92
Free discharge	43.3	100.0[2]	6894.2	3.11
Berth terms	15.6	100.0[2]	10238.2	2.26
Liner terms	4.5	25.0	5192.5	2.46

[1] ($/M.T./d) means dollars per M.T., adjusted by distance (100 maritime miles).

[2] 56.4 percent of shipments with free discharge terms used U.S. flag. This percentage was 42.8 for the case of berth terms agreement.

Source: Maritime Research Inc., Chartering Annual 1990 and Chartering Annual 1991.

this responsibility. U.S. flag vessels were used in 56.4 percent of U.S. rice shipments with free discharge terms, Similarly, 42.8 percent of shipments with berth terms used U.S. flag vessels to move rice cargoes from the U.S. Thus, this situation explains, at least partly, the fact that the U.S. shipments have the greatest ocean freight rates per weight and unit of distance (U.S.$ 3.11 per M.T. per 100 miles in free discharge terms, and U.S.$ 2.26 in berth terms, versus U.S.$ 0.92 per M.T. per 100 miles in free-in-and-out terms).

It is important to note in Table 7 that berth term agreements are also used for rice cargoes departing from the United States. Probably, in these cases, loading is the responsibility of the shipowner (explaining also the relatively high freight rate), and discharging is subject to the customs and conditions of the destination port.

Although not reported in this sample, a high proportion of the shipments moved under gross terms usually go to underdeveloped regions in Africa and Asia. When cargo handling facilities are poorly developed, as they are in most developing countries, rice shippers appear to be more likely to allow shipowners to assume the responsibility for loading and unloading the ship (Harrer, 1979).

Besides terms of shipping, there may be other factors which potentially contribute to the additional unit freight rates found for U.S. shipments. Flag of registry and Cargo preference policies are good examples.

Seasonality

The effects of seasonality are relatively stronger on the shipping of agricultural commodities than on other products, because most agricultural commodities traded in international markets are seasonally produced in temperate climates, primarily in the northen hemisphere. Adding to this characteristic, the fact that the suitability of the sea for shipping is influenced by the season of the year, one might expect that these factors influence the volumes of rice traded, as well as the transportation rates charged.

The number of shipments, total tonnage, and average rates charged per M.T. in each quarter of the year, by main origin, are presented in Table 8. Note that the effects of season of the year on the volume shipped from a particular origin region are different for the case of the U.S. and the Asian countries. During the winter period of January through March, a relatively small number of shipments, and volume of rice are transported from the U.S.; these values increase, however, during April-June, until those periods of the year corresponding to winter and fall in the United States. Shipments and volume of rice transported from Asia to different destinations seem to have a stable pattern

Table 8. Number of Shipments, Total Tonnage, and Mean Rate Charged for Rice Cargoes by Quarter of the Year, According to Main Origin, 1990-1991

	U.S.	Asia	Total
January-March			
- % of Shipments	8.9	35.1	16.0
- Total Tonnage	47,653	58,630	118,283
- Mean Rate ($/M.T./100 m.)	2.8	1.0	1.7
April-June			
- % of Shipments	20.3	22.5	19.8
- Total Tonnage	109,234	37,631	146,865
- Mean Rate ($/M.T./100 m.)	3.3	0.9	2.6
July-September			
- % of Shipments	36.1	27.5	32.9
- Total Tonnage	193,959	45,970	243,629
- Mean Rate ($/M.T./100 m.)	1.7	2.2	1.8
October-December			
- % of Shipments	34.7	14.9	31.3
- Total Tonnage	186,798	24,749	231,147
- Mean Rate ($/M.T./100 m.)	3.2	0.4	2.7

Source: Maritime Research Inc., Chartering Annual 1990 and Chartering Annual 1991.

throughout the year, decreasing slightly during the last months of the year (October-December).

In terms of unit freight rates, in general, there is no clear pattern during the year. On average, freight rates of the Asian countries were lower than those of the U.S., except for the months of July-September, in which the opposite occurs (2.2 dollars per M.T. per 100 miles for Asia versus 1.7 dollars per M.T. per 100 miles for the U.S.).

Summary

As a region, Asia has been a critical component of the world rice economy because its people have eaten rice as a staple food for thousands of years. Asia has also been the major rice producing region, and a major participant in the rice world trade. Major rice consuming, producing, and trading countries include China, Bangladesh, India, Indonesia, and Thailand.

Recent growth in the production and exports of rice in Asian countries has greatly affected the competitive position of U.S. rice in international markets. Transportation costs for carrying rice from the U.S. to the world markets has been one of the major factors affecting this U.S. competitive position.

U.S. fleet vessels can be viewed as two types: U.S. flag vessels and non-U.S. flag vessels. There has been a large difference in transportation rates between the two, with the U.S. flag vessels operating at much higher costs. The most important way for U.S. flag ships to continue operating and competing in the world market has been through government subsidization. For instance, U.S. cargo preference law requested that 75% of government-assisted rice exports be carried on U.S. flag vessels during 1990.

There are three major types of vessels for U.S. rice exports: liner, tanker, and tramp. Tramp vessels are the most important transportation means for carrying U.S. rice to the world market. They accounted for the largest part of U.S. rice shipments. Tankers are the least important vessels for U.S. rice exports.

There are four categories of terms of shipments in the world market: free-in-and out, free discharge, berth terms, and liner terms. The first two are the most important for transporting rice. The rice cargoes from the U.S. were mostly associated to free discharge terms, in which shippers are responsible for unloading, and shipowners are responsible for loading the rice. Most of non-U.S. shippers would rather assume the responsibility for loading and unloading a ship.

The majority of rice was shipped on U.S. flag vessels with the present sample. Other important non-U.S. flag ships included those of Cyprus, Greece, Jamaica, Panama, and Liberia. Likewise, rice transported from U.S. and Asia to different destinations seem to have a stable pattern throughout the year. Exceptions to this rule are the periods from January to March in the U.S., and from October to December in the Asian region.

CHAPTER III

METHOD AND DATA REQUIREMENTS

This chapter begins with a summary of the theoretical development of spatial equilibrium models. Then, the reactive programming model is presented in terms of its mathematical structure, and of its main operational characteristics. The second part of the chapter examines detailed information about those importing and exporting countries participating in the analysis, as well as the procedures used to estimate ocean freight rates, excess supply and demand functions, and other useful tools for the formulation and development of the mathematical programming used in this study.

Spatial Equilibrium Analysis

The theory of comparative advantage was formulated by David Ricardo to explain international trade patterns and proclaim its benefits. The construction of a general theory of location and space has been a challenge to economists since that time. In the quest for a general theory which considers the space dimension as well as other dimensions as a determinant of economic activities, one foundation stone was the general equilibrium theory, as elaborated by Walras

(1874)[9], Pareto (1909), Cassel (1923), Wicksell (1934), and their modern counterparts elaborated by Hicks (1937), Mosak (1944), Samuelson (1947), also Arrow and Debreu (1954) (cited by Takayama and Judge, 1971). However, these works were concerned with an economy in which all primary, intermediate, and final commodities were located at one point in space, and product transfers were accomplished with zero time and transport costs. General Equilibrium Models were and are amply used for comparative static evaluations of the effects of different policy issues on the behavior of the agricultural and non-agricultural sector of the economy (Norton and Hazzel, 1985; Adelman, 1986; Hertel and Tsigas, 1988; Sadoulet and de Janvry, 1992).

With the formulation of the transportation model by F.L. Hitchcock (1941)[10], economists were able to make great strides toward quantifying the locational advantages of different regions, and to obtain the least-cost flows of goods among regions based on predetermined supplies and requirements at the respective supply points and consumer centers.

It was in 1951 that Enke used a simple electric circuit

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[9] Years in parenthesis represent those years when the major publications were issued.

[10] The Russian L.V. Kantorovich formulated the first specification of the transportation problem in 1939, but his work became known in the West about a decade later (Paris, 1991).

to illustrate the equilibrium prices and quantities that resulted in a static model. The circuit was compared to the method of solution with digital computers and electronic differential analyzers. The main objective was to find a solution that could be used to determine the net price in each region, the amount of trade, the identification of exporters and importers, the aggregate trade in the community, and the general trade pattern (Enke, 1951). On this development, Samuelson (1952) showed how the general non-normative problem of partial equilibrium among spatially separated markets, as formulated by Enke, could be converted into a minimum-transport-cost problem in which standard mathematical programming could be used as a tool of analysis. The problem can be solved by trial and error of a systematic procedure consisting in varying shipments in the direction of increasing social payoffs.

Beckmann and Marschak (1955) modified the spaceless general activity analysis model of production and market allocation, to make it additive over discrete geographical areas. They described the technological relations between areas by transfer activities which express the possibility of flows of commodities from one region to another.

McKenzie (1954) used the activity analysis model elaborated by Samuelson, to present proof of the efficiency of competition and free trade in spatial equilibrium models of world production and trade, and to suggest the applicability of the activity analysis model to the theory of international trade. This model was subsequently extended by Takayama and Judge (1964), through the explicit introduction of transportation activities. In fact, Takayama and Judge used linear price dependent demand and supply functions to define an empirically oriented "quasi welfare function", extending the Samuelson (1952) and Beckmann and Marschak (1955) spatial models so that the spatial structure of prices, production, allocation, and consumption for all commodities could be determined within the model. They also proposed an algorithm which could be used to obtain directly and efficiently the competitive price and allocation solution (Takayama and Judge, 1971)

Tramel and Seale (1959, 1963) developed the Reactive Programming algorithm, which provides for the simultaneous determination of equilibrium shipping patterns between spatially separated producing areas and markets. This algorithm works either with fixed supplies at points of production and demand functions for the specified markets, or both supply and demand functions, and for making such calculations for either one or two competing products from one or more producing areas to one or more markets.

The Reactive Programming Model

In the late 1950's, Tramel and Seale (1959) introduced reactive programming, a spatial equilibrium model, useful for obtaining competitive equilibrium prices, quantities, and flows of a commodity between areas, given demand schedules, fixed or changing supplies, and transportation cost functions or constant unit transportation costs. Since its first formulation, many modifications in the algorithm have increased its efficiency as well as its ability to handle many diverse situations (Tramel and Seale, 1965; Hawks, 1970).

Reactive programming is, in fact, a spatial equilibrium computational procedure for solving a wide variety of interregional and international problems. It can be used to obtain a minimum cost spatial equilibrium solution in markets that may be characterized by linear or log-linear demand and supply relationships, fixed demand or supply quantities, two products produced and consumed, different time periods and regions of supply and demand, or various combinations of these conditions. With further modifications the program has also been used to determine spatial equilibrium in a market where a single product has two uses (Riley, 1974).

Mathematical Structure of the Model

A common "transportation problem" is a special type of linear programming problem in which fixed supplies in each of m regions are to be allocated to meet fixed demands in n markets, to minimize total transfer costs. Shipments from region i to region j are identified as Q_{ij}, the transport cost of one unit of product from origin i to destination as T_{ij}, and total transfer costs as $\Sigma_i\Sigma_jT_{ij}Q_{ij}$[11]. Shipments from each region may not exceed the quantity supplied ($\Sigma_jQ_{ij} \leq S_i$), and receipts at each market must be at least equal to the quantity demanded ($\Sigma_iQ_{ij} \geq D_j$). No negative shipments are allowed ($Q_{ij} \geq 0$).

The dual of this transportation problem can be formulated as follows:

Maximize $R = \Sigma_jD_jV_j - \Sigma_iS_iU_i$

subject to $V_j - U_i \leq T_{ij}$

$U_i, V_j > 0$

where U_i : shipping point prices

V_j : market prices

D_j : fixed demanded quantity

S_i : fixed supplied quantity

T_{ij} : transport cost of one unit of product from origin i to destination j

The objective in this dual formulation of the transportation problem is to maximize the difference between the value of market receipts and the cost of quantities supplied, that is $R = \Sigma_jD_jV_j - \Sigma_iS_iU_iR$, subject to the

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[11] The primal transportation problem is specified as (Nesa and Coppins, 1981):

Minimize Transport Cost = $\Sigma_i\Sigma_jT_{ij}Q_{ij}$

Subject to: $\Sigma_jQ_{ij} \leq S_i$ (S_i is supply, $i = 1,...,m$)
$\Sigma_iQ_{ij} \geq D_j$ (D_j is demand, $j = 1,...,n$)
$Q_{ij} \geq 0$

restrictions that $V_j - U_i \leq T_{ij}$ and the aforementioned constraints for U_i and V_j.

Reactive Programming is an extension of this dual transportation model that allows substitution of supply and demand functions for the fixed supply and demand quantities respectively (King and Gunn, 1981). There is a price-dependent demand function in each market in which the price of the commodity in demanding region j is a function of the total quantity received:

$$P_j = F_j\ (\Sigma_i Q_{ij}),\ i = 1,\ldots,m$$

$$\text{where } \Sigma_i Q_{ij} = D_j$$

The unit cost of production in the ith producing region is C_i, represented by:

$$C_i = G_i\ (\Sigma_j Q_{ij}),\ j = 1,\ldots,n$$

$$\text{where } \Sigma_j Q_{ij} = S_i$$

The net price for quantities shipped from region i to market j is $R_{ij} = P_j - C_i - T_{ij}$. The weighted average net price for all shipments from i is $R_i = \Sigma_j R_{ij} Q_{ij} / \Sigma_j Q_{ij}$. Deviation of the net price for a given route, R_{ij}, from the weighted average net price for all shipments from that region, R_i, is D_{ij}, where $D_{ij} = R_{ij} - R_i$.

The reactive programming model is formulated to solve the following m x n equations:

$$R_{ij} = F_j\ (\Sigma_i Q_{ij}) - T_{ij},$$

$$i = 1,\ldots,m, \quad \text{and} \quad j = 1,\ldots,n;$$

Subject to the following restrictions:

(1) Negative shipments are not permitted, i.e.

$$Q_{ij} \geq 0$$

(2) a. Net prices for all routes used by region i must be non-negative and equal to each other.

$$Q_{ij} \neq 0 \rightarrow R_{ij} = R_i \geq 0$$

b. Net prices for all routes not used by region i must be no larger than the net price for active routes.

$$Q_{ij} = 0 \rightarrow R_{ij} \leq R_i \geq 0$$

(3) Deviations from weighted average net prices are non-positive.

$$D_{ij} = R_{ij} - R_i \leq 0$$

a. Equality holds for active routes (see 2(a) above).

b. Either condition may hold for other routes (see 2(b) above).

(4) Shipments from region i may not exceed supply.

a. $R_i > 0 \rightarrow \Sigma_j Q_{ij} = S_i$

b. $R_i = 0 \rightarrow \Sigma_j Q_{ij} \leq S_i$

Supply is fully allocated if the weighted average net price is positive, but this is not necessary if net price is zero.

Operation of the Model

The operation of the reactive programming algorithm, as summarized by King and Ho (1972), is as follows. An initial set of supply and demand quantities is selected and a linear programming subroutine is used to allocate supplies among the markets. A market price is calculated from the demand function for each of the consuming areas. By subtracting transportation costs from these market prices, net shipping point prices are obtained for the shipments in the initial allocation. A new level of output for the first shipping area is selected consistent with the net revenue received. This new quantity is then allocated among markets so as to maximize net returns, given the market prices and previous shipping patterns of all other shippers.

The same process is repeated for the second shipping area given the behavior of all other shipping areas. The iterative routine continues until it is not profitable for any shipping area either to change the level of output, or to reallocate supplies.

To expedite obtaining an equilibrium solution the linear programming subroutine is called at least every 20 iterations[12]. Individual supply points reaching equilibrium may be temporarily ignored in subsequent iterations but again reevaluated after at least each 20 iterations. In addition, a rough level of accuracy may be accepted as a computer time saving device.

Several variations of the basic program are currently available. Supplies and/or demands may be treated as fixed or entered in functional form. Upper limits may be placed on one or more supply areas.

The main objective of this study was to evaluate the

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[12] One iteration considers all supply markets.

effects of changes in ocean freight rates on the international rice market flows, considering the competitive position of each country or region. Thus, it seemed to be more appropriate to use functional forms rather than fixed supply and demand quantities. This was done to obtain flexible import and export volumes and equilibrium prices. Consequently, the reactive programming model used here utilizes functional forms of excess supplies (export volumes) and excess demands (import volumes).

Assumptions of the Study

Specific assumptions on which the present study was based are basically the following:

a. Transportation rates in exporting and importing countries or regions could be represented by those rates estimated for a single port in that country or region.

b. Even though there are many different varieties of rice traded in the international market, for our purposes all rice was assumed homogeneous.

c. Excess of supply and excess of demand functions are readily available for each exporting and importing country or region.

d. The efficiencies of all ports in the study were assumed the same and had no impact on shipping rates.

Data Requirements

The 1990 calendar year was selected as the data base for this study. The main reason was data availability.

There were three basic components of the reactive programming model in this study, for which it was necessary to collect data: (i) excess supply functions, (ii) excess demand functions, and (iii) ocean freight rates. Specific data requirements for each component is described in next subsections.

Spatial Demarcation

Since the emphasis of this study was on international trade in rice, spatial demarcation was made on a country basis. This was so done because a country represents a logical unit in international trade, and because the data on rice is generally available on national levels.

Each nation is generally represented by one or two ports in such a way that the shortest navigable route between each pair of origin-destination points could be used in order to estimate the distances between two certain ports in two different countries. For instance, Bombay was used to represent India when trade takes place between India and any western area. Calcutta represented India in its trade with any eastern area. In few cases only one port was used to represent two or more neighboring countries, due to distance data availability. For example, Buenos Aires was used to represent Argentina, but in some cases this same country was represented by Rio de Janeiro. New Orleans was the port representing the U.S. in this study.

Due to data availability concerning elasticities and/or distances, the world rice market was divided into 12 exporting countries and one exporting region, as well as 43 importing countries or regional groups. Table 9 presents the list of the countries and regions mentioned.

Estimation of Excess Supply Functions

Price-dependent excess supply functions for each exporting country may be derived directly from the data using regression analysis. However, in the present study, excess of supply functions were formulated indirectly, using secondary data.

Linear price-dependent excess of supply functions were formulated for exporting countries using data from 1990 production, consumption, stocks, and trade. Estimates of domestic elasticities, coming from other studies, were used to calculate price elasticities of excess supply, which were in turn used to generate the linear price-dependent excess supply and demand functions (Bredhal et al., 1979). There are exactly the same number of price-dependent excess supply functions as there are exporting countries and regions.

Table 9. Rice Exporting and Importing Countries or Regions, and Their Representative Ports, Used to Calculate Distances, and to Estimate Ocean Freight Rates Utilized by the Reactive Programming Model

Countries or Regions Included	Representative Points (Ports)	Countries in the Regions
Exporters		
Argentina	Buenos Aires	
Australia	Geelong	
Burma	Bassein	
China	Shangai	
India	Bombay, Calcutta	
Italy	Venice, Palermo	
Pakistan	Karachi	
Spain	Valencia	
Thailand	Bangkok	
U.S.	New Orleans	
Uruguay	Montevideo	
Vietnam	Ho Chi Minh	
Ot.S.America[1]	Guayaquil	Colombia, Ecuador, Venezuela, Chile, Guyana, Surinam, Paraguay
Importers		
Angola	Luanda	
Cameroon	Duala	
Ghana	Accra	
Guinea	Conakry	
Liberia	Monrovia	
Madagascar	Diego Suarez	
Mauritania	Dakar	
Nigeria	Lagos	
Reunion	Reunion	
Senegal	Dakar	
Sierra Leona	Conakry	
Somalia	Mogadiscio	
South Africa	Capetown	
Tanzania	Dar es Salaam	
Zaire	Luanda	
Ot.S.S. Africa[2]	Dar es Salaam Luanda	Chad, Burkina, Ivory Coast, Mali, Benin, Gambia, Morocco, and Niger

(Continued)

Table 9. (Continued)

Countries or Regions Included	Representative Points (Ports)	Countries in the Regions
Bangladesh	Chittagong	
Hong Kong	Hong kong	
Indonesia	Jakarta, Surabaya	
Malaysia	Penang	
Philippines	Manila	
Singapore	Singapore	
Sri Lanka	Colombo	
Taiwan	Kaohsiung	
Ot.S.Asia[3]	Karachi	Afganistan, Nepal
Ot.E.As./Oc.[4]	Surabaya	Brunei, Cambodia, Laos, and Papua-New Guinea
E.C.10[5]	Bordeaux	Belgium, Luxemburg, Denmark, France, West Germany, Greece, Ireland, Netherlands, Portugal, U.K.
Ot.W.Europe[6]	Marseilles	Austria, Finland, Norway, Switzerland, Swaziland, Sweden
East Europe	Rejika	Bulgaria, Czechoslovakia, Hungary, East Germany, Poland, Romania, Yugoslavia
Ex-U.S.S.R.[7]	Odessa, Vladivostok	
Brazil	Rio de Janeiro	
Canada	Victoria	
Cuba	Havana	
Mexico	Tampico	
Peru	Callao	
Ot.C.A./Carib.[8]	Kingston	Guatemala, Jamaica, Nicaragua, Salvador, Costa Rica, Honduras

(Continued)

Table 9. (Continued)

Countries or Regions Included	Representative Points (Ports)	Countries in the Regions
Iran	Abaden	
Iraq	Basrah	
Kuwait	Kuwait	
Saudi Arabia	Jeddah	
Syria	Lattakia, Beirut	
U.A. Emirates[9]	Bandar Abbas	
Ot.Md.E./N.Af.[10]	Alexandria	Libya, Oman, Qatar Algeria, Cyprus, Israel, Jordan, Lebanon, Morocco, Turkey, Yemen

[1] Other South American countries.
[2] Other Sub-Sahara African countries.
[3] Other South Asian countries.
[4] Other East Asian and Oceania countries.
[5] E.C.10 refers to those 10 Europe Community countries that do not export rice (Spain and Italy are excluded).
[6] Other West European countries.
[7] Former Union of Soviet Socialist Republics.
[8] Other Central American and Caribbean countries.
[9] United Arab Emirates.
[10] Others Middle East and North African countries.

The general procedure required to calculate excess supply elasticities for exporters is expressed mathematically as:

$$Eesj = (Esj-Edj)\frac{Qdj}{Qxj} + Esj \qquad (1)$$

where

Eesj = elasticity of excess supply in exporting country or region j

Esj = elasticity of domestic supply in exporting country or region j

Edj = elasticity of domestic demand in exporting country or region j

Qdj = level of domestic demand of exporting country or region j, for 1990

Qxj = excess supply (exports) of exporting country or region j, for 1990

Thus, to calculate the elasticities of excess supply, Eesj, for 13 exporting countries or regions, elasticities of domestic supply in each exporting country or region (Esj), elasticities of domestic demand in each exporting country or region (Edj), domestic demand of each exporting country or region (Qdj), and export volumes of each exporting country or region (Qxj) were needed.

Domestic demands (Qdj) and export volumes were taken directly from data reported by the Foreign Agricultural Service (U.S.D.A., 1991). Domestic demand and supply price elasticities were taken from U.S.D.A.'s Trade Liberalization Database (Sullivan et al., 1989; Gardiner et al., 1989), and complemented by other sources (Tyers and Anderson, 1986; Rojko et al., 1978; Liu and Roningen, 1985; Zhang, 1990b). Accordingly, the price elasticities of excess supply for each exporting country or region could be estimated by equation (1) above, as shown in Table 10.

After the elasticity of excess supply was estimated, a linear price-dependent excess of supply function was approximated, to be used with the reactive programming model, in the following way:

$$Pxj = c + d\ Qxj \tag{2}$$

where Pxj : export price (F.O.B.) of exporting country or region in 1990, derived from total export values divided by export volumes for each exporting country or region j

Qxj : export quantities in 1990 (1000 M.T.), for each exporting country or region j

Estimates of coefficients c and d were derived from the formula of the price elasticities of supply and values of the variables Pxj and Qxj, specified in equation (2). The procedure is conveniently summarized in the following way:

$$Eesj = \frac{\Delta Qxj}{\Delta Pxj} . \frac{Pxj}{Qxj} \tag{3}$$

Thus,

$$Eesj = \frac{Pxj}{Qxj} . \frac{1}{\Delta Pxj / \Delta Qxj} \tag{4}$$

Table 10. Derivation of Price Elasticities of Excess Supply for Exporting Countries or Regions, Used to Estimate Price-dependent Excess Supply Functions

Exporting Countries or Region[1]	Elasticities of: Domestic[2] Supply (Esj)	Elasticities of: Domestic[2] Demand (Edj)	1990 Domestic Demand (Qdj)[3]	1990 Export Volume (Qxj)	Elasticity of Excess Supply (Eesj)[4]
			-----(1,000 M.T.)----		
Argentina	0.80	-0.40	156	70	3.474
Australia	0.60	-0.45	172	470	0.984
Burma	0.03	-0.06	7050	186	3.441
China	0.07	-0.05	123059	300	49.294
India	0.40	-0.50	71633	420	153.899
Italy	0.20	-0.14	340	595	0.420
Pakistan	0.03	-0.14	2250	904	0.453
Spain	0.48	-0.40	272	110	2.656
Thailand	0.33	-0.10	8600	3927	1.272
U.S.	0.40	-0.25	2709	2424	1.126
Uruguay	0.15	-0.20	85	250	0.269
Vietnam	0.20	-0.15	10460	1500	2.641
O.S.America	0.55	-0.40	2142	179	11.918

1 See footnote of table 9 for regions' shorthand.

2 (Sullivan et al.,1989; Gardiner et al., 1989; Tyers and Anderson, 1986; Rojko et al., 1978; Liu and Roningen, 1985; Zhang, 1990b).

3 Domestic demand includes apparent consumption, annual stock changes, and allowances for feed, seed, and waste.

4 $$Eesj = (Esj-Edj)\frac{Qdj}{Qxj} + Esj$$

Since,

$$\frac{\Delta Pxj}{\Delta Qxj} = d$$

Then,

$$Eesj = \frac{Pxj}{Qxj} \cdot \frac{1}{d}$$

And "d" and "c" can be estimated as

$$d = \frac{Pxj}{Qxj} \cdot \frac{1}{Eesj} \qquad (5)$$

$$\text{and} \quad c = Pxj - dQxj \qquad (6)$$

After the intercept and slope coefficients are derived, and in order to get an operationally feasible specification, the price-dependent excess supply equations for 13 exporting countries and regions were calculated from the above formulas as shown in Table 11.

Estimation of Excess Demand Functions

Similar to the derivation of elasticities of excess of supply, the elasticities of excess demand for importing countries and regions were calculated according to the following formula (Bredhal et al., 1979; Tomek and Robinson, 1990):

Table 11. The Estimated Excess Supply Functions for Exporting Countries or Regions, Used by the Reactive Programming Model

Exporting Countries or Region[1]	Elasticity of Excess Supply (Eesj)	1990 Export Prices (Pxj)[2]	1990 Export Volumes (Qxj)	Estimated Excess Supply Functions	
				c[3]	d[4]
		($/M.T.)	(1,000 M.T.)		
Argentina	3.474	372.3	70	265.14	1.531
Australia	0.984	363.5	470	-5.81	0.786
Burma	3.441	270.0	186	191.54	0.422
China	49.294	241.7	300	236.80	0.016
India	153.899	467.5	420	464.46	0.007
Italy	0.420	618.1	525	-852.90	2.802
Pakistan	0.453	325.0	904	-392.25	0.793
Spain	2.656	606.4	110	378.09	2.076
Thailand	1.272	270.4	3927	57.77	0.054
U.S.	1.126	324.9	2424	36.46	0.119
Uruguay	0.269	356.9	250	-969.87	5.307
Vietnam	2.641	250.0	1500	155.33	0.063
O.S.America	11.918	415.7	179	380.82	0.195

1 See footnote of table 9 for regions' shorthand.
2 Export prices (F.O.B.) were obtained from FAO Yearbook of Trade (1991), as follows: Px = Export Values/Export Volumes.
3 $c = Pxj - dQxj$
4 $d = [(Pxj/Qxj) x (1/Eesj)]$

$$Eedi = (Edi - Esi)\frac{Qdi}{Qmi} + Esi \qquad (7)$$

where

Eedi = elasticity of excess demand in importing country or region i

Edi = elasticity of domestic demand in importing country or region i

Esi = elasticity of domestic supply in importing country or region i

Qdi = level of domestic demand of country or region i, for 1990

Qmi = excess of demand (imports) of country or region i, for 1990

Thus, to calculate the elasticities of excess of demand, Eedi, for 43 importing countries or regions, elasticities of domestic supply and demand in each importing country or region (Esi and Edi), domestic demand of each importing country or region (Qdi), and export volumes of each importing country or region (Qmi) were needed.

Domestic demands (Qdi) and export volumes (Qmi) were taken directly from data reported by the Foreign Agricultural Service (U.S.D.A., 1991). Domestic demand and supply price elasticities were taken from U.S.D.A's Trade Liberalization Database (Sullivan et al., 1989; Gardiner et al., 1989), and complemented by other sources (Rojko et al., 1978; Liu and Roningen, 1985; Tyers and Anderson, 1986; Zhang, 1990b).

Similar to the excess of supply calculations, the elasticities of excess of demand for each importing country or region were estimated by equation (7). The results are shown in Table 12.

Linear price-dependent excess demand function were also estimated for each importer, resulting in equations with the following form:

$$Pmi = a + b\ Qmi \qquad (8)$$

where Pmi : export price (C.I.F.) of importing countries or regions in 1990, derived from total import values divided by import volumes for each importing country or region i

Qmi : import quantities in 1990 (1000 MT), for each importing country or region i

Similarly, coefficients a and b were derived from the formula of the price elasticities of demand and the values of the variables specified in equation (8), as follows:

$$b = \frac{Pmi}{Qmi} \cdot \frac{1}{Eedi} \qquad (9)$$

$$\text{and} \quad a = Pmi - bQmi \qquad (10)$$

After the intercept and slope coefficients were derived, the excess demand equations for 43 importing countries or regions were calculated from above formulas, as shown in Table 13.

<u>Estimation of Ocean Transportation Costs</u>

The model constraint requiring prices at import points and export points to differ by the transportation cost between the two points is an important component of the

Table 12. Derivation of Price Elasticities of Excess Demand for Importing Countries or Regions, Used to Estimate Price-dependent Excess Demand Functions

Importing Countries or Region[1]	Elasticities of[2] Domestic Demand (Edi)	Domestic Supply (Esi)	1990 Domestic Demand (Qdi)[3]	1990 Import Volume (Qmi)	Elasticity of Excess Demand[3] (Eedi)
			----(1,000 M.T.)---		
Angola	-0.30	0.30	63	50	-0.456
Bangladesh	-0.03	0.04	17864	100	-12.465
Brazil	-0.45	0.40	7400	405	-15.131
Cameroon	-0.30	0.05	114	50	-0.748
Canada	-0.25	0.10	130	130	-0.250
Cuba	-0.05	0.15	545	200	-0.395
Ghana	-0.30	0.30	142	75	-0.836
Guinea	-0.30	0.30	461	120	-2.005
Hong Kong	-0.07	0.07	395	400	-0.068
Indonesia	-0.22	0.20	28185	60	-197.095
Iran	-0.30	0.50	1840	850	-1.232
Iraq	-0.30	0.50	585	360	-0.800
Kuwait	-0.30	0.50	85	90	-0.256
Liberia	-0.30	0.05	283	120	-0.775
Madagascar	-0.30	0.05	163	155	-0.318
Malaysia	-0.33	0.50	1500	367	-2.892
Mauritania	-0.30	0.05	90	60	-0.475
Mexico	-0.40	0.65	440	130	-2.904
Nigeria	-0.51	0.30	740	200	-2.697
Peru	-0.20	0.15	780	246	-0.960
Philippines	-0.33	0.25	6360	360	-9.997
Reunion	-0.30	0.30	50	50	-0.300
Saudi Arabia	-0.30	0.50	525	525	-0.300
Senegal	-0.30	0.05	495	390	-0.394
Sierra Leone	-0.30	0.30	416	110	-1.969

(Continued)

Table 12. (Continued)

Importing Countries or Region[1]	Elasticities of[2] Domestic Demand (Edi)	Elasticities of[2] Domestic Supply (Esi)	1990 Domestic Demand (Qdi)[3]	1990 Import Volume (Qmi)	Elasticity of Excess Demand[3] (Eedi)
			----(1,000 M.T.)---		
Singapore	-0.05	0.07	195	220	-0.036
Somalia	-0.30	0.30	98	90	-0.353
South Africa	-0.30	0.33	300	300	-0.300
Sri Lanka	-0.30	0.04	1700	200	-2.850
Syria	-0.30	0.50	135	140	-0.271
Taiwan	-0.25	0.20	1573	4	-176.763
Tanzania	-0.30	0.30	537	50	-6.144
U.A.Emirates	-0.30	0.50	220	220	-0.300
Ex-U.S.S.R.	-0.15	0.45	1914	400	-2.421
Zaire	-0.30	0.30	255	80	-1.613
E.C.10	-0.50	0.35	981	1090	-0.415
Ot.W.Europe	-0.44	0.20	164	152	-0.491
East Europe	-0.15	0.30	489	284	-0.475
Ot.C.Am/Carib.	-0.65	0.58	1144	346	-3.487
Ot.S.S.Africa	-0.30	0.30	1772	853	-0.946
Ot.S.Asia	-0.50	0.40	2245	85	-23.371
Ot.E.As./Oc.	-0.15	0.20	2769	266	-3.443
Ot.Md.E./N.Af.	-0.20	0.15	2361	866	-0.804

[1] See footnote of table 9 for regions' shorthand.

[2] (Sullivan et al., 1989; Gardiner et al., 1989; Rojko et al., 1978; Liu and Roningen, 1985; Tyers and Anderson, 1986; Zhang, 1990b).

[3] Domestic demand includes apparent consumption, annual stock changes, and allowances for feed, seed, and waste.

[4] $$Eedi = (Edi - Esi)\frac{Qdi}{Qmi} + Esi$$

Table 13. The Estimated Excess Demand Functions for Importing Countries or Regions, Used by the Reactive Programming Model

Importing Countries or Region[1]	Elasticity of Excess Demand (Eedi)	1990 Import[2] Prices (Pmi)	1990 Import Volumes (Qmi)	Estimated Excess Demand Functions	
				a[3]	b[4]
		($/M.T.)	(1,000 M.T.)		
Angola	-0.456	268.4	50	857.00	-11.772
Bangladesh	-12.465	314.8	100	340.06	-0.253
Brazil	-15.131	363.0	405	386.99	-0.059
Cameroon	-0.748	294.5	50	688.22	-7.874
Canada	-0.250	390.4	130	1952.00	-12.012
Cuba	-0.395	229.8	200	811.57	-2.909
Ghana	-0.836	300.0	75	658.85	-4.785
Guinea	-2.005	337.2	120	505.38	-1.401
Hong Kong	-0.068	400.0	400	6260.81	-14.652
Indonesia	-197.095	285.0	60	286.45	-0.024
Iran	-1.232	354.1	850	641.57	-0.338
Iraq	-0.800	364.7	360	820.58	-1.266
Kuwait	-0.256	617.6	90	3034.30	-26.852
Liberia	-0.775	369.2	120	845.33	-3.968
Madagascar	-0.318	233.0	155	965.56	-4.726
Malaysia	-2.892	302.7	367	407.35	-0.285
Mauritania	-0.475	220.0	60	683.16	-7.719
Mexico	-2.904	351.0	130	471.87	-0.930
Nigeria	-2.697	272.0	200	372.85	-0.504
Peru	-0.960	344.9	246	704.26	-1.461
Philippines	-9.997	215.4	360	236.95	-0.060
Reunion	-0.300	386.3	50	1673.97	-25.753
Saudi Arabia	-0.300	565.0	525	2448.33	-3.587
Senegal	-0.394	230.0	390	813.41	-1.496

(Continued)

Table 13. (Continued)

Importing Countries or Region[1]	Elasticity of Excess Demand (Eedi)	1990 Import[2] Prices (Pmi)	1990 Import Volumes (Qmi)	Estimated Excess Demand Functions	
				a[3]	b[4]
		($/M.T.)	(1,000 M.T.)		
Sierra Leone	-1.969	354.5	110	534.53	-1.637
Singapore	-0.036	370.3	220	10553.55	-46.288
Somalia	-0.353	350.0	90	1340.57	-11.006
South Africa	-0.300	294.9	300	1277.90	-3.277
Sri Lanka	-2.850	268.4	200	362.58	-0.471
Syria	-0.271	334.3	140	1565.93	-8.797
Taiwan	-176.763	352.0	4	353.99	-0.498
Tanzania	-6.144	352.9	50	410.34	-1.149
U.A. Emirates	-0.300	387.1	220	1677.43	-5.865
Ex-U.S.S.R.	-2.421	371.5	400	524.95	-0.384
Zaire	-1.613	445.2	80	721.29	-3.451
E.C.10	-0.415	679.7	1090	2317.53	-1.503
Ot.W.Europe	-0.491	536.5	152	1630.22	-7.196
East Europe	-0.475	425.7	284	1322.24	-3.157
Ot.C.Am/Carib.	-3.487	324.7	346	417.82	-0.269
Ot.S.S.Africa	-0.946	297.0	853	610.81	-0.368
Ot.S.Asia	-23.371	352.0	85	367.06	-0.177
Ot.E.As./Oc.	-3.443	317.6	266	409.83	-0.347
Ot.Md.E./N.Af.	-0.804	367.1	866	823.57	-0.527

[1] See footnote of table 9 for regions' shorthand.
[2] Import prices (C.I.F.) were obtained from FAO Yearbook of Trade (1991), as follows: Pmi = Import Values/Import Volumes.
[3] $a = Pi - bQmi$
[4] $b = (Pmi/Qmi)x(1/Eedi)$

spatial equilibrium model. Transportation costs are a main component of our spatial equilibrium problem.

Maritime transportation cost data were not available for all possible trade routes in the model. Using data compiled by Maritime Research Inc. for 1990, estimates were made based on regression analysis in which transportation cost was a function of distance, and a dummy variable. This dummy variable represents the difference between ocean freight rates for U.S. flag and foreign vessels.

The estimated equation and relevant statistics are as follows:

$$\text{Ln TCij} = -0.266 + 0.4872 \text{ Ln DISTij} + 0.603 \text{ Fij}$$

$$(0.67) \quad (5.92) \qquad\qquad (5.01)$$

$$R^2 = 0.65 \quad \text{Std.Error} = 0.37 \quad \text{d.f.} = 37$$

where:

TCij = ocean transportation cost (in U.S. dollars/M.T.) from exporting country or region i to importing country or region j

Dij = distance between exporting country or region i and importing country or region j (nautical miles)

Fij = dummy variable for shipments occurring on U.S. flag vessels. This value was 0 for foreign flag vessels, and 1 for U.S. flag vessels

Ln = natural logarithm

The numbers appearing in parentheses below the estimated coefficients are their t-ratios, which all were statistically significant at the 95 percent probability level. Table 35 in appendix section shows the observations used to run the regression model.

It must be mentioned that this mixed logarithm specification (including a double logarithm and the dummy variable for type of flag vessel) was better than the quadratic or linear function, in terms of better fitness (R^2 adjusted), more efficiency (less variability of the estimators of the parameters), and statistical significance of the estimators.

The use of this mixed logarithm equation to estimate transportation costs implies the existence of increasing costs, but at a decreasing rate, when distance is increased.

For foreign flag shipment, the log of the ocean transportation cost function was as follows:

$$\text{Ln } TCij = -0.266 + 0.4872 \text{ Ln } DISTij$$

For U.S. flag shipments, the log of the ocean transportation cost function was as follows:

$$\text{Ln } TCij = 0.337 + 0.4872 \text{ Ln } DISTij$$

After the ocean transportation costs were estimated in logarithmic values, these were transformed to real values (U.S. dollars per metric ton). Tables 36 and 37 in appendix section depict distances and costs of transportation used to obtain results for the base solution of minimum cost, in which no shipment is obligated to be loaded on specific flag vessel conditions. This was done to have a base comparison for evaluation of the effects of U.S. Cargo Preference Law.

In reality, foreign countries never use U.S. flag vessels. The U.S. flag vessels are used only for U.S. rice exports, in a certain percentage given by the cargo preference policies. The distances between the ports were taken from the Reed's Marine Distance Tables (Caney and Reynolds, 1978).

Postoptimality Analysis

The main objective of this study was to analyze the effects of changes in ocean freight rates on flows of rice trade. Therefore, postoptimality analysis was used, which permitted for variation in ocean freight rates. Four different scenarios, presented in the next chapter, were utilized for the comparison of ocean freight rates in different conditions with the results obtained from an optimum solution of minimum transportation cost. For this purpose, the reactive programming package for the Mississippi State University main frame computer (RP-MSU-05-062281) was utilized.

Summary

The introduction of demand and supply functions in a spatial equilibrium context can be traced back to articles by Enke in 1951, and Samuelson in 1952. Solutions to practical problems of this type having linear demand and supply functions have been found using quadratic programming

(Takayama and Judge, 1964), and for problems with great flexibility in terms of supply and demand relations, using reactive programming. The earliest version of the reactive programming model was reported by Tramel and Seale in 1959.

Reactive programming, the algorithm used in this study, has a wide applicability and flexibility. Demand and supply functions may be entered in linear, log-linear, or log-log form. Supplies and demands may also be fixed in some or all regions; in fact, reactive programming has been also designed to solve transportation problems as a special case in which all supplies and demands are given at fixed quantities.

There were three basic components of reactive programming in this study: excess supply functions, excess demand functions, and transportation costs. Excess supply and demand functions were indirectly estimated using secondary information obtained from past studies (elasticities of domestic supply and demand, imports, exports, demand, and supply for each of the countries or regions participating in the analysis).

Transportation cost data were not available for all possible international routes of rice shipment. Thus, estimation of shipping costs became a necessary step before the trade model was established. Logarithm functions along with the use of a dummy variable which related ocean freight rates to distances between ports of rice exporting and importing, were used to estimate values of ocean freight rates for the all routes. About 65 percent of the total variation of ocean freight rates was explained by variations in the distances between ports.

CHAPTER IV

ANALYSIS OF RESULTS

Results of the analysis of ocean freight rates in the international rice trade are presented below. Four different scenarios were selected. In each scenario, models representing different levels of ocean freight rates variation were analyzed and compared to a base solution, estimated in base of minimum transportation costs, without any kind of preferences in terms of specific flag vessels.

The first section presents a comparative analysis of the actual flows, prices and quantities of rice shipped and received from one country to other, as compared to the optimum solution obtained with the reactive programming algorithm, belonging to the base solution. Second, the effects of U.S. cargo preferences policies are evaluated in terms of their impact on the optimum market shares of rice exporting countries or regions. Third, postoptimality analysis was conducted in order to evaluate changes in the level of ocean transportation costs of the major four rice exporting countries. The last section also contains postoptimality analysis regarding the effects of simultaneous changes in ocean freight rates (for all the exporting countries and regions) on the optimum flows, volumes traded and prices of rice, obtained from the base solution. Special emphasis has been given to the competitive position of the U.S.

The Base Solution

The base solution is one in which optimum results for 1990 rice trade flows were obtained from the Reactive Programming model. For obtaining these results, excess supply and demand functions were estimated from other studies (as mentioned in the methodological section), and transportation costs were those in which no cargo would be obligated to be released on specific flag vessel conditions. This was done to be able to evaluate the effect of different levels of action of the U.S. cargo preference policy on the optimum equilibrium position of the international rice market.

The main objective of this study was to evaluate the effect of changes in ocean freight rates with respect to an optimum equilibrium position obtained in the base solution, thus ocean transportation costs were considered to be the only factors influencing the optimum solution.

Scenario I: Actual Trade Versus Optimum Trade

In this section, results of the actual trade for 1990 are compared to results obtained in the base solution, in which net returns were maximized.

<u>Trade Volumes</u>

Actual rice volume of trade, and the results of optimum rice volumes from the base solution, for exporting countries or regions, are presented in Table 14. In general we can see that the optimum trade volume of the base solution (12,252 M.T.) was larger than that representing the total actual volume of rice trade (11,265 M.T.)

In relation to individual countries or regions, according to the base solution, some exporting countries like India, Spain, and South American countries (except Argentina), simply would stop exporting. Other countries such as Argentina, Australia, and Italy would show important decreasing values in their exports; these estimated values were -52.8, -22.5, and -21.1 percent, respectively. Under the conditions of the base solution, the U.S. would experience a market share reduction equivalent to -11.9 percent, from the actual level of 2,424 M.T. in 1990 to an optimum level of 2,135 M.T., under the base plan. In contrast, the optimum export volume for China would increase notably, from only 300 M.T. to 2,053 M.T. Results from the base solution revealed that rice exports from Burma and Vietnam also would increase by 25.8 and 26.9 percent, respectively. Thailand would slightly increase its exports as a result of the optimum plan (1.8 percent).

As a consequence of increased exports in the optimum solution of the rice trade model, China's market share

Table 14. Comparison of Trade Volumes and Market Share of Actual and Optimum Solution for Exporting Countries or Regions, 1990

Exporting Countries or Region[1]	Actual Exports (A)[2]	Optimum Exports (B)[3]	% Change from Actual Exports ((B-A)/A)*100
	----- (1000 M.T.)	-----	(%)
Argentina	70	33	-52.8
	(0.6)[4]	(0.3)	
Australia	470	364	-22.5
	(4.2)	(3.0)	
Burma	186	234	25.8
	(1.6)	(1.9)	
China	300	2053	584.3
	(2.7)	(16.8)	
India	420	0	-100.0
	(3.7)	---	
Italy	525	414	-21.1
	(4.7)	(3.4)	
Pakistan	904	876	-3.1
	(8.0)	(7.2)	
Spain	110	0	-100.0
	(1.0)	(0.0)	
Thailand	3927	3996	1.8
	(34.9)	(32.6)	
U.S.	2424	2135	-11.9
	(21.5)	(17.4)	
Uruguay	250	243	-2.8
	(2.2)	(2.0)	
Vietnam	1500	1904	26.9
	(13.3)	(15.5)	
O.S.America	179	0	-100.0
	(1.6)	---	
Total Volume	11265	12252	8.8

[1] See footnote of Table 9 for regions' shorthand.
[2] (U.S.D.A., 1991).
[3] Results of the base solution.
[4] Figures in parenthesis are market shares.

would increase from 2.7 to 16.8 percent of the total rice trade. Market shares for Burma and Vietnam also would increase, although more slightly than China. Argentina, Australia, and other South American countries are regions with reduced market share in the optimum model (Table 14). The competitive position of the U.S. rice industry appear to be relatively weak, as compared to other main rice exporters such as China, Burma, Vietnam, and Thailand.

U.S. Trade Patterns

The actual and optimum U.S. rice trade patterns are shown in Table 15. One of the main differences between the actual trade and the optimum base solution was that the U.S. would ship to fewer countries and regions in the base solution than they actually did in 1990. In 1990, 30 countries and regions imported rice from the U.S. In the base optimum solution this number would be reduced to only 10.

Major actual rice importers of U.S. rice, such as Iraq, Saudi Arabia, the E.C., Middle East and other African countries, would be replaced, in the base solution, by countries like, Mexico, Peru, Senegal, Liberia, and Sierra Leone, and countries of the Central America and Caribbean region. In other cases, countries like Brazil and Mauritania seem to be potential importers for U.S. rice.

Table 15. Comparison of U.S. Trade Patterns of Actual and Optimum Solution (Base Solution)

Importing Countries or Regions[1]	Actual (A)[2]	Optimum (B)	% Change (B-A)/A*100
	(1,000 M.T. milled equivalent)		
Angola	50		-100.0
Bangladesh	1		-100.0
Brazil		163	
Canada	121		
Ghana	25		-100.0
Guinea	25	120	380.0
Hong Kong	5		-100.0
Indonesia	8		-100.0
Iraq	222		-100.0
Kuwait	1		-100.0
Liberia	61	128	109.8
Madagascar	2		-100.0
Malaysia	1		-100.0
Mauritania		45	
Mexico	113	174	54.0
Peru	72	258	258.3
Saudi Arabia	191		-100.0
Senegal	38	320	742.1
Sierra Leone	15	121	232.0
Singapore	5		-100.0
South africa	109		-100.0
Syria	10		-100.0
U.A. Emirates	4		-100.0
Zaire	1		-100.0
E.C.10[3]	331	421	27.2
Ot.West Europe	86		-100.0
Eastern Europe	12		-100.0
Ot.C.Amer/Carib.	353	385	9.1
Ot.S.S. Africa	177		-100.0
Others South Asia	19		-100.0
Ot.E.Asia/Oceania	3		-100.0
Ot.Md.East/N.Afr.	363		-100.0
Total	2424	2135	-11.9

[1] See footnote of Table 9 for regions' shorthand.
[2] (U.S.D.A., 1991).
[3] E.C.10 in this case means all the E.C. countries except Spain and Italy, the two rice exporting countries.

International Import Prices

As shown in Table 16, the average equilibrium trade price obtained from the base solution would decrease, as compared to that of its actual 1990 level. This is consistent with the fact that in the base solution net returns were maximized. The world average equilibrium price for rice would be 318.3 dollars per metric ton in the base solution, 16.2 percent lower than the actual world average import price of 380 dollars per metric ton. Among the importing countries, the equilibrium import prices for all the African countries, Cuba, and Sri Lanka would be relatively higher than actual levels. On the contrary, for all other countries, the equilibrium import prices would be relatively lower than their actual price levels. It is important to note that of all the regions, the 10 importing countries of the E.C. would have the largest price decreases. E.C. import equilibrium prices would decrease by more than 50 percent (from 679.7 to 338.4 dollars respectively), as compared to actual price paid.

Scenario II. Effects of U.S. Cargo Preference Policies

As mentioned above in Chapter III, there were some differences in transportation costs between U.S. flag vessels and Non-U.S. flag vessels. The former are usually higher than the latter. In this study, the base solution has been a result of using the lowest cost level provided

Table 16. Comparison of World Trade Prices of Actual and Optimum Solutions for Importing Countries or Regions

Importing Countries or Regions[1]	Actual Import Prices (A)	Optimum Import[2] Prices (B)	% Change from A (B-A)/A*100
	--- (C.I.F. $ per M.T.) ---		
Angola	268.4	332.7	24.0
Bangladesh	314.8	307.4	-2.4
Brazil	363.0	339.7	-6.4
Cameroon	294.5	337.9	14.7
Canada	390.4	321.4	-17.7
Cuba	229.8	308.1	34.1
Ghana	300.0	336.0	12.0
Guinea	337.2	337.3	0.0
Hong Kong	400.0	289.8	-27.6
Indonesia	285.0	286.5	0.5
Iran	354.1	320.7	-9.4
Iraq	364.7	320.8	-12.0
Kuwait	617.6	320.7	-48.1
Liberia	369.2	338.4	-8.3
Madagascar	233.0	321.2	37.9
Malaysia	302.7	297.5	-1.7
Mauritania	220.0	335.4	52.5
Mexico	351.0	309.6	-11.8
Nigeria	272.0	338.2	24.3
Peru	344.9	326.9	-5.2
Philippines	215.4	237.0	10.0
Reunion	386.3	319.7	-17.2
Saudi Arabia	565.0	319.8	-43.4
Senegal	230.0	335.4	45.8
Sierra Leone	354.5	337.3	-4.9
Singapore	370.3	293.9	-20.6
Somalia	350.0	319.6	-8.7
South Africa	294.9	328.4	11.4
Sri Lanka	268.4	307.7	14.6
Syria	334.3	327.2	-2.1
Taiwan	352.0	286.9	-18.5
Tanzania	352.9	320.2	-9.3
U.A. Emirates	387.1	318.3	-17.8
Ex-U.S.S.R.	371.5	297.8	-19.8
Zaire	445.2	332.7	-25.3

(Continued)

Table 16. (Continued)

Importing Countries or Regions[1]	Actual Import Prices (a)	Optimum Import[2] Prices (b)	% Change from A (b-a)/a*100
	---(C.I.F. $ per M.T.)---		
E.C.10	679.7	338.4	-50.2
Others West. Europe	536.5	332.4	-38.0
Eastern Europe	425.7	316.2	-25.7
Ot.C.Am.and Caribb.	324.7	314.3	-3.2
Ot.S.S.Africa	297.0	324.2	9.2
Others South Asia	352.0	307.3	-12.7
Ot.E. Asia/Oceania	317.6	295.9	-6.8
Ot.Md East/N.Africa	367.1	326.8	-11.0
Average[3]	380.0	318.3	-16.2

[1] See footnote of Table 9 for regions' shorthand.
[2] Results of the base solution.
[3] Weighted by import volumes.

by using Non-U.S. flag vessels. The effects of different level of use of U.S. flag vessels, on the optimum solution is discussed in this section.

According to the cargo preference policy amendment of 1990 (U.S. Congress, 1990), 75 percent of government-sponsored rice exports should have been shipped by U.S. flag vessels in 1990. Likewise, during 1989 and 1991, on average, government-sponsored rice programs accounted for 14.7 percent of the total exports in those years (Appendix Table 4). Therefore, the solutions discussed in this section have used 50, 75, and 100 percent of that 14.7 percent of rice shipped under government-sponsored programs.

Trade Volumes

Results of three alternative U.S. cargo preferences policies are shown in Table 17. As a whole, these results show that the effects of the U.S. cargo preference policies on the world trade volumes in the rice trade market are minor. However, among exporting countries, the U.S. export volumes would be affected, to some extent. Decreases ranged from 0.7 percent to 1.6 percent, if cargo preference policy dictated that 50 and 100 percent of government-sponsored traded rice, respectively, were shipped on U.S. flag vessels. If the U.S. flag vessels would ship 75 percent of the total U.S. government-sponsored rice exports, the actual case during 1990, total U.S. rice trade would decreased by

Table 17. Effects of Different Levels of the U.S. Cargo Preference Policy on the Optimum Rice Trade Volumes of the World Market

Exporting Countries	Optimum Export Volumes				Percentage Change From Base Solution		
	Base[1] (A)	50%[2] (B)	75%[2] (C)	100%[2] (D)	50% (B-A)/A*100	75% (C-A)/A*100	100% (D-A)/A*100
	--------(1000 M.T.)-------------				-----------(%)-------------------		
Argentina	33	33	33	33	0.0	0.0	0.0
Australia	364	364	364	364	0.0	0.0	0.0
Burma	234	234	234	234	0.0	0.0	0.0
China	2053	2057	2061	2066	0.2	0.4	0.6
Italy	414	414	414	414	0.0	0.0	0.0
Pakistan	876	877	877	877	0.0	0.0	0.0
Thailand	3996	3998	3999	4000	0.1	0.1	0.1
U.S.	2135	2119	2109	2100	-0.7	-1.2	-1.6
Uruguay	243	243	243	243	0.0	0.0	0.0
Vietnam	1904	1905	1906	1907	0.1	0.1	0.2
Total	12252	12244	12240	12238	-0.1	-0.1	-0.1

[1] Base solution.
[2] Refers to percentages of U.S. Government assisted shipments under cargo preference policies. 75% was the actual percentage for 1990.

1.2 percent, in relation to the optimum results of the base solution. China would be a potential beneficiary of U.S. rice export losses, resulting from U.S. cargo preference policies.

Results shown in Table 17 indicate that the larger increase in the percentage of U.S. flag vessels used for hauling the U.S. government handled rice exports, the larger the decrease in the U.S. rice export volumes in the world rice market. This is the case even if these decreases were proportionally smaller than those changes in the percentages of rice obligated to be shipped on U.S. flag vessels. Without financial support for the U.S. flag vessel users, the U.S. cargo preferences policy would reduce the U.S. export revenues.

U.S. Trade Patterns

The optimum U.S. rice trade patterns resulting from the base solution, along with additional solutions in which U.S. cargo preference policies would be enacted, are showed in Table 18. Rice importing countries of the E.C. and Brazil would be the U.S. partners most affected in their trade under the effect of the U.S. cargo preference policies analyzed. On the contrary, Mexico and other Central American and Caribbean countries would slightly increase their levels of rice imports, resulting from these policies.

Table 18. Comparison of U.S. Trade Pattern Optimum Solution and the Results of Different Levels of U.S. Cargo Preference Policy

Importing Countries or Regions[1]	Optimum Import Volumes				Percentage Change From Base Solution		
	Base[2] (A)	50%[3] (B)	75%[3] (C)	100%[3] (D)	50% (B-A)/A*100	75% (C-A)/A*100	100% (D-A)/A*100
	----------(1000 M.T.)-----------				---------------(%)---------------		
Brazil	163	160	158	157	-1.8	-3.1	-3.7
Guinea	120	120	120	120	0.0	0.0	0.0
Liberia	128	128	128	128	0.0	0.0	0.0
Mauritania	45	45	45	45	0.0	0.0	0.0
Mexico	174	175	176	178	0.6	1.1	2.3
Peru	258	259	259	260	0.4	0.4	0.8
Senegal	320	320	320	320	0.0	0.0	0.0
Sierra Leone	121	120	120	120	-0.8	-0.8	-0.8
E.C.10	421	403	392	380	-4.2	-6.8	-9.7
Ot.C.Am/Carib.	385	389	391	392	1.0	1.6	1.8
Total	2135	2119	2109	2100	-0.7	-1.2	-1.6

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.
[3] Refers to percentages of U.S. Government assisted shipments under cargo preference policies.

International Import Prices

The impact of the U.S. cargo preference policy on the equilibrium prices are shown in Table 19. This table reveals that no major impacts on the world rice trade prices result.

Equilibrium prices would decrease in Mexico and other Central American and Caribbean countries. For the rest of importing countries or regions there would be little change in terms of C.I.F. international price. The total average equilibrium price would be unaffected as a result of this kind of policy.

Scenario III: Effects of Changes in Ocean Freight Rates of Major Rice Exporting Countries

The effects of changes of ocean freight rates in specific rice exporting countries, on volumes of trade, trade patterns, and equilibrium import prices, are evaluated in this section.

Trade Volumes

Tables 20, 21, 22, and 23 show the optimum rice volumes resulting from different levels of change in rice ocean freight rates for major exporting countries, such as the U.S., Thailand, China, and Vietnam.

In general, as expected, decreasing ocean freight rates in a particular rice exporting country would have the effect

Table 19. Effects of Different Levels of U.S. Cargo Preferences Policy on the Equilibrium International Trade Prices

Importing Countries or Regions[1]	Equilibrium Trade Prices				% of Change from Base Solution		
	Base (A)	50%[2] (B)	75%[2] (C)	100%[2] (D)	50% (B-A)/A*100	75% (C-A)/A*100	100% (D-A)/A*100
	------(C.I.F. $ per M.T.)---------				-----------------(%)-------------		
Angola	332.7	333.1	333.3	333.5	0.1	0.2	0.2
Bangladesh	307.4	307.7	307.9	308.1	0.1	0.2	0.2
Brazil	339.7	340.2	340.4	340.7	0.1	0.2	0.3
Cameroon	337.9	338.3	338.5	338.7	0.1	0.2	0.2
Canada	321.4	321.8	322.0	322.2	0.1	0.2	0.2
Cuba	308.1	304.8	303.1	302.2	-1.1	-1.6	-1.9
Ghana	336.0	336.4	336.6	336.8	0.1	0.2	0.2
Guinea	337.3	337.5	337.6	337.7	0.1	0.1	0.1
Hong Kong	289.8	290.2	290.4	290.6	0.1	0.2	0.3
Indonesia	286.5	286.5	286.5	286.5	0.0	0.0	0.0
Iran	320.7	321.0	321.2	321.4	0.1	0.2	0.2
Iraq	320.8	321.1	322.3	323.3	0.1	0.5	0.8
Kuwait	320.7	321.0	321.2	321.4	0.1	0.2	0.2
Liberia	338.4	339.0	339.0	339.2	0.2	0.2	0.2
Madagascar	321.2	321.5	321.7	321.9	0.1	0.2	0.2
Malaysia	297.5	297.8	298.0	298.2	0.1	0.2	0.2
Mauritania	335.4	335.5	335.4	335.4	0.0	0.0	0.0
Mexico	309.6	306.5	304.8	303.1	-1.0	-1.6	-2.1
Nigeria	338.2	338.5	338.7	338.9	0.1	0.1	0.2
Peru	326.9	325.9	325.3	324.7	-0.3	-0.5	-0.7
Philippines	237.0	237.0	237.0	237.0	0.0	0.0	0.0
Reunion	319.7	320.0	320.2	320.4	0.1	0.2	0.2
Saudi Arabia	319.8	320.0	320.2	320.4	0.1	0.2	0.2

(Continued)

Table 19. (Continued)

Importing Countries or Regions[1]	Equilibrium Trade Prices				% of Change from Base Solution		
	Base (A)	50%[2] (B)	75%[2] (C)	100%[2] (D)	50% (B-A)/A*100	75% (C-A)/A*100	100% (D-A)/A*100
	------(C.I.F. $ per M.T.)---------				----------------(%)--------------		
Senegal	335.4	335.5	335.4	335.4	0.0	0.0	0.0
Sierra Leone	337.3	337.5	337.6	337.7	0.1	0.1	0.1
Singapore	293.9	294.2	294.4	294.6	0.1	0.2	0.2
Somalia	319.6	319.9	320.1	320.3	0.1	0.2	0.2
South Africa	328.4	328.7	328.9	329.1	0.1	0.2	0.2
Sri Lanka	307.7	308.0	308.2	308.4	0.1	0.2	0.2
Syria	327.3	327.6	327.8	328.0	0.1	0.2	0.2
Taiwan	286.9	287.3	287.5	287.7	0.1	0.2	0.3
Tanzania	320.2	320.5	320.7	320.9	0.1	0.2	0.2
U.A. Emirates	318.3	318.6	318.8	319.0	0.1	0.2	0.2
U.S.S.R.	297.8	298.2	298.4	298.6	0.1	0.2	0.3
Zaire	332.7	333.1	333.3	333.5	0.1	0.2	0.2
E.C.10	338.4	338.7	338.9	339.1	0.1	0.1	0.2
Ot.W. Europe	332.4	332.7	332.9	333.1	0.1	0.2	0.2
East Europe	316.2	316.5	316.7	316.9	0.1	0.2	0.2
Ot.C.Am/Carib.	314.3	311.8	310.4	309.0	-0.8	-1.2	-1.7
Ot.S.S.Africa	324.2	324.5	324.7	324.9	0.1	0.2	0.2
Ot.S. Asia	307.3	307.7	307.9	308.1	0.1	0.2	0.3
Ot.E.As./Oc.	295.9	296.2	296.4	296.6	0.1	0.2	0.2
Ot.Md.E./N.Af.	326.8	327.1	327.3	327.5	0.1	0.2	0.2
Average	318.3	318.3	318.4	318.5	0.0	0.0	0.1

[1] See footnote of Table 9 for regions' shorthand.
[2] Refer to percentages of trade shipped under U.S. cargo preference policies. 75 percent was the actual value for 1990.

Table 20. Effects of Percent Changes in U.S.'s Ocean Freight Rates on the Optimum International Trade Volumes

Exporting Countries	Optimum Export Volumes				
	- 50%	- 25%	Base[1]	+ 25%	+ 50%
	(1000 M.T.)				
Argentina	32	33	33	33	34
Australia	361	362	364	365	367
Burma	230	233	234	235	237
China	1960	2006	2053	2102	2145
Italy	414	414	414	414	415
Pakistan	875	875	876	877	878
Thailand	3968	3982	3996	4010	4024
U.S.	2323	2230	2135	2040	1946
Uruguay	242	242	243	243	243
Vietnam	1880	1892	1904	1915	1927
Total	12285	12269	12252	12234	12216
	(% Change from Base)				
Argentina	-3.0	0.0	0.0	0.0	3.0
Australia	-0.8	-0.5	0.0	0.3	0.8
Burma	-1.7	-0.4	0.0	0.4	1.3
China	-4.5	-2.3	0.0	2.4	4.5
Italy	0.0	0.0	0.0	0.0	0.2
Pakistan	-0.1	-0.1	0.0	0.1	0.2
Thailand	-0.7	-0.4	0.0	0.4	0.7
U.S.	8.8	4.4	0.0	-4.4	-8.9
Uruguay	-0.4	-0.4	0.0	0.0	0.0
Vietnam	-1.3	-0.6	0.0	0.6	1.2
Total	0.3	0.1	0.0	-0.1	-0.3

[1] Base solution.

Table 21. EFfects of Percent Changes in China's Ocean Freight Rates on the Optimum International Trade Volumes

Exporting Countries	Optimum Export Volumes				
	- 50%	- 25%	Base[1]	+ 25%	+ 50%
	(1000 M.T.)				
Argentina	23	28	33	37	38
Australia	343	354	364	370	373
Burma	212	223	234	246	251
China	3216	2652	2053	1533	1203
Italy	410	412	414	416	417
Pakistan	865	870	876	883	886
Thailand	3829	3911	3996	4091	4132
U.S.	2001	2072	2135	2176	2198
Uruguay	239	241	243	243	244
Vietnam	1792	1835	1904	1985	2031
Total	12930	12598	12252	11980	11773
	(% Change from Base)				
Argentina	-30.3	-15.2	0.0	12.1	15.2
Australia	-5.8	-2.7	0.0	1.6	2.5
Burma	-9.4	-4.7	0.0	5.1	7.3
China	56.6	29.2	0.0	-25.3	-41.4
Italy	-1.0	-0.5	0.0	0.5	0.7
Pakistan	-1.3	-0.7	0.0	0.8	1.1
Thailand	-4.2	-2.1	0.0	2.4	3.4
U.S.	-6.3	-3.0	0.0	1.9	3.0
Uruguay	-1.6	-0.8	0.0	0.0	0.4
Vietnam	-5.9	-3.6	0.0	4.3	6.6
Total	5.5	2.8	0.0	-2.2	-3.9

[1] Base solution.

Table 22. Effects of Percent Changes in Thailand's Ocean Freight Rates on the Optimum International Trade Volumes

Exporting Countries	Optimum Export Volumes				
	- 50%	- 25%	Base[1]	+ 25%	+ 50%
	(1000 M.T.)				
Argentina	27	30	33	34	36
Australia	352	358	364	366	368
Burma	237	236	234	228	224
China	1913	1951	2053	2175	2281
Italy	412	413	414	415	416
Pakistan	877	877	876	878	879
Thailand	4438	4220	3996	3793	3603
U.S.	2063	2098	2135	2149	2166
Uruguay	241	242	243	243	243
Vietnam	1925	1925	1904	1930	1966
Total	12485	12350	12252	12211	12182
	(% Change from Base)				
Argentina	-18.2	-9.1	0.0	3.0	9.1
Australia	-3.3	-1.6	0.0	0.5	1.1
Burma	1.3	0.9	0.0	-2.6	-4.3
China	-6.8	-5.0	0.0	5.9	11.1
Italy	-0.5	-0.2	0.0	0.2	0.5
Pakistan	0.1	0.1	0.0	0.2	0.3
Thailand	11.1	5.6	0.0	-5.1	-9.8
U.S.	-3.4	-1.7	0.0	0.7	1.5
Uruguay	-0.8	-0.4	0.0	0.0	0.0
Vietnam	1.1	1.1	0.0	1.4	3.3
Total	1.9	0.8	0.0	-0.3	-0.6

[1] Base solution.

Table 23. Effects of Percent Changes in Vietnam's Ocean Freight Rates on the Optimum International Trade Volumes

Exporting Countries	Optimum Export Volumes				
	- 50%	- 25%	Base[1]	+ 25%	+ 50%
	(1000 M.T.)				
Argentina	28	31	33	34	34
Australia	355	360	364	365	366
Burma	232	233	234	235	236
China	1948	1976	2053	2109	2172
Italy	413	414	414	415	415
Pakistan	876	876	876	877	879
Thailand	3984	3991	3996	4012	4031
U.S.	2079	2106	2135	2143	2150
Uruguay	241	242	243	243	243
Vietnam	2296	2101	1904	1784	1646
Total	12452	12330	12252	12217	12172
	(% Change from Base)				
Argentina	-15.2	-6.1	0.0	3.0	3.0
Australia	-2.5	-1.1	0.0	0.3	0.5
Burma	-0.9	-0.4	0.0	0.4	0.9
China	-5.1	-3.8	0.0	2.7	5.8
Italy	-0.2	0.0	0.0	0.2	0.2
Pakistan	0.0	0.0	0.0	0.1	0.3
Thailand	-0.3	-0.1	0.0	0.4	0.9
U.S.	-2.6	-1.4	0.0	0.4	0.7
Uruguay	-0.8	-0.4	0.0	0.0	0.0
Vietnam	20.6	10.4	0.0	-6.3	-13.5
Total	1.6	0.6	0.0	-0.3	-0.7

[1] Base solution.

increasing the volume of exports for this particular country. On the contrary, increasing freight rates for one particular rice exporting country would lead to reductions of rice exports in this country, in favor of the world market share for other exporting countries.

The particular effect of decreasing ocean freight rates would be different from one country to other. Results indicate that the effect of U.S. changing ocean freight rates would have a minor impact on export volumes, as compared to the same effects on export volumes resulting from decreasing ocean freight rates in countries like China, Thailand, and Vietnam. For example, a 25 percent decrease of U.S. ocean freight rate would raise U.S. rice exports in 4.4 percent. The same reduction would raise its rice exports by 5.6 percent for Thailand, 10.4 for Vietnam, and 29.2 for China. Likewise, a 50 percent decrease of U.S. ocean transportation rates would increase U.S. rice exports by 8.8 percent. Exports would increase 11.1 percent for Thailand, 20.6 percent for Vietnam, and 56.6 percent for China.

Notice that related to the aforementioned results, changes in the total level of rice world trade would be more responsive to changes in ocean freight rates in China than to the some changes in the U.S.. Thailand and Vietnam would stay in a intermediate position.

<u>Trade Patterns</u>

Rice trade patterns resulting from changes in ocean freight are shown in Tables 24 to 27. In general, the U.S. rice trade patterns did not vary much when U.S. ocean freight rates change between 25 and 50 percent, except for Brazil and the European Community countries. The partnership between the U.S. and Brazil, and between the U.S. and rice importing countries of the European Community, would be the most affected by changes in ocean freight rates. For instance, if U.S. ocean freight rates were reduced by 50 percent, the U.S. exports to Brazil and the European Community would increase from 163 M.T. to 205 M.T., and from 421 M.T. to 621 M.T., respectively. In these some circumstances, decreased exports to Mexico, Peru, and other Central American and Caribbean countries would result (Table 24). The rest of U.S. rice importing countries or regions slightly would increase their import volumes from the U.S. if ocean freight rates would decrease, and would slightly decrease their import volumes if those rates were increased.

Unlike the U.S., changes in China's ocean freight rates would have not only important effects on the rice export levels of this country, but also notable effects on its rice trade pattern (Table 25). In the base solution, China would trade with nine countries and regions. This number would increase to 12 and 14 if ocean freight rates would decrease by 25 and 50 percent, respectively. Likewise, the number of

Table 24. Effects of Percent Changes in U.S.'s Ocean Freight Rates on its Optimum Trade Pattern

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	(1000 M.T.)				
Brazil	205	183	163	143	130
Guinea	121	120	120	120	120
Liberia	128	128	128	128	127
Mauritania	45	45	45	45	45
Mexico	161	168	174	182	188
Peru	255	257	258	260	261
Senegal	320	320	320	320	319
Sierra Leone	121	121	121	120	120
E.C.10	621	523	421	318	212
Ot.C.Am/Caribb.	346	365	385	404	424
Total	2323	2230	2135	2040	1946

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

Table 25. Effects of Percent Changes in China's Ocean Freight Rates on its Optimum Trade Pattern

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	(1000 M.T.)				
Angola	46	45	45		
Brazil	464	20			
Cameroon	46	45			
Cuba	168	165	163	160	
Canada	40	136	136	135	53
Ghana	71	69	67		
Hong Kong			408	408	408
Nigeria	98	82			
Somalia	293			92	
Syria	142				
Taiwan		125	134	143	145
Ex-U.S.S.R.	224	585	591	595	597
Zaire	116	114	113		
E.C.10	1136	1177	396		
O.W.Europe	95	89			
O.Md.E./N.Af.	277				
Total	3216	2652	2053	1533	1203

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

Table 26. Effects of Percent Changes in Thailand's Ocean Freight Rates on its Optimum Trade Pattern

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	(1000 M.T.)				
Angola	45				
Brazil	384				
Bangladesh			128	139	146
Cameroon	46	45	45		
Cuba	164				
Ghana	69	68			
Hong Kong					407
Iran		72	73	69	63
Iraq	260	395	395	394	393
Kuwait		101	101	101	101
Madagascar				136	136
Malaysia				401	416
Nigeria	86	77	69		
Reunion				53	53
Singapore			222	222	222
Somalia				93	93
South Africa	291	290	290		
Sri Lanka			117	122	126
Syria	141	141	141	141	
U.A.Emirates		232	232	232	231
E.C.10	1018	1047	506		
Zaire	114				
O.W.Europe	89	87	85		
O.S.S.Africa	783	720	543	302	517
O.S.Asia			106	123	362
O.E.As./Ocean.				327	337
O.Md.E./N.Af.	948	945	943	938	
Total	4438	4220	3996	3793	3603

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

Table 27. Effects of Percent Changes in Vietnam's Ocean Freight Rates on its Optimum Trade Pattern

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	(1000 M.T.)				
Angola	45				
Cameroon	45	45			
Ghana	68				
Madagascar			136		
Malaysia			386	393	401
Nigeria	81	74			
Reunion			53		
Saudi Arabia	111	593	593	593	
Singapore				222	222
Somalia	142	118	93		
South Africa	290	122			
Sri Lanka				16	109
Tanzania			78		
Zaire	113				
E.C.10	1314	1063			
O.W.Europe	87	86			
O.S.S. Africa			236		
O.S. Asia				224	570
O.E.As./Oceania			329	336	344
Total	2296	2101	1904	1784	1646

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

its rice partner countries would decrease to six and four countries if ocean freight rates were increased by 25 and 50 percent respectively. Countries or regions increasing Chinese imports would be Brazil, Cuba, the E.C., Nigeria, Syria, non-E.C. countries of Western Europe and countries of the Middle East. The affected countries, as consequence of increasing freight rates would be Angola, Cameroon, Ghana, Zaire, and those importing countries of the European Community.

Rice trade patterns for Thailand were initially more diversified (15 countries and regions traded with this exporting country in the base solution) than those from other exporting countries. This diversification would be maintained as a result of variations in freight rates. New countries or regions trading with Thailand if ocean freight rates were diminished, would include Angola, Brazil, Cuba, Ghana, the E.C., and Zaire. Countries that would stop importing from Thailand, as a result of the aforementioned decreased levels of freight rates, would be Iran, Kuwait, Singapore, Sri Lanka, and U.A. Emirates (Table 26). New countries trading with Thailand as a result of increasing freight rates would include Bangladesh, Madagascar, Malaysia, Reunion, Somalia, and others countries from Asia and Oceania. Also as a result of increasing ocean freight rates, countries like Nigeria, South Africa, those of the European Community, and other Western Europe countries would stop importing rice from Thailand. In short, there is a rice trade pattern for low ocean freight rates in Thailand, and another for higher ocean freight rates. Both are diversified.

For Vietnam, the impact of decreasing ocean freight rates would change trade patterns more than was the case for the United States. Vietnam would increase diversification if freight rates were diminished. Trade with countries or regions such as Angola, Brazil, Ghana, South Africa, Zaire, the E. C., and other Western Europe countries would be included. Madagascar, Malaysia, Reunion, Tanzania, and some other countries of South Asia would be excluded (Table 27). If freight rates were increased, as compared to the base optimum solution, new Vietnam's partners would be Hong Kong, Singapore, Sri Lanka, and others from Asia and Oceania. On the contrary, countries such as Madagascar, Reunion, Somalia, Tanzania, and other African countries, would stop importing rice from this exporting country.

International Import Prices

If ocean freight rates were diminished by 50 percent in China, Thailand, and Vietnam, equilibrium import prices would decrease, at average, at levels of 3.1, 1.0 and 0.8 percent respectively (Table 28). Average prices would remain almost constant if U.S. ocean freight rates were

Table 28. Effects of Changes in Ocean Freight Rates of Major Exporting Countries on the Average[1] International Trade Prices

Exporting Countries	Percentage of Change in Ocean freight Rates: Decreases 50 %	Decreases 25 %	Base Solution	Increases 25 %	Increases 50 %
	-------------(C.I.F.$/ M.T.)---------------				
China	308.3	313.4	318.3	322.6	324.9
Thailand	315.1	316.9	318.2	319.4	320.6
U.S.	317.9	318.1	318.3	318.5	318.8
Vietnam	315.8	317.2	318.3	319.1	320.8
	--------(% Change from Base Solution)-------				
China	-3.1	-1.5	0.0	1.4	2.1
Thailand	-1.0	-0.4	0.0	0.4	0.8
U.S.	-0.1	-0.1	0.0	0.1	0.2
Vietnam	-0.8	-0.3	0.0	0.3	0.8

[1] Average weighted by import volumes.

decreased in 25, and 50 percent, respectively. Similarly, equilibrium import prices would increase, on average, if ocean freight rates were increased in China, Thailand, and Vietnam. Results from increasing U.S. freight rates would have little effect on import prices.

Also Table 28 show that changes of 50 percent in U.S. ocean freight rates would lead to changes in average import prices ranging between 317.9 and 318.8 dollars per M.T. The same price variation range in China would be between 308.3 and 324.9 dollars per M.T. For Thailand it would be between 315.1 and 320.6 dollars per M.T., while these values would be 315.8 and 320.8 for Vietnam.

These findings are consistent with the aforementioned results which indicated that changes in ocean freight rates in major rice exporting countries like China, Thailand, and Vietnam would tend to have a greater effect than that produced due to changes in U.S. ocean freight rates, in terms of rice trade volumes and trade patterns.

Scenario IV: Effects of Simultaneous Changes in all Ocean Freight Rates

Trade Volumes

The optimum flows from changing ocean freight rates in all the rice exporting countries and regions, as compared to the optimum results of the base solution, are shown in Table

29. As expected, these results indicated that simultaneous decreases of 25 and 50 percent in all ocean transportation costs would lead to increases of 3.7 and 7.5 percent in world volumes trade, respectively. Increases of 25 and 50 percent in ocean freight rates would lead to 3.4 and 6.7 percent decreased volumes of total rice traded in the international market.

It should be noted that countries with greater market shares in the international rice market, except the U.S., would be relatively more responsive to changes in ocean freight rates. Countries such as China, for instance, would decrease its rice exports by 28.5 percent if ocean freight rates were increased by 50 percent, and would increase its rice exports by 31.5 percent if ocean freight rates were decreased in 50 percent. Thailand, Vietnam, and Australia also showed important changes in their rice exports due to ocean freight rate variations. Small rice exporting countries like Argentina, Uruguay, Italy, and Pakistan, would slightly change their world market shares under this new ocean freight rates structure. The market shares of other big rice exporting countries, such as the U.S. and Burma, would be neutral, in the sense that they basically would not change their level of exports if ocean freight rates were varied simultaneously for all the world rice trade routes (Table 29).

Table 29. Effects of Simultaneous Changes in all Ocean Freight Rates on the Optimum International Trade Volumes

Exporting Countries	Optimum Export Volumes				
	- 50%	- 25%	Base[1]	+ 25%	+ 50%
	(1000 M.T.)				
Argentina	25	29	33	36	36
Australia	371	368	364	357	345
Burma	234	233	234	234	234
China	2700	2372	2053	1743	1467
Italy	411	413	414	416	417
Pakistan	869	872	876	881	884
Thailand	4162	4073	3996	3936	3841
U.S.	2138	2137	2135	2137	2137
Uruguay	240	241	243	243	243
Vietnam	2024	1963	1904	1847	1783
Total	13174	12701	12252	11830	11387
	(% Change from Base)				
Argentina	-24.2	-12.1	0.0	9.1	9.1
Australia	1.9	1.1	0.0	-1.9	-5.2
Burma	0.0	-0.4	0.0	0.0	0.0
China	31.5	15.5	0.0	-15.1	-28.5
Italy	-0.7	-0.2	0.0	0.5	0.7
Pakistan	-0.8	-0.5	0.0	0.6	0.9
Thailand	4.2	1.9	0.0	-1.5	-3.9
U.S.	0.1	0.1	0.0	0.1	0.1
Uruguay	-1.2	-0.8	0.0	0.0	0.0
Vietnam	6.3	3.1	0.0	-2.9	-6.4
Total	7.5	3.7	0.0	-3.4	-7.1

[1] Base solution.

Trade Patterns

Tables 30 to 33 show changes in the international trade patterns of the major rice exporting countries, associated with simultaneous changes in freight rates of all the routes. Notice from these tables that changing ocean freight rates would alter optimum volumes of U.S. rice exports in a minor way. Except for the E.C., other countries would decrease their levels of rice imports from the U.S., if ocean freight rates were increased. These decreases would be relatively low, as is the case for Canada, Mexico, Peru and Liberia. In other cases, these changes would be relatively high, such as that in Brazil. Brazil would stop importing U.S. rice at 25 percent level of increase in ocean freight rates. Guinea, Sierra Leone, and Central American and Caribbean countries would decrease imports but would remain as importers (Table 30).

Simultaneous changes in ocean freight rates of all rice exporting countries and regions would have a greater impact in the base optimum solution for China than in the U.S., in terms of both volumes of total rice traded and trade patterns. If freight rates were decreased by 50 percent, E.C. rice imports from China would increase 91 percent (from 396 thousand M.T. to 913 thousand M.T.). If freight rates were increased by 50 percent, the E.C. countries would stop importing rice from China. Similar results were obtained for rice imported by Cuba.

Table 30. Effects of Simultaneous Changes in all Ocean Freight Rates on the Optimum Trade Pattern of the U.S.

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	---------------(1000 M.T.)----------------				
Brazil	468	373	163		
Guinea	136	128	120	112	103
Liberia	134	131	128	125	121
Mauritania	48	46	45	44	42
Mexico	184	179	174	169	162
Peru	270	264	258	252	245
Senegal	334	327	320	312	304
Sierra Leone	135	127	121	113	106
E.C.10		155	421	648	717
O.C.Am./Carib.	429	407	385	362	337
Total	2138	2137	2135	2137	2137

[1] See footnote of Table 9 for regions' shorthand.
[1] Base solution.

Table 31. Effects of Simultaneous Changes in all Ocean Freight Rates on the Optimum Trade Pattern of China

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	--------------(1000 M.T.)----------------				
Angola	47	46	45	40	32
Brazil	108				
Cuba	171	167	163	159	13
Canada	137	136	136	135	134
Ghana	72	70	67	65	62
Hong Kong	400	404	408	410	417
Taiwan	131	133	134	136	136
Ex-U.S.S.R.	602	596	591	586	570
Zaire	119	116	113	109	103
E.C.10	913	704	396	103	
Total	2700	2372	2053	1743	1467

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

Table 32. Effects of Simultaneous Changes in all Ocean Freight Rates on the Optimum Trade Pattern of Thailand

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	(1000 M.T.)				
Brazil	16				
Bangladesh	163	147	128	111	
Caameron	48	34	45	43	41
Iran	125	102	73	58	15
Iraq	406	401	395	389	382
Kuwait	102	101	101	101	100
Nigeria	116	95	69	45	31
Singapore	222	222	222	222	222
South Africa	296	293	290	287	280
Sri Lanka	135	126	117	107	98
Syria	143	142	141	140	139
U.A.Emirates	234	233	232	231	229
E.C.10	422	471	506	560	594
O.W.Europe	95	90	85	79	74
O.S.S.Africa	511	528	543	550	575
O.S. Asia	151	128	106	88	152
O.Md.E./N.Afr.	977	960	943	925	909
Total	4162	4073	3996	3936	3841

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

Table 33. Effects of Simultaneous Changes in all Ocean Freight Rates on the Optimum Trade Pattern of Vietnam

Importing Countries or Regions[1]	Optimum Import Volumes				
	- 50%	- 25%	Base[2]	+ 25%	+ 50%
	(1000 M.T.)				
Madagascar	140	138	136	135	133
Malaysia	398	392	386	378	370
Reunion	53	53	53	52	52
Saudi Arabia	598	595	593	591	589
Somalia	94	93	93	92	91
Tanzania	91	85	78	71	65
O.S.S.Africa	314	275	236	205	165
O.E.As/Oceania	336	332	329	323	318
Total	2024	1963	1904	1847	1783

[1] See footnote of Table 9 for regions' shorthand.
[2] Base solution.

Variations in volumes of rice, and rice trade patterns for Thailand and Vietnam would be relatively smaller than those for China, but larger than those for the U.S. (Tables 32 and 33).

International Import Prices

As trade theory suggests, lower levels of ocean freight rates would cause the international trade prices to decrease. The effects of decreasing ocean freight rates of rice would cause prices to be lower than those of the base solution, and increasing ocean freight rates would lead to increasing equilibrium prices, as compared to base solution prices (Table 34).

The average equilibrium world price would decrease from 318.3 in the base solution to 310.9, and 303.6, as a result of decreased ocean freight rates of 25 and 50 percent, respectively. This average price would increase from 318.3 to 325.8 and 333.7 if ocean freight rates were increased in 25 and 50 percent, respectively.

On a country basis, it can be noted in Table 34 that in the majority of importing countries the prices would vary notably due to changes in ocean freight rates. Countries in which these equilibrium prices would be relatively more responsive to changes in ocean freight rates would be Cuba, and most of African countries. International rice prices

Table 34. Effects of Simultaneous Changes in all Ocean Freight Rates on the Equilibrium International Trade Prices

Importing Countries or Regions[1]	Equilibrium Trade Prices					% Change Range
	- 25% (A)	- 50% (B)	Base Solution	+ 25% (C)	+ 50% (D)	(D-A)/A
	(C.I.F. $ per M.T.)					(%)
Angola	311.6	322.0	332.7	343.6	355.0	13.9
Bangladesh	298.9	303.1	307.4	311.9	316.9	6.0
Brazil	315.5	327.9	339.7	349.5	355.3	12.6
Cameroon	314.2	325.9	337.9	350.1	362.3	15.3
Canada	305.9	313.6	321.4	329.5	338.0	10.5
Cuba	299.7	304.2	308.1	312.7	317.9	60.7
Ghana	313.2	324.5	336.0	347.7	359.9	14.9
Guinea	314.3	326.1	337.3	349.2	361.7	47.4
Hong Kong	290.1	289.9	289.8	290.0	290.6	0.2
Indonesia	286.5	286.5	286.5	286.5	286.5	0.0
Iran	305.6	313.0	320.7	328.5	336.9	10.2
Iraq	305.6	313.1	320.8	328.6	337.0	10.3
Kuwait	305.6	313.0	320.7	328.5	336.9	10.2
Liberia	314.8	327.9	338.4	350.6	363.4	15.4
Madagascar	305.8	313.4	321.2	329.2	337.5	10.4
Malaysia	293.9	295.7	297.5	299.6	301.9	2.7
Mauritania	313.4	324.7	335.4	346.8	358.9	14.5
Mexico	300.5	305.3	309.6	314.6	320.1	6.5
Nigeria	314.3	326.2	338.2	350.4	362.9	15.5
Peru	309.1	318.3	326.9	336.2	346.1	12.0
Philippines	237.0	237.0	237.0	237.0	237.0	0.0
Reunion	305.0	312.3	319.7	327.3	335.2	9.9
Saudi Arabia	305.0	312.3	319.8	327.3	335.2	9.9
Senegal	313.4	324.7	335.4	346.8	358.9	14.5
Sierra Leone	314.3	326.1	337.3	349.2	361.7	15.1
Singapore	292.2	292.9	293.9	295.0	296.7	1.5
Somalia	305.0	312.2	319.6	327.2	335.1	9.9
South Africa	309.4	318.8	328.4	338.1	348.4	12.6
Sri Lanka	299.1	303.3	307.7	312.2	317.4	6.1
Syria	308.9	318.0	327.3	336.7	346.8	12.3
Taiwan	288.7	287.8	286.9	286.3	286.3	-0.8
Tanzania	305.3	312.7	320.2	327.9	336.0	19.9
U.A. Emirates	304.4	311.2	318.3	325.5	333.3	9.5
U.S.S.R.	294.1	295.9	297.8	300.0	302.6	8.5
Zaire	311.6	322.1	332.7	343.6	355.0	13.9
E.C.10	314.4	326.3	338.4	350.6	363.4	15.6
O.W. Europe	311.4	321.8	332.7	343.1	354.4	13.8
East. Europe	303.3	309.7	316.2	322.9	330.1	8.8
O.C.Am.& Ca.	302.8	308.9	314.3	320.5	327.1	8.0
Ot.S.S.Africa	307.3	315.7	324.2	332.9	342.1	11.3
O.S. Asia	298.9	303.1	307.4	311.9	316.9	6.0
O.As./Oceania	293.1	294.5	295.9	297.6	299.5	2.2
O.Midd. East	308.6	317.6	326.8	336.1	346.0	12.1
Average[2]	303.6	310.9	318.3	325.8	333.7	9.9

[1] See footnote of Table 9 for regions' shorthand.
[2] Weighted by import volumes.

would remain stable in Hong Kong, Taiwan, Indonesia, and the Philippines.

Summary

A reactive programming model was developed to estimate the effects of changes in ocean freight rates on rice exports, rice patterns, and equilibrium prices of 13 exporting and 43 importing countries and regions. The model was structured to account for 1990 rice trade flows and prices. Four different scenarios were utilized, in which different variations of ocean freight rates were compared to an optimum base solution of minimum transportation cost.

The primary findings were as follows: (1) The U.S.'s competitive position would be notably diminished under the optimum base solution as compared to its actual value in 1990. On the contrary, the competitive positions of China, Vietnam, and Thailand would be enhanced. (2) Different levels of U.S. cargo preference policies (50, 75, and 100 percent) would reduce the U.S. export volumes of rice slightly. (3) Effects of changes in ocean freight rates for individual rice exporting countries would have a greater impact on export levels, rice trade patterns, and import prices, for countries like China, Vietnam, and Thailand, than on the same variables measured for the United States. (4) Simultaneous changes in ocean freight rates of all the 13 exporting countries or regions, as compared to results of the base solution, show that only countries with large shares in the international rice market, such as China, Thailand, and Vietnam, would significantly change their export volumes. The competitive position of the U.S. would be neutral, in the sense that it basically would not change rice exports if ocean freight rates were simultaneously modified.

CHAPTER V

SUMMARY AND CONCLUSIONS

Although many studies have been conducted to analyze the international rice trade, the effects of ocean freight rates have received little attention. In this research, countries engaged in trade depended on the "trade resistant factors" such as transportation costs, tariffs, and other restrictions, as well as supply and demand.

The main objective of this study was to analyze the competitive position of the U.S., and other major rice exporting countries, under selected alternative levels of ocean freight rates in the world rice market. Specific objectives of the study were: (1) to describe international rice trade flows and to describe the major characteristics of the transportation rice industry around the world; (2) to develop a spatial equilibrium model to estimate equilibrium trade volumes of rice, trade prices, and international trade patterns; and (3) to analyze the effects of changes in different levels of ocean freight rates on rice trade.

A reactive programming model was used in order to solve the aforementioned spatial equilibrium problem, and to obtain equilibrium trade volumes, optimum trade prices, and international trade patterns. Then, comparisons were made between a base solution of minimum transportation cost (in which no cargo would be obligated to be shipped on specific flag vessels conditions), and results for the same year 1990, using four different scenarios: (1) the actual world trade as compared to the optimum rice trade obtained from the base solution, (2) different levels of U.S. cargo preference policies, (3) changes in ocean freight rates of major exporting countries: U.S., Thailand, China, and Vietnam, and (4) simultaneous changes in all ocean freight rates of the exporting countries and regions studied.

Results included the following:

- In the first scenario, the export volumes of the base solution for the U.S. would decrease, as compared to the actual U.S. exports, by 11.9 percent, from 2,424,000 M.T. to 2,135,000 M.T. The export volumes for China, however, would increase by 584.3 percent; those from Vietnam and Burma would increase by 26.9 and 25.3 percent, respectively. Results from the base solution also revealed that rice exports from Thailand would increase slightly by 1.8 percent, as compared to its respective actual exports.

The U.S., under the base solution, would ship to a smaller number of countries and regions than it actually did in 1990. This reduction would be from 30 actual different countries and regions to only 10 countries and regions in the base solution.

Likewise, the total export volumes of rice under the base solution would be 8.8 percent higher than those corresponding to the actual volumes exported for all the countries and regions in 1990. World average import prices would decrease notably from 380.0 to 318.3 C.I.F. dollars per metric ton.

- In order to evaluate the effects of cargo preference policy, a comparison was made between the base solution and three different levels of application of this policy: 50, 75, and 100 percent of the total U.S. government-assisted rice cargoes transported on U.S. flag vessels. This was called Scenario II. Results indicated that different levels of U.S. cargo preference policy would slightly reduce the U.S. export volumes, ranging between 0.7 and 1.6 percent export reduction as a result of using U.S. flag vessels to transport between 50 and 100 percent of the total U.S. government-assisted rice exports. Major exporting countries such as China, Vietnam, and Thailand, would benefit from the aforementioned losses of U.S. rice exports.

Likewise, Brazil and the E.C. are those rice partners of the U.S. whose imports would decrease as a result of U.S. cargo preference policies. International import prices would be affected very little because of the application of this policy.

- In the third scenario, the effects of changes in ocean freight rates for individual rice exporting countries were evaluated. Results suggest a greater impact of changes in ocean freight rates on export levels, rice trade patterns, and equilibrium prices, for countries like China, Vietnam, and Thailand, in this respective order, than on the same variables measured for the U.S. For example, an ocean freight rate decrease of 50 percent in each country would lead to increased levels of rice exports of 56.6 percent for China, 20.6 percent for Vietnam, 11.1 percent for Thailand, and 8.8 percent for the United States.

The U.S. rice trade pattern would be almost invariable if U.S. ocean freight rates were changed between 25 and 50 percent, except for the cases of Brazil and the European Community as a region. Changes in China and Vietnam, on the contrary, show not only important effects on their rice export levels, but also on their rice trade patterns. For instance, if ocean freight rates were increased, the number of rice import countries and regions would be reduced at 55 percent in China, and 40 percent in Vietnam, respectively.

- Simultaneous changes in ocean freight rates of all the 13 exporting countries and regions, as compared to those results obtained from the base solution, were evaluated in scenario IV. Only countries with large market shares in the international rice market, such as China, Thailand, and Vietnam, would change notably their export volumes as a consequence of decreasing ocean freight rates. The position of the U.S. would be neutral, in the sense that they basically would not change their level of exports if ocean freight rates were simultaneously modified.

In terms of trade patterns of major exporting countries, changes in simultaneous ocean freight rates would have less important effects than those changes in individual exporting countries (Scenario III). The most important effects were found for imports of Brazil and the E.C. in the U.S. trade patterns; Cameroon, Brazil, Hong Kong, and the E.C. in China trade patterns; Sub Sahara African countries in Vietnam trade patterns; and Bangladesh, Nigeria, South Africa, and other Southern Asian countries, in the case of Thailand trade patterns.

In Scenario IV, import prices, as expected, would move in the same direction of ocean freight rates. For instance, the average import prices would decrease from 318.3 to 303.6 $/M.T. if ocean freight rates were decreased at 50 percent, and the average raised from 318.3 to 333.7 if ocean freight rates were increased in the same proportion.

The general results of this study have shown that the competitive position of the U.S. rice industry would be reduced from its current level in the world rice market, if the use of U.S. flag vessels were encouraged. The results also indicated that even when ocean freight rates have an important influence on the international rice trade, its effect is different in each major exporting country. China is the most sensitive to changes in ocean freight rates, not only in terms of its level of exports, but also in terms of its rice trade patterns. Also Vietnam and Thailand's rice exports and trade patterns would respond markedly to changes in ocean freight rates, while the response of the U.S., in the same terms, could be considered of relatively minor importance.

To enhance the competitive position for the U.S. rice industry, domestic production, increase exports, and trade liberalization, should be encouraged.

Limitations and Recommendations

This study is limited in several respects. Its limitations are basically related to the assumptions which were made for the analysis, and the lack of available data at the moment in which this study was carried out. Thus, limitations and areas for potential improvements are as follows:

1. There is a need to develop a spatial equilibrium model to analyze the effects of ocean transportation costs considering rice as a nonhomogeneous product. In fact, two primary types of rice in the world market are indica and japonica; and of secondary importance are aromatic, or fragrant, and glutinous rices. Therefore, differentiation of rice in the world market may give interesting and more concrete results.

2. A second limitation of the study is that only major exporting and importing countries or regions were included for the analysis. It was assumed that other countries did

not have any influence on the international rice trade. While the inclusion of all the trading countries and regions could have provided a more comprehensive analysis of the international rice trade, it could have made the study more complex and unmanageable and, in turn, obscured the original objectives.

3. The study was limited by lack of data related to ocean freight rates for all the exporting and importing areas considered. In fact, this has been one of the primary reasons for the absence of transportation cost evaluations in international trade studies. Since such data were simply unavailable, the needed shipping rates in the model, were estimated as a function of the distance between the ports of exporting and importing countries or regions. While this was a reasonably assumption for the purposes in hand, the fact remains that the shipping costs are also influenced by other factors, such as the efficiency of port facilities, the size of the shipments, and so on. Certainly, if such information were available, it would have provided a more accurate estimate of ocean freight rates, which would have permitted a better analysis of the transportation costs, and their effects on international rice trade.

APPENDIX

Table 35. Observations of Unit Ocean Freight Rates (UOFR), Distances, and Type of Flag Vessels in the World Rice Trade, 1990

Distance (D)	Ln[1](D)	Freight Rates (UOFR)	Ln(UOFR)	Flag Vessels
(miles)		($ per M.T.)		
1,155	7.05	21.00	3.04	Foreign
5,603	8.63	100.00	4.61	Foreign
6,235	8.74	41.34	3.72	Foreign
1,155	7.05	25.00	3.22	Foreign
2,807	7.94	20.39	3.02	Foreign
5,603	8.63	84.00	4.43	Foreign
5,603	8.63	32.50	3.48	Foreign
5,603	8.63	100.00	4.61	Foreign
2,807	7.94	26.46	3.28	Foreign
1,155	7.05	25.13	3.22	Foreign
1,155	7.05	29.46	3.38	Foreign
1,155	7.05	22.49	3.11	Foreign
9,487	9.16	29.21	3.37	Foreign
6,526	8.78	66.50	4.20	Foreign
5,423	8.60	39.68	3.68	Foreign
2,885	7.97	26.45	3.28	Foreign
5,603	8.63	100.00	4.61	Foreign
6,050	8.71	33.07	3.50	Foreign
4,879	8.49	79.00	4.37	Foreign
4,064	8.31	20.94	3.04	Foreign
1,155	7.05	21.00	3.04	Foreign
4,879	8.49	90.00	4.50	Foreign
6,260	8.74	59.50	4.09	Foreign
4,636	8.44	66.96	4.20	Foreign
7,884	8.97	109.75	4.70	U.S.
6,260	8.74	99.75	4.60	U.S.
1,155	7.05	45.61	3.82	U.S.
5,603	8.63	88.23	4.48	U.S.
5,603	8.63	101.99	4.62	U.S.
5,603	8.63	112.99	4.73	U.S.
1,155	7.05	36.57	3.60	U.S.
7,884	8.97	102.50	4.63	U.S.
5,603	8.63	103.99	4.64	U.S.
5,603	8.63	88.99	4.49	U.S.
4,268	8.36	68.27	4.22	U.S.
7,884	8.97	102.50	4.63	U.S.
4,636	8.44	72.15	4.28	U.S.
7,884	8.97	109.75	4.70	U.S.
1,155	7.05	57.49	4.05	U.S.
1,155	7.05	48.83	3.89	U.S.

[1] Ln refers to natural logarithms.

Source: Maritime Research Inc., Chartering Annual 1990.

Table 36. Marine Distances from Exporting Countries or Regions to Importing Countries or Regions, Used to Estimate Ocean Freight Rates

Importing Countries or Regions	Exporting Countries or Regions												
	U.S.	Thailand	China	Pakistan	Burma	Australia	Italy	Uruguay	Argentina	India	Vietnam	Spain	Ot.South America
	(nautical miles)												
Angola	6526	8022	8529	6262	7016	7696	4250	3350	3400	6186	7810	4250	6638
Bangladesh	11324	2375	3745	1880	600	5741	6115	9139	9251	2160	2180	6535	11956
Brazil	5136	9634	10877	7905	8765	7635	5910	1045	1142	7863	9422	4605	5157
Cameroon	6125	8927	10069	7036	7850	8915	5184	4404	4501	6960	8572	4474	6272
Canada	5405	7843	5710	9886	8134	7276	8740	8316	8281	9445	6597	8740	4264
Cuba	621	11768	9693	8833	10667	8720	5785	5610	5725	9019	11064	5090	1905
Ghana	5603	8977	9492	7348	8005	8691	3315	3063	3036	7206	8765	3315	5767
Guinea	4636	9607	10122	6709	8487	9290	2329	3645	3742	6897	9395	2329	4819
Hong Kong	10630	1489	824	4336	2565	4480	7770	10475	10587	3900	927	8200	9505
Indonesia	11703	1486	2553	3875	1880	3562	6990	9118	9230	3080	1486	7420	10445
Iran	9814	4696	6057	643	3063	7444	4618	9087	9184	1500	4511	4976	10486
Iraq	9870	4708	6086	2732	3577	7525	4684	8787	8899	1587	4565	5042	10500
Kuwait	9793	4676	6037	2563	3527	7424	4605	8732	8829	1537	4491	4963	10450
Liberia	4879	9367	10614	6958	8405	9470	3982	3119	2614	7515	9155	2678	5097
Madagascar	9724	4817	5959	2515	3295	5687	4553	5879	5976	2440	4462	4179	9605
Malaysia	11221	1199	2580	2596	766	4652	6050	8884	8996	2144	1005	6470	11093
Mauritania	4268	9487	10665	6296	8130	10044	3205	2761	2761	6482	9104	1900	4562
Mexico	733	12250	10178	9663	11497	9202	6615	6430	6439	9849	11546	5330	2369
Nigeria	5749	8959	10202	7230	8090	9026	4815	3268	3260	7188	8747	4105	5918
Peru	2767	11155	9557	10508	11786	7000	7415	3978	4043	10694	10781	6110	706
Philippines	10780	1465	1128	4212	2435	3950	7669	10246	10358	3770	907	8030	9615
Reunion	9400	4507	5649	2820	3261	4730	4775	5521	5521	2600	4153	5387	9458

(Continued)

Table 36. (Continued)

Importing Countries or Regions	U.S.	Thailand	China	Pakistan	Burma	Australia	Italy	Uruguay	Argentina	India	Vietnam	Spain	Ot.South America
	Exporting Countries or Regions												
	(nautical miles)												
Saudi Arabia	7204	5155	6525	2166	4003	7605	2038	8223	8335	2353	4160	2400	7845
Senegal	4268	9487	10665	6296	8130	10044	3205	2761	2761	6482	9104	1900	4562
Sierra Leone	4636	9607	10122	6709	8487	9290	2329	3645	3742	6897	9395	2329	4819
Singapore	11514	831	2192	2885	1100	4275	6340	9189	9301	2435	831	6765	10726
Somalia	6707	4534	5396	1863	3250	5972	5135	6126	6126	1915	4129	5135	10188
South Africa	7290	6402	7649	4675	5540	6470	6675	3621	3718	4630	6190	5495	7333
Sri Lanka	9980	2415	3785	1341	1276	5165	4775	7956	8068	889	2220	5195	10612
Syria	6635	6135	7565	3135	5020	8550	1383	7235	7335	3330	5950	1760	7220
Taiwan	10383	1685	600	2785	5281	4852	7724	10481	10593	4070	1312	8336	9267
Tanzania	9676	5423	6565	2405	3700	5977	4206	5931	6028	2330	5068	4813	9657
U.A.Emirates	9328	4212	5573	643	3063	6960	4141	8267	8364	1073	4027	4499	9657
Ex-U.S.S.R.	6260	3066	1639	4024	4164	5691	2940	11447	11512	4230	2422	2445	9986
Zaire	6526	8022	8529	6262	7016	7696	4250	3350	3400	6186	7810	4250	8044
E.C.10	4855	9015	10190	5820	7655	11275	2682	5932	6050	6005	8630	1395	6638
Ot.W.Europe	5300	7395	8825	4395	6280	9845	1220	5905	6005	4590	7210	345	5890
East Europe	6260	7125	8555	4120	5905	9590	129	6855	6955	4315	6940	1260	6845
Ot.C.Am/Carib.	1155	11316	9244	8727	10541	8522	4865	4967	5224	8913	10612	4355	1438
Ot.S.S.Africa	6526	5423	6565	2405	3700	5977	4206	3350	3400	2330	5068	4250	8044
Ot.S.Asia	11324	2375	3745	1880	600	5741	6115	9139	9251	2160	2180	6535	11956
Ot.E.Asia/Oc.	11703	1486	2553	3875	1880	3562	6990	9118	9118	9230	856	7420	10071
Ot.Md.E./N.Af.	6410	6020	7450	3014	4899	8485	1001	7015	7115	3209	5835	1554	7000

[1] See Table 9 for regions' shorthand.

Source: Caney, R.W. and J.E. Reynolds, Reed's Marine Distance Table, Thomas Reed Publications Limited, London, 1978.

Table 37. Ocean Freight Rates Estimated from Exporting Countries or Regions to Importing Countries or Regions, Used by the Reactive Programming Model

Importing Countries or Regions	Exporting Countries or Regions												
	U.S.	Thailand	China	Pakistan	Burma	Australia	Italy	Uruguay	Argentina	India	Vietnam	Spain	Ot.South America
	($ per M.T.)												
Angola	55.32	61.18	63.03	54.22	57.31	59.95	44.89	39.98	40.27	53.90	60.38	44.89	55.78
Bangladesh	72.37	33.81	42.21	30.17	17.30	51.98	53.60	65.19	65.58	32.28	32.43	55.36	74.31
Brazil	49.23	66.89	70.96	60.74	63.87	59.72	52.72	22.66	23.67	60.58	66.16	46.68	49.33
Cameroon	53.64	64.45	68.34	57.39	60.53	64.41	49.45	45.68	46.16	57.09	63.19	46.03	54.26
Canada	50.47	60.51	51.84	67.73	61.59	58.34	63.79	62.26	62.13	66.24	55.62	63.79	44.96
Cuba	17.59	73.73	67.08	64.12	70.29	63.71	52.17	51.39	51.90	64.77	71.55	49.02	30.37
Ghana	51.36	64.62	66.40	58.62	61.11	63.61	39.77	38.27	38.11	58.06	63.87	39.77	52.09
Guinea	46.83	66.79	68.52	56.07	62.88	65.71	33.49	41.66	42.19	56.83	66.07	33.49	47.73
Hong Kong	70.17	26.93	20.19	45.33	35.10	46.06	60.23	69.67	70.03	43.05	21.38	61.83	66.45
Indonesia	73.54	26.90	35.02	42.92	30.17	41.19	57.21	65.12	65.50	38.37	26.90	58.90	69.57
Iran	67.49	47.13	53.35	17.89	38.27	58.99	46.75	65.01	65.34	27.03	46.21	48.48	69.70
Iraq	67.68	47.19	53.47	36.20	41.28	59.30	47.07	63.95	64.35	27.78	46.48	48.79	69.75
Japan	65.23	37.17	26.88	51.95	43.66	47.90	66.69	70.13	70.34	49.97	33.37	67.31	61.15
Kuwait	67.42	47.03	53.26	35.09	40.99	58.91	46.68	63.76	64.10	27.35	46.11	48.42	69.59
Liberia	48.01	65.98	70.12	57.08	62.58	66.33	43.49	38.61	35.43	59.26	65.24	35.85	49.05
Madagascar	67.19	47.72	52.93	34.77	39.66	51.74	46.42	52.58	53.00	34.26	45.97	44.53	66.79
Malaysia	72.04	24.23	35.20	35.31	19.48	46.91	53.32	64.30	64.69	32.17	22.24	55.09	71.64
Mauritania	44.98	66.39	70.28	54.37	61.58	68.26	39.13	36.38	36.38	55.14	65.07	30.33	46.47
Mexico	19.07	75.19	68.70	66.98	72.90	65.41	55.69	54.93	54.96	67.61	73.05	50.13	33.77
Nigeria	52.01	64.56	68.78	58.16	61.43	64.79	47.71	39.50	39.45	57.99	63.81	44.14	52.75
Peru	36.42	71.84	66.62	69.78	73.79	57.25	58.88	43.47	43.81	70.38	70.65	53.58	18.72
Philippines	70.65	26.72	23.52	44.70	34.22	43.32	59.85	68.92	69.29	42.35	21.15	61.21	66.82
Reunion	66.09	46.19	51.57	36.76	39.46	47.29	47.51	51.00	51.00	35.33	44.39	50.39	66.29

(Continued)

Table 37. (Continued)

Importing Countries or Regions	Exporting Countries or Regions												
	U.S.	Thailand	China	Pakistan	Burma	Australia	Italy	Uruguay	Argentina	India	Vietnam	Spain	Ot.South America
	($ per M.T.)												
Saudi Arabia	58.05	49.32	55.32	32.33	43.60	59.61	31.38	61.92	62.33	33.66	44.43	33.98	60.52
Senegal	44.98	66.39	70.28	54.37	61.58	68.26	39.13	36.38	36.38	55.14	65.07	30.33	46.47
Sierra Leone	46.83	66.79	68.52	56.07	62.88	65.71	33.49	41.66	42.19	56.83	66.07	33.49	47.73
Singapore	72.95	20.27	32.51	37.17	23.24	45.02	54.55	65.36	65.75	34.22	20.27	56.30	70.48
Somalia	56.07	46.33	50.43	30.04	39.39	52.98	49.23	53.65	53.65	30.44	44.26	49.23	68.73
South Africa	58.39	54.81	59.77	47.03	51.08	55.09	55.94	41.52	42.06	46.80	53.92	50.88	58.56
Sri Lanka	68.05	34.09	42.43	25.59	24.98	49.37	47.51	60.93	61.35	20.95	32.72	49.51	70.11
Syria	55.77	53.68	59.45	38.71	48.69	63.11	25.98	58.18	58.57	39.86	52.89	29.22	58.12
Taiwan	69.37	28.60	17.30	36.54	49.90	47.89	60.06	69.69	70.05	43.96	25.32	62.33	65.63
Tanzania	67.03	50.55	55.49	34.02	41.96	53.01	44.67	52.81	53.23	33.50	48.91	47.70	66.96
U.A.Emirates	65.84	44.70	51.23	17.89	38.27	57.09	44.33	62.08	62.43	22.96	43.73	46.15	66.96
Ex-U.S.S.R.	54.21	38.29	28.22	43.71	44.45	51.75	37.51	72.75	72.95	44.79	34.13	34.29	68.07
Zaire	55.32	61.18	63.03	54.22	57.31	59.95	44.89	39.98	40.27	53.90	60.38	44.89	61.26
E.C.10	47.90	64.76	68.74	52.32	59.80	72.21	35.87	52.81	53.32	53.13	63.39	26.09	55.78
Ot.W.Europe	49.99	58.80	64.09	45.63	54.30	67.60	24.44	52.69	53.13	46.61	58.08	13.21	52.63
East Europe	54.21	57.74	63.12	44.22	52.69	66.74	8.18	56.67	57.07	45.23	57.01	24.83	56.63
Ot.C.A./Carib.	23.80	72.34	65.55	63.74	69.88	63.01	47.95	48.43	49.64	64.40	70.11	45.43	26.48
Ot.S.S. Africa	55.32	50.55	55.49	34.02	41.96	53.01	44.67	39.98	40.27	33.50	48.91	44.89	61.26
Ot.S.Asia	72.37	33.81	42.21	30.17	17.30	51.98	53.60	65.19	65.58	32.28	32.43	55.36	74.31
Ot.E.As/Ocean.	73.54	26.90	35.02	42.92	30.17	41.19	57.21	65.12	65.12	65.50	20.56	58.90	68.35
Ot.Md.E./N.Af.	54.84	53.19	59.01	37.97	48.11	62.87	22.19	57.31	57.70	39.15	52.39	27.50	57.25

[1] See Table 9 for shorthand names of countries or regions.

Table 38. U.S. Rice Exports by Export Program, 1980-1991

Fiscal Year	Food Aid Programs (A)[1]	C.C.C. Credit Programs	C.C.C. African Relief Exports	E.E.P.[2]	Export Programs	Exports Outside Specified Exp. Prog.	Total U.S. Rice Exports (B)	Rate of Change A/B*100
	(1000 M.T.)							(%)
1980	540	168	0	0	708	2,247	2,955	18.0
1981	360	452	0	0	812	2,360	3,172	11.3
1982	374	14	0	0	388	2,523	2,911	12.9
1983	475	328	0	0	803	1,473	2,276	20.9
1984	464	571	49	0	1,084	1,209	2,293	20.2
1985	577	359	180	0	1,116	856	1,972	29.3
1986	313	477	0	23	813	1,569	2,382	13.1
1987	486	636	0	28	1,150	1,304	2,454	19.8
1988	350	443	0	120	913	1,220	2,173	16.1
1989	408	826	0	20	1,254	1,787	3,041	13.4
1990	350	663	0	0	1,013	1,484	2,497	14.0
1991	411	183	0	76	670	1,748	2,418	17.0
Average[3]	390	557	0	32	979	1,673	2,652	14.7

[1] Include P.L.480 Programs, and Section 416 Overseas Donations.
[2] Export Enhancement Programs.
[3] Average 1989-1991.

Source: U.S.D.A., 1992.

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