ALTERNATIVE HEDGING STRATEGIES

FOR RICE-WHEAT TRADE

IN ASIA

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TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

Table Page

Table Page

LIST OF FIGURES

Figure | Page

Figure Page

Figure | Page

CHAPTER I

INTRODUCTION

As a result of sustained economic growth in most Asian countries, Asia's share of world trade has consistently increased since the late 1960s. Asia surpassed Western Europe in the early 1980s as the largest regional market for U.S. agricultural products. Asia is the only region whose imports exceeded the average growth rate of U.S. farm goods exports in each of the last 3 decades. The share of U.S. farm exports imported by Asian countries expanded to 43 percent by 1988-90 (Giordano and Landers, 1993).

Relatively strong and consistent income growth is a key factor driving the region's per capita food demands, share of global farm imports, and share of farm imports from the U.S. Table 1.1 shows some major Asian countries' real GDP growth rate and per capita income. The region's growth rate was higher than that of industrialized countries, including the United States, over the last two decades. Moreover, the real annual GDP growth rate of China and some other Asian countries is projected even higher in the near future. At the same time, the expansion of the manufacturing sector has pulled labor away from agriculture, resulting in decreased grain production and further increased import demand for food grain.

TABLE 1.1

SECTED ASIAN COUNTRIES:
REAL GDP GROWTH AND PER CAPITA INCOME

Country	Real Annual GDP Growth 1970-79	Real Annual GDP Growth 1980-91	Per Capita Income 1989	Proj. Real Annual GDP Growth 1992-2000
	Percent		Dollars	Percent
Bangladesh	2.3	4.2	180	3.8
China	5.1	8.8	360	6.0
Hong Kong	8.8	6.5	10320	5.6
India	3.3	5.3	350	5.0
Indonesia	7.0	5.4	490	6.0
Japan	4.2	4.1	23730	3.4
Malaysia	7.6	5.5	2130	6.8
Myanmar	4.1	4.4	400	3.0
Pakistan	4.6	6.1	370	6.2
Philippines	5.8	1.2	700	4.8
South Korea	9.2	9.2	4400	7.3
Taiwan	9.1	7.9	7512	6.4
Thailand	6.9	7.6	1170	7.0
Vietnam	N/A	N/A	230	6.5
Total	4.5	4.9	--	4.4
United States	2.8	3.1	21100	2.8
Ind. countries	3.1	3.0	--	2.9

N/A = Not available; -- = Not applicable;
Source: USDA, ERS 1992 fall baseline estimates.

The income effects on food demand largely reflect the traditional pattern of income elasticities of demand across Asian countries at different stages of development. In lower income areas, relatively large shares of additional income go for food. In higher income areas, smaller shares of additional income are spent on food, but diets consist of higher-value foods.

Problem Statement

Asia, especially East Asia, is projected to maintain strong growth in import demand for major agricultural products in the 1990s (Giordano and Landers, 1993; Gehlhar, Hertel and Martin, 1994). A growing Asian market will create significant potential for U.S farm export gains in the 1990s. Hence, meeting import demand for agricultural products, especially for food grain, will remain critical to U.S. interests.

Both opportunities and challenges exist for U.S. agricultural trade. The strong growth in import demand in the 1990s suggests the potential to increase U.S. exports, especially in meeting Asia's net demand for high-value food products and wheat.

One important challenge is the degree of uncertainty in the Asian market outlook. Southeast Asia and China, the source of much of the increased Asian import demand in the last two decades, may be somewhat unstable and unpredictable. China accounts for the bulk of the region's projected import growth. But its technical and policy developments affecting farm output and consumption are particularly difficult to predict, and are likely to remain so (Webb, 1993).

The key agricultural commodities for U.S. exporters to this region are rice and wheat. Rice and wheat are the highest and second highest volume of production of any crop in Asia, but they account for the most agricultural imports from outside the region. Meeting increasing food demand of Asian and stabilizing food supply in Asia by alternative rice and wheat marketing approaches is of political as well as economical significance.
Therefore, maximizing expected returns from wheat and rice exports, while managing associated risks with these exports, are concerns of U.S. exporters and policy makers.

Rice Trade in Asia

Rice is the basic foodstuff for more than half the population in Asia and a main source of income for most small farms in Asian countries. Billions of people's health depends on the ability to purchase sufficient quantities of rice. Rice is also an important source as well as use of foreign exchange for many countries. Bangladesh spends about 10 percent of its annual export earnings on rice imports. Thailand received annually about 15 percent of its foreign exchange from rice exports.

Table 1.2 and 1.3 illustrate the importance of Asian rice importers in world rice trade. As a region, Asia is a net rice exporter. Thailand, Pakistan, Vietnam, and China join the United States to supply the bulk of world rice exports.

TABLE 1.2

LONG-TERM TRENDS FOR RICE IMPORTS IN SELECTED ASIAN AREAS

	Imports				Growth Rates		
	1962-64	1969-71	1979-81	1988-90	1960's	1970's	1980's
	........................Thousand tons			....	......................percent		....
Asia	5,020	5,127	4,786	3,295	3.0	-1.0	-5.2
Japan	314	60	35	17	-21.1	-5.3	-7.8
China	59	3	174	524	-33.4	48.0	13.0
South Asia	1,570	1,386	457	1,061	-1.8	-10.5	9.8
World	614	8,317	13,017	12,689	1.3	4.6	-0.3

Sources: Import data: FAO Annual Reports.
Export data: U.S. Bureau of the Census.

TABLE 1.3

RICE TRADE IN ASIA

Country or Region	1990	1991	1992	1993	1994[(f)]
	..............1,000 tons (milled)......				
Exporters:					
World	11,661	12,009	14,133	14,829	15,802
United States	2,420	2,197	2,106	2,641	2,600
Australia	470	400	500	500	775
China	326	689	933	1,374	1,600
Pakistan	904	1,297	1,358	937	1,300
Taiwan	79	229	188	101	225
Thailand	3,938	3,988	4,776	4,798	4,000
Vietnam	1,670	1,048	1,914	1,800	2,100
Asia's and Oceania's Share of World's Exports (%)	70	71	74	--	--
Importers:					
World	11,661	12,009	14,133	14,829	15,802
China	57	67	93	100	100
Indonesia	77	192	650	50	50
Japan	11	34	17	107	2,400
Korea Democratic	27	194	10	150	150
Malaysia	298	367	444	400	400
Philippines	538	91	0	250	300
Sri lanka	139	208	330	250	250
Asia's and Oceania's Share of World's Imports (%)	18	17	18	16	29

(f) = forecast.
Source: USDA, Foreign Agricultural Service, World Grain Situation and Outlook, various issues.

One of the most important determinants of rice trade is the price. Among seventeen countries found by Siamwalla and Haykin (1983) to be price-responsive, China is the most price responsive, followed by the United States.

Commonly, world prices of rice are for milled rice. Rough rice is less frequently traded internationally, since hulls have very little value. There are 2 sets of milled prices in the Asian market. The first set is Thai rice prices. Although these prices are posted by the Thai Board of Trade, actual trades are often discounted from this price by 10 to 15 percent. Since 1984, nominal price quotes have been solicited from Thailand exporters by the U.S. agricultural attache in Bangkok (Herrmann,1993).

The second set of prices is USDA-announced world market prices. The USDA attempts to collect and summarize all available information about prices in order to offer U.S. exporters a benchmark price, to help them compete in the world market. The world market prices for milled rice are announced by the Secretary of Agriculture every Tuesday afternoon. Hence, some analysts use the Tuesday settlement price of the futures contracts determined prior to the announcement as the futures price for rice (Herrmann,1993). But, in Petzel and Monke's (1979) study of market integration, they found that U.S.-announced rice prices lagged Thai prices by a month. These prices are in cents per pound and include individual prices for whole kernels by class of rice (long, medium, and short) (USDA, ERS, April 1994)

Rough rice futures contracts traded on the Chicago Rice and Cotton Exchange (CRCE) and delivered in eastern Arkansas provide daily futures prices for U.S. number 2 long grain rough rice in lots of 2,000 hundredweight (the equivalent of 90.7 metric tons). The par milling yield of the rough rice is 55/70, 55 percent head rice and 15 percent broken rice, for a total milling yield of 70 percent (Herrmann,1993).

Retail prices vary substantially from country to country, resulting from quality differences and social and political considerations. In 1991, the retail price for average quality Japonica type rice in Japan was 3.67 U.S. dollars per kilogram, while in Korea it was 1.90 U.S. dollars per kilogram. In the same time period, Ponlai (a japonica rice) price in Taiwan was 1.22 US. dollars per kilogram, fine quality rice in Bangladesh was 0.36 U.S. dollars per kilogram, long grain rice in New Zealand was 1.10 U.S. dollars per kilogram, Basmati rice in Pakistan was 0.28 U.S. dollars per kilogram, and medium grain rice was 0.88 U.S. dollars per kilogram (Dyck, 1993).

China's domestic rice price was lower than the cost, insurance, and freight (CIF) of imported rice. In 1991, for example, the average imported rice from Thailand was $285 a ton, or RMB 1.71 yuan per kilogram. Adding a 0.3 percent bank finance fee, a 0.15 percent commodity inspection fee, a 1 percent foreign service charge, a 0.3 percent customs service charge, and a 2.7 percent port construction fee, the domestic delivery price was RMB 1.78 yaun per kilogram. In this period, China's domestic rice price ranged from RMB 1.2 to 1.4 yuan, lower than the price of imported rice (Theiler and Tuan, 1994). A revolution in rice consumption patterns started in the early 1980's and was completed in 1993, when the planned purchase and planned supply system was ended and farmers were allowed to respond to market signals and consumers to purchase rice in open markets. Specifically, the consumers in South China bid up the price for high-quality intermediate and late crop rice at the expense of the low-quality indica rice With higher incomes, urban consumers intend to pay top prices for special rice such as jasmine Thai rice (Tuan, 1991).

Japonica rice is more highly prized by Japanese consumers. Good quality

Northern rice produced in China likely will continue to enter into the Japanese market, which was opened to a degree by the recent Uruguay Round Accord. Thus, China is a potential major competitor with the United States in Asian markets.

In most years, China is a rice importer and exporter. As Table 1.3 indicates, China's rice exports increased from 933,000 tons in 1991/92 to 1.5 million tons in 1993/94. High quality rice—Japonica rice was shipped to Japan, and lower quality rice was shipped to Cuba, Europe, and Africa. Most imports of low quality rice come from North Korea and Thailand, and some from Vietnam.

While China is both a rice exporter and an importer, Japan is primarily an importer. Rice is the staple food of Japan. Japan consumed an average 9.61 million tons rice annually from 1989-91. But, because of the small size of Japan's farms and high cost of labor, rice productivity is low and uncompetitive internationally. Hence, Japan has been reluctant to open its rice market. Under the recent Uruguay Round Draft Final Act, Japan would have to allow a minimum amount of rice imports--starting at 3 percent and increasing to 5 percent of domestic consumption during the 1986 base period (approximately 300,000 to 500,000 tons) (Caplan,1993).

The United States is a net rice exporter to the Asian market. It is projected to export 2.7 million tons of rice in 1995 (USDA, July 1994). The largest net exporter is Thailand. It is projected to export 4.4 million tons of rice in 1994/95, almost one-third of the world market. (This projection differs slightly from that shown in Table 1.3.) Normally, about 45 percent of Thai rice exports consist of low quality second-crop rice that competes with rice from Vietnam, Pakistan, and Burma. The remainder of its exports is high quality rice that competes with U.S. rice for markets in Europe and the Middle East. Due to the pressure of more competition from Vietnam in the low-end market in recent years, Thai exporters have began orienting sales towards higher quality markets. Hence, the possibility of direct competition between U.S. and Thai rice is increasing. However, due to quality assurances and reliable shipping and delivery facilities, U.S. rice can be competitive in Asian markets even with a $30-50 premium over Thai rice (USDA, 1995). Table 1.4 indicates the U.S. share of exports in selected Asian rice markets.

TABLE 1.4

U.S. SHARE OF RICE MARKETS IN ASIA (%)

	Japan	NIC's	S.E.Asia	China	S. Asia
1979-81	2.9	36.8	8.2	0.0	0.0
1988-90	5.9	2.7	13.0	0.0	0.0

Source: International Agricultural and Trade Reports, Situation and Outlook Series, USDA, RES, RS-92-5, August 1993.
NIC's: The Newly Industrialized Countries, including Hong Kong, Singapore, South Korea, and Taiwan.

Wheat Trade in Asia

Wheat is the second most important food grain in Asia, and one of the region's largest agricultural imports. In the past 30 years, wheat imports in Asia expanded from 12.5 to 32.3 million tons (Webb, 1993). Table 1.5 shows the amount of wheat imported by Asian countries, and the amount imported by these countries from the U.S.

TABLE 1.5

ASIAN WHEAT IMPORTERS

Country or Region	Wheat Consumption	Wheat Imports 1/ Total	From United States
	......1,000 mt......		
China	109,000	6,700	2,118
Indonesia	2,650	2,600	45
Japan	6,200	5,700	3,383
Pakistan	17,750	2,750	1,638
Philippines	2,000	2,000	1,579
South Korea	3,420	3,895	1,461
Sri Lanka	900	855	780
Taiwan	900	900	841
8-country subtotal	142,820	25,400	11,845
Rest of Asia 2/	63,945	6,890	4,127
Total Asia 2/	206,765	32,290	15,972
World	550,494	109,402	37,000
	......Percent......		
Share of World:			
8 Countries	25.9	23.2	32.0
Total Asia	37.6	29.5	43.2

1/ July 1992-June 1993. 2/ Excludes Oceania.

Sources: Webb, Alan. " Determinants of Wheat Imports in Asia." Situation and Outlook Series, International Agriculture and Trade Reports, Asia and Pacific Rim, USDA, ERS, RS-93-6, September, 1993.

The expanding use of wheat in Asia can be explained by higher income and urbanization, which create preferences for convenient, wheat-based foods. In some areas, such as South Asia and the coastal provinces of China, wheat import demand is driven by growing middle classes. However, the key reason for the expansion of wheat imports in Asia is wheat's low price relative to rice in meeting the shortfalls of food grain production. In 1991, world wheat prices were only about two-thirds of China's guaranteed price, and U.S. EEP wheat prices are only about half the level of China wheat price (Tuan, 1991). Table 1.6 shows that the retail prices of wheat in U.S. are much lower than the wheat prices in major Asian countries.

TABLE 1.6

RETAIL PRICES OF WHEAT IN ASIAN MARKETS, 1991

Commodity	Japan (Tokyo)	Korea (Seoul)	Taiwan	China	Australia	New Zealand	U.S.
	..................................U.S. dollars per kiloram......................................						
Wheat Flour	1.50	1.09	0.85	--	0.92	0.75	0.51
Bread White	2.94	--	--	--	1.59	1.37	1.57

--: Not available.
Source: Dyck, J. "Asia's Diverse Food System." USDA, ERS, International Agriculture and Trade Reports, Situation and Outlook Series, RS-93-6, September 1993.

The determinants of wheat imports in Asia include the diversity of culture, marketing institutions, government regulations, climate, and location. Among them, foreign exchange reserve, credit, export subsidies, concessional supplies and pricing are extremely important to many buyers. In order to take advantage of lower prices resulting from an exporter's credit or subsidy program, some countries with inadequate foreign exchange or credit may purchase wheat that is less suited to their end-use requirement. End-use requirements determine the classes and quantities of imported wheat. In Asia, soft wheat is imported mainly for making noodles, while harder, high protein wheat is for breads, rolls, and pastries. By blending different wheat classes together and altering processing techniques, some Asian mills partly substitute one class of wheat for another.

China is the largest wheat producer, consumer, and importer in Asia, resulting from its growing population and poor transportation infrastructure, which inhibits the flow of wheat from producing areas to coastal cities. In the 1980's, China's wheat imports accounted for between 6 and 14 percent of world wheat imports. Limited by foreign exchange, China is an extremely price conscious buyer. Historically, considerations for quality have been of much less importance in purchase decisions. With increasing income, however, residents of coastal cities have become more concerned with wheat quality. Since subsidies on flour have been eliminated recently, consumers in coastal areas have shifted purchases to special grade flours in free markets (Webb, 1993).

According to the statistics, the price of China's exported rice averaged $194 per ton during 1953-83, while the price of China's imported wheat averaged $93.5 in the same period (Chen and Buckwell, 1991). Given the higher price of rice and lower price for wheat in the world market, an exchange of China's rice for foreign wheat is regarded by Chinese authorities as economically rational. Mr. Chen Ming (a high official in China's Ministry of foreign trade) pointed out clearly in 1964 that exporting some rice, some soybean and some processed food grain for exchange of wheat "is a good means ... of making money" (quoted from Wong 1980, p12).

Almost all of Taiwan's and South Korea's wheat consumption relies on imported wheat, mainly from the United States. Almost 50 percent of South Korea's wheat flour use is for noodles, while 22 percent is for bread and confectionery. Traditionally, Pakistan has imported primarily soft white wheat to supplement domestic supplies of semi-hard white varieties favored by Pakistanians. In the Philippines, 50 to 60 percent of the milled flour is purchased by bakers, 28 to 30 percent by noodle manufactures, and the remainder by fast food outlets and households (Webb, 1993).

As Table 1.7 indicates, the key factor in Philippine wheat purchase decisions is price, followed by quality. In contrast, Taiwan is a very quality-sensitive market. Its "base price system" allows flour millers to purchase the best quality wheat. Protein and moisture are the most important quality factors to Taiwan's importers and also to Japan's importers. Some Japanese millers complained of high (exceeding 10 percent) protein levels for U.S. western white (WW) and low (below 14 percent) protein levels in DNS wheat.

TABLE 1.7

KEY DETERMINANTS OF WHEAT IMPORT IN ASIA

Country	Buying Agency	Purchase criteria		Key Quality Concerns about U.S. wheat
		First	Second	
China	CEROILS	Price	Quality	Foreign materials
Indonesia	BULOG	Price	Freight	No significant purchases
Japan	Food Agency	Trade Relations	Quality	WW protein too high HRS protein too variable
Pakistan	MFAC	Price	Credit	Low protein of U.S. white
Philippines	private	Price	Quality	WW protein too high; HRS protein too variable
South Korea	Private	Price	Quality	WW protein too high; HRS protein too variable
Sri lanka	CWE	Price	Credit	Pest infestation
Taiwan	TFMA	Quality	Trade Relations	WW protein too high HRS protein too variable

Source: Webb, Alan. " Determinants of Wheat Imports in Asia". Situation and Outlook Series, International Agriculture an Trade Reports, Asia and Pacific Rim, USDA, ERS, RS-93-6, September, 1993.

The competition in the Asian wheat market is mainly among three exporting countries--- United States, Canada, and Australia. Table 1.8 indicates the relative market shares of each of these countries for exports to selected Asian countries.

TABLE 1.8

MARKET SHARES FOR MILLING WHEAT, 1991

Importer	Exporting Country		
	United States	Canada	Australia
	..................Percent..................		
China	37	36	11
Indonicia	0	24	41
Japan	58	24	18
Pakistan	56	8	17
Philippines	78	16	1
South Korea	80	2	18
Sri lanka	91	0	1
Taiwan	80	15	0

Source: Webb, Alan. " Determinants of Wheat Imports in Asia". Situation and Outlook Series, International Agriculture and Trade Reports, Asia and Pacific Rim, USDA, ERS, RS-93-6, September, 1993.

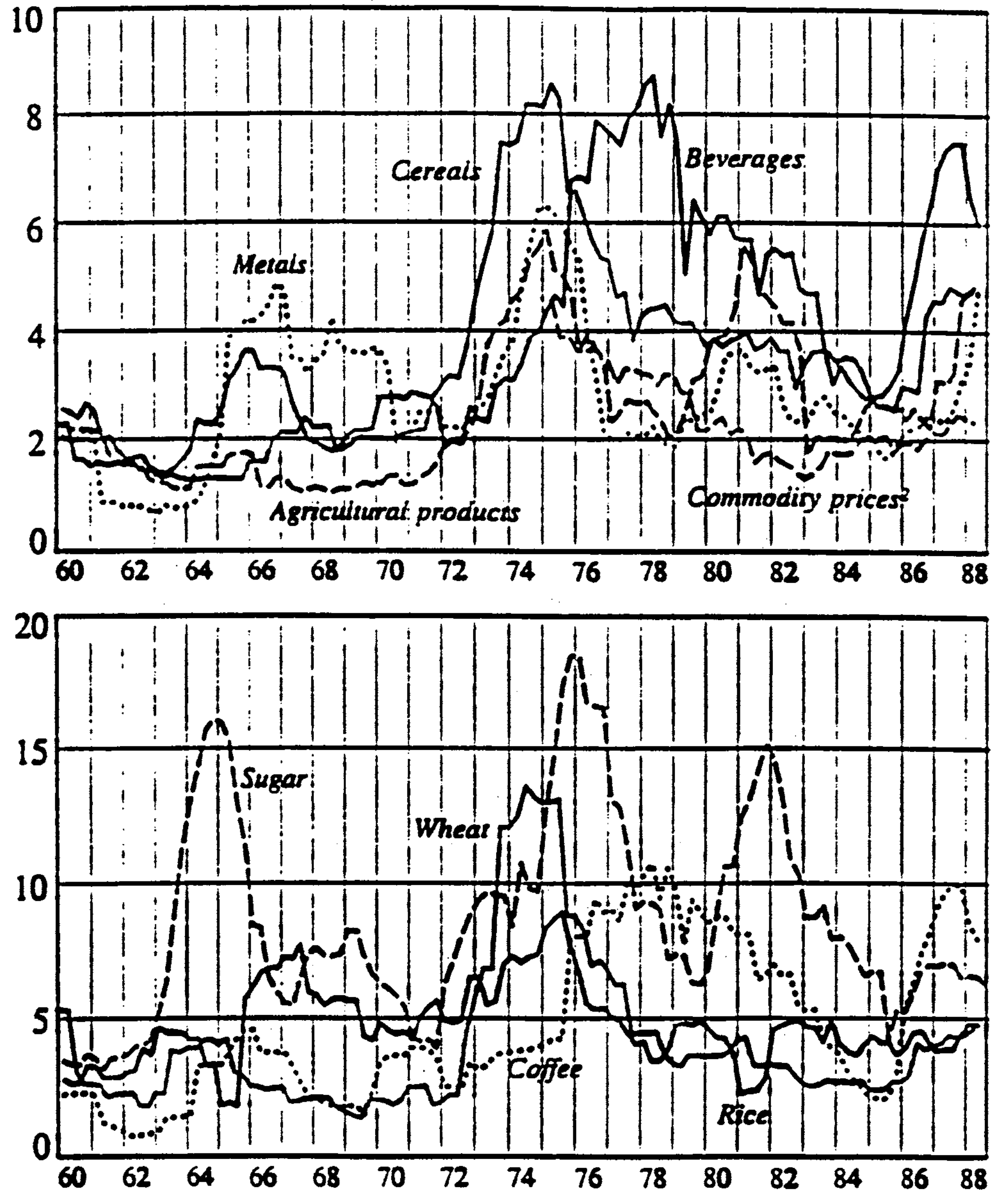
Each country offers a set of different (but largely similar) wheat classes and marketing services. The United States exports five major classes: hard red winter (HRW), hard red spring (HRS), soft red winter (SRW), white and durum wheat. Australia exports standard white (ASW), hard, and prime hard (APH) wheat. Canada exports western red spring (CWRS) and amber durum (CAD). Since one class of wheat can be substituted for another if they are in the same protein level, competition exists among different classes of wheat from the three major suppliers in the Asian market. HRS and HRW from the United States compete with the CWRS from Canada and APH from Australia in the high-protein market (for bread flour). White wheat and, to a much lesser extent, SRW from the United States compete with ASW from Australia in the low-protein market (flour used for egg noodles, cakes, and pastry) (Webb, 1993).

U.S. grain marketing firms are competitive in the Asian wheat market. The major strengths of U.S. competitiveness include a well-developed transportation and storage system that can ship large volumes of wheat and other grains to any part of the world at any time. The U.S. government promotes U.S. wheat sales in lower income Asian countries by providing export firms with financial tools, such as the Export Enhancement Program (EEP) and GSM-102 credit. Strong trade relations have also helped the United States remain dominant in Korea, Taiwan and Japan (Webb, 1993).

Risk and Uncertainty in Asian Rice and Wheat Markets

Generally, trade companies utilize export or investment credit insurance to reduce their commercial and political risks, and use financial risk management techniques such as hedging to reduce their foreign exchange and economic risks, especially price volatility (Van Horn, 1989).

Figure 1.1 shows large short-term fluctuations of prices of non-oil primary commodities over the last two decades in response to shifts in both demand and supply factors. The aggregate index has moved sharply but the price for cereals has moved even more sharply.



1/ Commodity price volatility is measured as the standard deviation of the 24-month percentage change in commodity prices expressed in SDRs.

2/ Index of commodity prices excluding oil and gold and using exports of developing countries as weights.

Source: Mathieson, D.J., David Folkerts-Landau, Timothy Lane, and Igbal Zaidi. Managing Financial Risks in Indebted Developing Countries. International Monetary Fund, Washington, D.C., Occasional Paper, June 1989, p.5.

Figure 1.1. **Indices of Commodity Price Volatility, 1960-88**
(In Percent Per Annum)

According to Van Horn (1989), there are three kinds of risks in international transactions: commercial risks, political risks, and foreign exchange risks. Commercial risks include risks for the sellers: protracted default by buyer, buyer insolvency, or the buyer's inability to pay as a result of natural disaster; and risks for the buyers: receiving poor-quality or untimely goods from the seller. Political risks include delays in foreign exchange transfer, not getting paid or losses of property because of political unrest, war, insurrection, revolution, expropriation, confiscation, government interference in the business, unforeseen cancellation of an import or export license, and extra charges arising from diversion of a shipment. Foreign exchange risks include: devaluation or shifts in exchange rates, currencies no longer convertible to dollars, and changes in government rules on foreign exchange.

Risk in rice and wheat trade is actually much more than that mentioned above. For example, storing rice is very risky to rice importers and exporters. Barker, Herot and Rose (1985) estimated that rice storage losses range from below 1 percent to as high as 10 percent.

International trade in rice is even more risky. According to Herrmann (1993), international rice trade in Asia is a function of excess domestic supply and demand -- a trade of residual supply. As a result, the international rice market is thin in relation to world production: less than 5 percent of annual production of rice is traded internationally, compared with about 19 percent for wheat since 1960 (Henneberry, 1985; Setia et al., 1994). This provides opportunities for high price volatility and high search cost, due to the possibility that a large trade may affect the market price. The volatility creates added incentives for self-sufficiency in rice, further thinning the market. Similar conclusions have been made by Siamwalla and Haykin (1983).

This kind of international market is very sensitive to variation in supply and demand. For example, if Indonesia has a poor harvest and needs to buy in the world market, such a large purchase will shock the world grain market. Based on 1984 rice market records (Herrmann, 1993), each additional million tons that Indonesia might purchase could raise the world rice price about \$50 a ton starting from \$200 a ton (including cost, insurance, and freight (c.i.f.)). On the other hand, if Indonesia were to export a million tons of rice, also starting from \$200 a ton, rice prices would drop about \$80 a ton to \$120 a ton, a level that Timmer (1986) calls a stabilized price level. At that level, using rice as livestock feed becomes economical.

Such a scenario is not unrealistic. A recent example is that Indonesia switched from net exporter to net importer in late 1994 because of drought-reduced production. Since about 90 percent of the world's rice crop is produced in Asia and 45 percent of the Asian crop is in nonirrigated areas (Henneberry, 1985), much of the production for major Asian producing countries depends heavily on the Asian monsoons that usually occur between June and September. Timely Asian monsoons will suggest improved crop prospects and diminished import needs. But, unfortunately, the Asian monsoon is unstable.

The sources of instability of world rice market may also include government interventions. Governments sometimes estimate the situation for their domestic market improperly. Consequently, inappropriate policies may be imposed on imports and exports.

On the supply side, Australia experienced a serious drought in 1994. Wheat production was projected to decrease 47 percent from 1993/94 to 9 million tons, the lowest since 1982/83 (USDA, October, 1994). Australia trading agency would be forced to curtail wheat exports, which implies that the United States would export more to Asia. But, at that time, it was uncertain how much low-protein U.S. wheat was available to ship to markets such as South Korea where low-protein white wheat is desired for certain food products, since dry conditions in the northwestern part of the United States raised the protein levels of white wheat. In Thailand, the largest rice exporter, the export price of rice is affected by the country's domestic price support and export assistance programs (USDA, October, 1994).

On the demand side, the sources of uncertainty are more complicated. In Japan, the poor rice crop outlook, coupled with low stocks, was projected to force the government to import up to 1.6 million tons of rice by the end of 1994 to meet domestic consumption needs. However, due to the special protection for traditional domestic rice production protection, the government insists that any imports are only on an "emergency basis" (USDA, October, 1994).

China is the key source of uncertainty in the Asian Market because of its size and the sensitivity of the projections to alternative assumptions on economic growth, policy, consumer preferences, and farm productivity. Changing policies, rapid income growth, and poor historical stock, consumption and price data add to the uncertainty in projecting food demand. In 1989, as China's grain supply stagnated, surplus rice provinces set up barriers to block sales to Guangdong province because they could not make a profit from grain transfers based on government fixed prices. Consequently, the state allowed Guandong to import a large amount of rice from foreign countries, mainly Thailand, resulting in net rice imports of 880,000 tons in 1989 (Webb, Webb, and Coyle, 1992).

In addition, when considering the East Asian market, traders cannot afford to ignore the onrushing economic integration of China with Hong Kong and Taiwan. However, the use of demand parameters based on the Taiwan experience in an alternate scenario may lead to significantly different demand projections, particularly for wheat (Webb, Webb, and Coyle, 1992).

The small number of participants and the instability of participation in the world rice market are two structural characteristics for labeling the rice market as a "thin" market. As long as participants float in or out of the market, trade channels are not well established, and transaction costs, or search costs, are high. High transaction costs are an indicator of thin markets. An example of high transaction cost in rice markets is the following: A number of brokerage houses located in the United States, Europe, Singapore, and Hong Kong are able to earn substantial brokerage fees. It was reported that 5 or 10 percent brokerage fees are not uncommon for those houses (Siamwalla and Haykin, 1983). Such high fees are inconceivable in wheat trade.

History and Potential of Using Rice-Wheat Futures Markets in Asia

The earliest rice futures market in history was in Asia. In the 1930s and 1940s, a futures market for rice existed in Japan, but was closed by occupation forces (Herrmann, 1993). Without the existence of a futures market, trading risk was very high. Traders were exposed to large losses or profits when there was no hedging alternatives (Stucker, 1984). About twenty years later, thirty contracts were traded on the New York Mercantile Exchange. During the period of April 1981 to June 1983, thousands of rice contracts were traded on the New Orleans Cotton Exchange (NOCE). In September 1983, the Chicago Rice and Cotton Exchange (CRCE) got permission to trade the NOCE contracts on the MidAmerica floor. In August 1986, MidAmerica affiliated with the Chicago Board of Trade. International Rice market information has become more available since 1986 (Herrmann, 1993).

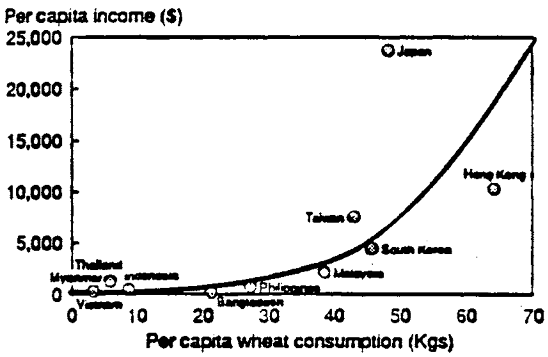
Now, six contract months (January, March, May, July, September, and November) are traded by the CRCE on the floor of the Chicago Board of Trade. All the trades are cleared through (and guaranteed by) the Board of Trade Clearing Corporation. The CRCE rice contract specifies 2,000 hundredweight, the equivalent of 90.7 metric tons, of U.S. number 2 or better long grain rough rice for delivery in one of the twelve counties in eastern Arkansas (Herrmann, 1993).

Considering that single actors may manipulate a thin market (such as the rice market), position limits (250 contracts net in one month and 500 net in all contracts) are designed to minimize the potential for manipulation, but bona fide hedgers can apply for exemption to those limits (Herrmann, 1993).

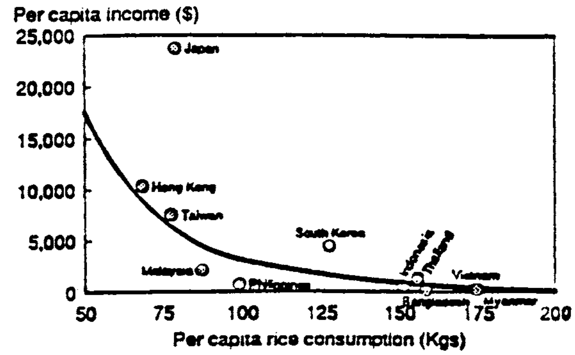
However, the rice futures market is recognized as less efficient than the wheat futures market. In global trade, wheat is the most common substitute for rice. The ratio of rice prices to wheat prices has more than doubled over the last sixty years. According to Siamwalla and Haykin (1983), three possible explanations are: 1) The supply of wheat has grown faster than the supply of rice; 2) The population in predominantly rice-consumption areas has grown faster than that in wheat-eating areas; 3) Income elasticities are higher among rice consumers than among wheat consumers. This suggests that demand for rice increases faster than demand for wheat as consumers' income grows.

In Asia, per capita consumption of rice has tended to fall in the higher income countries. In the traditional rice-consumption area of Asia, slower growth in per capita rice demand (resulting mainly from urbanization) is typically accompanied by rising demand for wheat. The figures below, based on 1989 data, show the contrasting trends for rice and wheat consumption in the traditional rice-consuming countries of Asia. While two figures indicate the strong relationship between per capita income and wheat and rice consumption, the other two figures show the relationship between the degree of urbanization and wheat and rice consumption. Urbanization is a key stimulus to wheat demand in Asia, because urban consumers seek a diet which is more diverse and more convenient. Hundreds of millions of consumers in Chinese coastal areas also adhere to this pattern, although India, Pakistan, and rural China are not included in these figures.

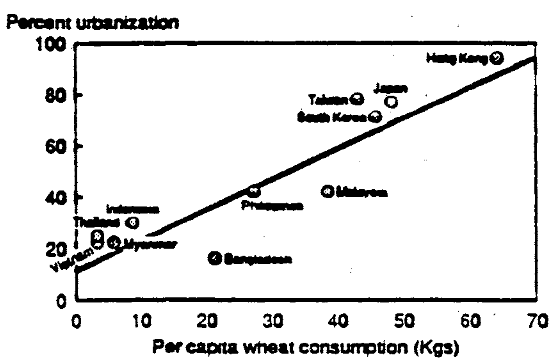
Wheat Consumption versus Income



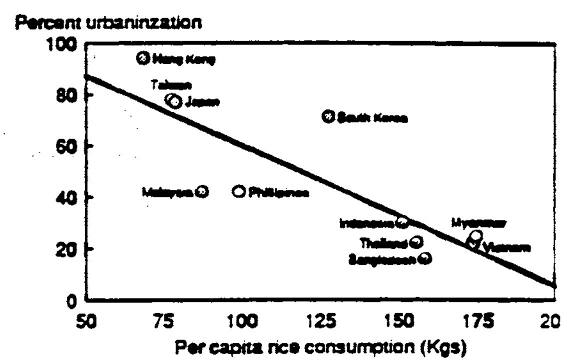
Rice Consumption versus Income



Wheat Consumption versus Urbanization



Rice Consumption versus Urbanization



Source: USDA, ERS, Asia, Situation and Outlook Series, RS 92-5 August 1993, p.81.

Figure 1.2. Trends in Asian Demand for Rice And Wheat, Selected Countries

Liberalization of grain trade in Asia is proceeding. The Philippines and South Korea have already eliminated their state trading agencies. Pakistan and Taiwan have made changes in their import regimes in the past years. According to the report by West (1994), China has required its state-owned trade corporations to be legally and economically independent, or self-sufficient, in their business dealings, and to operate without state subsidies or preferential access to foreign currency. In April 1993, the government announced the end of its planned supply system in which it guaranteed urban residents wheat rations. Dismantling trade barriers will open China's market to U.S. exporters as well as exporters from other countries, although strong consumer preference for U.S. goods bodes well for U.S. exporters.

The infrastructure for grain trade in some Asian countries (such as China) is very weak, lacking marketing facilities (including processing and storage capabilities and transportation capacity). This is one of the main reasons why inter-provincial grain trade in China was only 7.7 million tons on average for 1953-57 and 11.6 million tons in 1978 (Walker 1984, p184). Using world grain futures markets may help food grain procurement and distribution in developing countries with such weaknesses.

However, evidence from the Commodity Futures Trading Commission (CFTC) indicates low participation by less developed countries in futures trading in almost all markets (Thompson, 1985). According to Thompson, two factors may explain the reluctance of LDCs to use futures markets: 1) They view futures trading as too costly, since to maintain a futures position traders need extremely liquid financial reserves. Traders from LDCs may be unable to solve the problem of foreign exchange scarcity;

2) They see futures trading as too risky, with potential for financial disaster. Basis risk is likely to be greater for exporters from LDCs than for other hedgers because the cash market transactions of LDCs are usually more widely separated in either space, time, or form from their futures market transactions.

Research Objectives and Significance

The question of how wheat and rice traders can utilize alternative hedging strategies to enhance returns and reduce risks in trade with Asian countries, where exports and imports are exposed to substantial price and exchange rate instability, is a concern of many international agencies dealing wheat and rice trade. Since hedging participants are likely to hold an array of cash goods (i.e. wheat and rice) in certain markets, cross hedging multiple cash goods and multiple futures contracts is a consideration of this analysis.

The general objective of this research is to identify risk management strategies for firms that conduct trade in wheat and rice with Asian countries. The specific objectives are:

1) to measure the price uncertainty perceived by exporters and importers of wheat and rice;

2) to develop a hedging model to generate expected utility maximizing hedging strategies for multiple commodities and multiple risks; and

3) to use the model to identify practical strategies that will enhance risk-adjusted returns to trade.

Models for multicommodity hedging are few and rough (Anderson and Danthine, 1981). According to Fackler and McNew (1993), few empirical studies using a multiproduct approach have been published. Specifically, the author has found no research on risk management in wheat-rice trade.

Organization of this Dissertation

The remainder of this dissertation is organized as follows. Chapter II reviews risk management theory and portfolio theory. Standard hedging theory is discussed in the multicommodity context, and is associated with maximizing expected utility theory. Chapter III presents procedures for market investigation and determining the potential for using the wheat futures market as a cross hedge for rice trade. Detailed descriptions of the model are also provided. The results from empirical estimations are reported in Chapter IV, followed by comparisons of the alternative trade strategies. Summary and implications are presented in Chapter V.

CHAPTER II

LITERATURE REVIEW

The background literature relevant to this study falls into three major categories: 1) theory and practice of risk management and the portfolio theory; 2) studies on hedging models; and 3) the theory of expected utility.

Risk Management and Portfolio Theory

Hedging as a Tool of Risk Management

According to the bulk of the literature, the futures market is a convenient mechanism through which price risk can be transferred from one agent to another, while the former desires "insurance" against the price risks he faces, and the latter expects to collect a premium (Johnson, 1960).

The growing importance and usefulness of hedging instruments for institutional traders and portfolio managers have been proved by the fact that trading activity in the futures markets for some cash commodities is often larger than activity in the underlying cash markets (Mathieson et al., 1989). According to an editorial in Oil & Gas Journal (November 29, 1993, p21), hedging has become an essential activity even to companies that do not trade futures contracts, options, swaps, or related financial instruments.

Although a very broad range of markets and instruments can now be used to hedge commodities and assets, the basic purpose of hedging instruments and strategies is generally quite similar across markets. That purpose is to hedge against adverse movements in the prices of primary products (such as wheat and rice). The hedger can eliminate much of the risk associated with price fluctuations to the extent that the price of hedging instrument is correlated with the price of the primary product.

Unfortunately, hedgers can not eliminate all the risk due to the existence of basis risk. The differences in basis generally reflect the cost of storage (including the interest rate), the cost of transportation, and the relative value of commodities with different grades or types. All the above mentioned costs may change over time, and it may lead to unpredictable changes in the basis, hence the existence of the basis risk. Hedging replaces commodity price risk with basis risk.

The traditional theory of hedging held that the primary motivation for hedging in futures markets was to reduce the risk of price changes. Under the traditional hedge role (Often called a full hedge), the position in the spot market is offset by an equal but opposite position in the futures market. But, the presence of basis risk implies that the traders, attempting to stabilize revenue flows by means of hedging activities, will seek trading rules that incorporate basis risk explicitly (Bond and Thompson, 1985). This will lead to hedging decisions that are more complex than a full hedge.

The traditional theory was challenged by Working (1953a, b, 1961), who asserted that the major motivation for hedging in futures markets was not to reduce risk but rather to profit from favorable changes in basis. Hedgers hedge because of an expected return rising from anticipation of favorable relative price movements in the spot and futures markets. A intelligent hedger may know basis trends. "He buys the spot commodity because the spot price is low relative to the futures price and he has reason to expect the spot premium to advance; therefore he buys spot and sells the future" (Working, 1953, p.325).

Bond, Thompson and Geldard (1985) extended the previous work by allowing for optimal hedging decisions to be determined jointly with decisions to store and sell grain. In this way, the hedgers are concerned not only with the desire to stabilize revenue, but also with the desire to maximize expected return.

Hedging is therefore expected to have following functions: 1) reduce risk; 2) stabilize revenue; 3) profit from favorable changes in basis; 4) profit with given facilities (given purchase funding, Sarassorro; given storage facilities, Thompson and Bond; given processing facilities, Fackler, etc.); 5) help in pricing cash commodities. However, the focus of hedging is still on risk reduction. Hedging does enable firms to select the types and degrees of risk that they bear.

Hedgers can utilize technical analysis tools such as moving averages to assist them in deciding the optimum time to place and lift a hedge. As a result of selecting optimum time to hedge, expected profits will be increased and price risk will be reduced. This is supported by Shields's study (1980) on feedlot operation in Oklahoma and Hobbs et al. (1987) on Kentuky soybean producers. However, although such trend-following methods are widely used, they are controversial.

Portfolio Theory

Modern portfolio theory is initially set forth by Harry M. Markowitz in 1952 (Cohen, Zinbarg, and Zeikel, 1987). In Markowitz's theoretical framework for the systematic composition of optimum portfolios, he applied the complex mathematics of quadratic programming to the question of how to select from among hundreds of individual securities.

According to Markowitz, rational investors will prefer a portfolio containing minimum expected deviation of returns around the mean, given expected rate of return (where the expected return is the mean of a probability distribution.

Since then, investment risk was defined as the uncertainty or variability of returns, measured by the standard deviation of expected returns about the mean, for portfolio planning purposes. Although some authors have used different measures of uncertainty, such as the mean absolute deviation, most researchers believe that the standard deviation represents the most workable concept of variability.

Markowitz suggested that risk averse investors should try to minimize the deviations from the expected portfolio rate of return by diversifying their selections. But, simply holding different assets will not reduce the uncertainty of a portfolio's expected rate of return significantly, if the relevant variables contained a high degree of positive covariance. Effectiveness of the diversification, according to Markowitz, can only be achieved when the portfolio is composed of assets that do not fluctuate in a similar fashion. Under this condition. the uncertainty of the portfolio's rate of return is significantly less than the uncertainty of the individual components of the portfolio.

The practical obstacles that restrict the use of the portfolio model include that it requires a large number of mathematical calculation, especially the calculation for covariances among variables. Another problem which has hindered the acceptance of portfolio theory is the seasonality of return. Portfolio risk measures appears sensitive to the time period of view (Cohen, Zinbarg, and Zeikel, 1987). Nevertheless, despite some imperfections, portfolio theory is widely used by investment and trade researchers.

Many agents, governments, and other decision makers face multiple risks simultaneously. Recent literature addressing how such decision makers can utilize portfolio theory to determine optimal hedges in multiple futures contracts includes Alexander, Musser, and Mason (1986), Thompson and Bond (1987), and Peterson and Leuthold (1987).

The normal distribution of commodity futures price changes is important in the assumptions for portfolio hedging models. Hudson, Leuthold and Sarassoro (1987) examined the distribution of futures price changes during the period from January 1974 through December 1982 for wheat, soybeans and live cattle. With an assessment of the impact of the reported computational errors and an examination of the impact of the increased price volatility, they demonstrated a move toward normality of futures price changes. Their results also suggest that the variance exists and is defined, so that portfolio models can be used optimally.

Hedging Models

Hedging Alternatives

Theoretical and empirical approaches to commodity hedging by risk averse agents are well developed. Various hedging alternatives have been suggested, tested, and compared. Hedging decisions in which the position in the spot (physical commodity) market is offset by an equal but opposite position in the futures market are commonly referred to as "routine hedging" (Kamara, 1982). Under this traditional hedge rule, the ratio of futures commitments to expected sales is unity.

A "naive hedge" is defined as a one-to-one futures position in the same asset traded (Grant and Eaker, 1989). A hedge of the same commodity as one in cash position which the hedgers has or expects to have in the future is referred to as "direct hedge" (Lee, Hayenga, and Lence). If one commodity is hedged with one futures contract, it can also be called a "single commodity hedge".

A "simple hedge" is referred to a risk-minimizing futures position in the same asset, and hence is the expected value of a coefficient from regressing the spot price on futures price. When there are multiple futures, Anderson and Danthine (1980, 1981) suggest the variance-minimizing positions are simply the expected values of ordinary least-squares regression coefficients. If the portfolio is composed of linear combinations of spot positions, the risk-minimizing futures positions are still linear combinations for the individual spot positions.

Baesel and Grant (1982) extend the analysis trading multiple contracts at many dates. While the dependent variable is always a spot position and the independent variable always the futures prices, the variance-minimizing hedges are now the expected values of a vector of regression coefficients. These kinds of hedges are referred to as "complex hedges" (Grant and Eaker, 1989).

However, no study estimated complex hedge models within the constraints of a fixed production relationship among hedged commodities before Tzang and Leuthold's (1990) study of the soybean complex. In their model, inputs and outputs have a fixed relationship with each other (60 pounds of soybeans yields about 48 pounds of soybean meal and 11 pounds of soybean oil). If a soybean processor follows minimum risk hedge estimations for soybeans, soybean meal, and soybean oil independently and neglects the fixed production relationships among them, its hedging positions may be incorrect.

If the number of assets traded in futures markets is assumed small relative to those traded in spot markets, which is a more realistic assumption, many potential hedgers will be unable to trade in identical assets. Multivariate “cross hedging” was therefore introduced directly in this situation. According to Anderson and Danthine’s definition (1980), cross hedges involve a cash good that differs in type, grade, location, or delivery date from that specified in the futures contract. Cross hedging is a risk minimizing futures position for different commodities in different asset forms, and involves a basis that does not necessarily converge to zero by the relevant date. In addition, since many potential hedgers may hold portfolios of assets and portfolio hedging is potentially valuable as mentioned above, a combination of cross-hedges can eliminate more risk than a single cross hedge (Grant and Eaker, 1989). The proportion of output that should be hedged by futures contracts is given by the coefficient of the multiple regression of cash prices on the futures prices. However, the estimation problem will become more complicated when multiple products are hedged with multiple futures contracts.

Miller (1985) investigated the cross-hedging relationship between millbrants and corn, oats, wheat, and soybean meal futures. His study demonstrates that corn and soybean meal futures together produced the lowest mean square error, supporting the idea of multiple cross-hedges.

Most empirical studies use a single period model (Howard and D’Antonio, 1991). In this single holding period, the hedge is placed at the beginning of the period, and lifted at the end. Such a model was first applied by Johnson and Stein in the early 1960s, and has been discussed by numerous authors. A single-period model is desirable for its simplicity, and is appropriate if the autocorrelation of the spot series is zero. However, world trade is truly multiperiod. If the spot series autocorrelation is not zero, "multiperiod hedging" will be appropriate and may be more realistic for trade agencies. Multiperiod hedging requires hedge rebalancing. Hedgers can trade in more than two futures contracts, but need to close the first futures when it near maturity and readjust the position for second futures.

Noteworthily, the potential risk reduction of a cross-hedge varies over time. In addition, the potential risk reduction is not always realized since the optimal size of the cross-hedge varies over time (Grant and Eaker, 1989). As a consequence, complex hedges or cross hedges do not necessarily perform better than naive or simple hedges. The results of hedging effectiveness tested by Grant and Eaker show substantial risk reduction (about 90%) by diversification in the portfolio of corn, oats and wheat spot positions, but suggest simultaneously that a multivariate hedge does not perform better than naive hedge, a multiperiod hedge is not superior to single-period hedge, and, complex hedges are not more effective than naive multiperiod hedges.

The fast-growing hedging menu looks somewhat hasty. Sometimes, readers may be confused by the terms "complex hedge", "cross hedge", or "multiproduct hedge", because authors have not provided clear definitions for them. A common feature for the three kind of hedges is that all of them deal with different commodities in different markets. But, it is unclear if there is a "fixed relationship" among the underlying various risks (such as in hedging soybeans, soybean meal, and soybean oil) or not (such as hedging wheat and rice). Although the fixed relationship assumption can be applied to a lot of situations (e.g. cattle feeding, crude oil processing, and numerous relationships among financial instruments of various yields and maturities), relaxing the assumption of existing "strong" or "fixed" production relationships may be more realistic for general applications. Since it has been shown (by Tzang and Leuthold, etc.) that "simultaneous hedge ratios for multiple and related risks are quit different from those determined when each individual risk is considered separately" (p.497), more precise definitions for those different situations are required.

Define a hedge whith a fixed production relationship among hedged commodities as "complex hedge", and a hedge where no such technical relationship exists among hedged commodities (in different asset forms) as a "multiproduct hedge". Most studies, including Peterson and Leuthold's study of commercial feedlot hedging, and Tzang and Leuthold's study of soybean producer hedging, fit the former category. Although Fackler and McNew (1994) assert that they are using "multiproduct approach" in their recent study on central Illinois soybean processors. However, they assume a " fixed input/output ratio", which is consistent with the above definition of a complex hedge (47 pounds of meal and 11 pounds of oil per bushel of soybeans.

Optimal Hedge Ratio Estimation

The hedge ratio for the firm is a measure of the size of the futures position per unit of the cash commodity. As the hedge ratio varies, the expected return and the variance of the return changes. The optimal hedge ratio can be decomposed into both a speculative and a pure hedge component. If the futures markets are unbiased, the speculative component drops out and the "pure hedge" component remains.. Because of basis risk, which causes unanticipated changes in the relative price between the position being hedged and the futures contract, no hedge ratio can completely eliminate risk.

The most practical way to determine the hedge ratio is to estimate it statistically. The hedge ratio that minimizes risk can be computed by taking the derivative of the function of variance of the return to the hedged portfolio with respect to the portion hedged. The result, labeled h^* in figure 2.1, is often less than 1.0, a fully hedged position (labeled h' in figure 2.1).

Myers and Thompson (1989) noted that the hedge ratio can be estimated using a simple least squares regression of the cash price on both the futures price and variables that influence the conditional expectations of the cash and futures prices at the time the hedge is placed. If the cash and futures prices are conditionally bivariate normally distributed, the regression coefficient associated with the futures price is a maximum likelihood estimate of this ratio. According to Judge et al. (1985, p.470), maximum likelihood estimates of the hedge ratio can be obtained using the iterated seemingly unrelated regression (SUR) approach.

A second type of hedge ratio maximizes expected utility of end-of-period profit (Heaney and Poitras, 1991). This ratio is a function of both the risk-return possibility curve which is available in the market and the firm's utility function. Given a firm's utility function, the maximum expected utility hedge ratio can be computed. The generated hedge ratio h^{**} sets the firm's subjective marginal rate of substitution between risk and return equal to the slope of the risk-return possibility curve.

A considerable amount of literature has contributed to the estimation of hedge ratios (e.g., Hill and Schneeweis, 1982; Stulz, 1984; Toevs and Jacob, 1986; Herbst, Kare and

Caples, 1989). Much of the literature focuses on estimating hedge ratios using an ordinary least squares (OLS) regression of cash prices on future prices, with the optimal hedge ratio being the estimated slope coefficient. However, this type of estimation is criticized as optimal only for a strictly restricted set of utility functions.

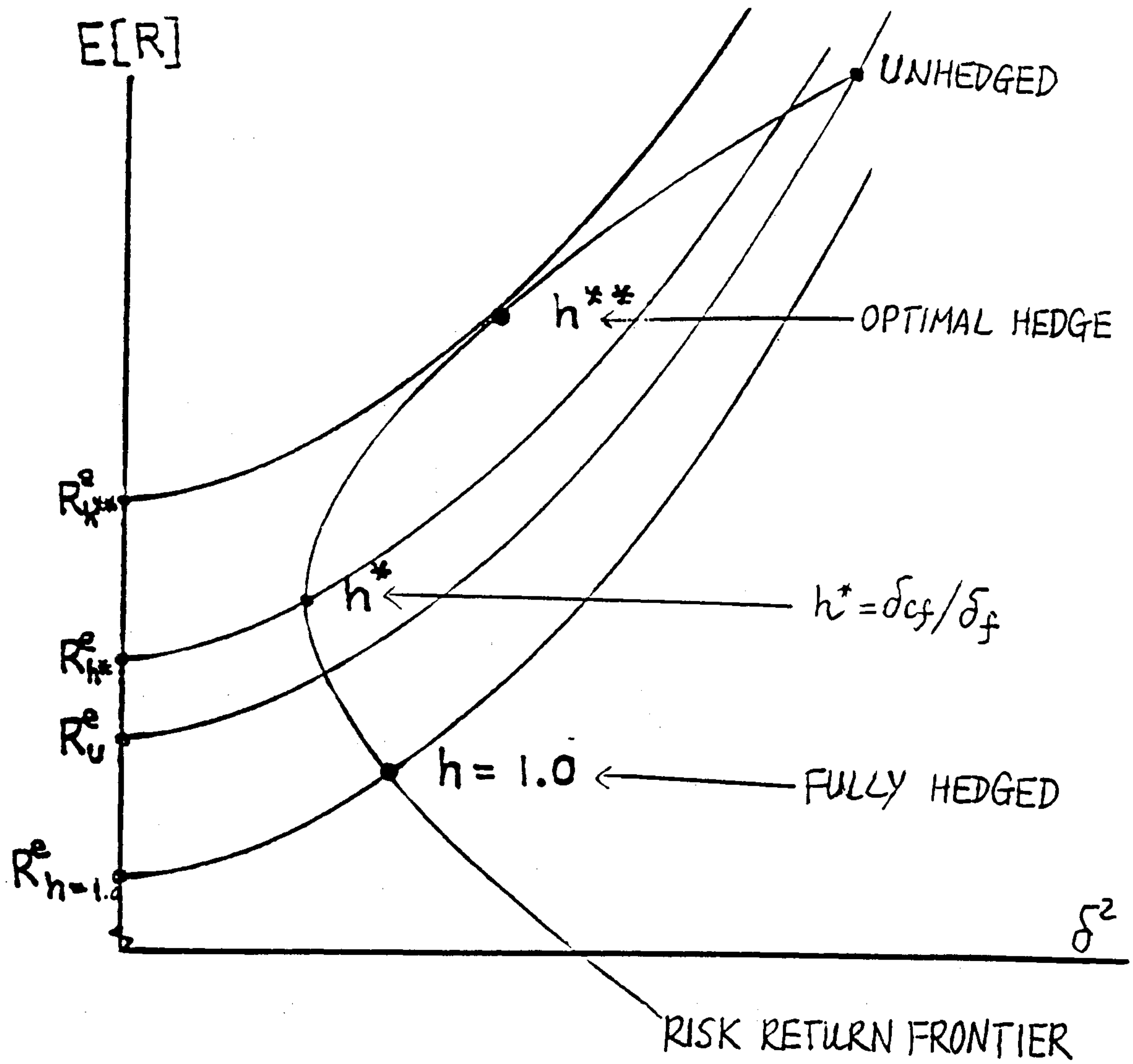
The major restrictive assumptions necessary are: the expected return to hedging a futures contract must be zero, and the processes generating the covariance matrix of cash and futures prices must be constant over time. Particularly, it does not account for temporal evolution in the processes generating asset prices.

Recent work on hedge ratio estimation demonstrates that the ratio depends on the objective function selected. However, existing evidence to date is restricted to comparisons of specific objective functions.

Trying to reveal the relationship between a general expected utility function and the OLS estimate of the hedge ratio, Heaney and Poitras (1991) proved that in the context of some accepted methods of empirical estimation such as a myopic model, an OLS-based hedge ratio (HOLS), is a robust estimate of the optimal hedge ratio whenever expected returns to hedging spot and futures equals zero. It occurs when the current futures price is an unbiased predictor of the distant futures price. If the optimization problem is appropriately specified, the robustness of HOLS depends solely on distributional parameters.

In a study of hedging 20-year Treasury bonds for one-month holding periods, Cecchetti, Cumby and Figlewski (1988) demonstrated within a mean-variance framework that the "optimal" hedge ratio is determined by the firm's objective function selected. Their estimates, obtained from an autoregressive conditional heteroskedasticity (ARCH) specification of the joint distribution of returns to cash and futures positions, are used to obtain a time series of hedge ratios that maximize expected utility for a firm with logarithmic utility. The expected return and the variance of the return varies according to the changes of the hedge ratio, which is depicted by the risk-return frontier in figure 2.1.

Baillie and Myers (1991) and Myers (1991) employed a multivariate generalized autoregressive conditional heteroscedasticity (GARCH) model, proposed first by Bollerslev (1986), to estimate optimal hedge ratios. They found that GARCH-based hedge ratios out-performed those obtained by the traditional regression approach. Results reported by Myers (1991) and Sephton (1993) also support the superiority of multivariate GARCH models in estimating time-varying hedge ratios. According to Sephton, the multivariate generalized autoregressive conditional heteroscedasticity model can be employed to solve the problem that the traditional method of calculating the optimal hedge ratio does not account for temporal evolution in the process generating asset prices. Hence, the Cecchetti, Cumby and Figlewski (1988) analysis is extended in two directions: GARCH model and multivariate framework. This led to ratios with a lower conditional variance of market returns than the traditional method did.



Source: Cecchetti, S.G., R. E. Cumby, and S. Figlewski. Estimation of the Optimal Futures Hedge. Research Working Paper, RWP 86-10, Research Division, Federal Reserve Bank of Kansas City, December 1986, p.6.

Figure 2.1. **Risk Return Frontier**

To account for exchange rate uncertainties faced by offshore traders dealing on U.S. futures exchanges, Thompson and Bond (1987) use a standard mean-variance (E-V) model to derive the optimal hedge ratio. They showed how currency risk can affect an offshore trader's perception of total risk and how use of currency futures contracts can affect the optimal hedging decision. However, despite the inclusion of exchange rate risk into the decision framework, their estimation methods are consistent with traditional hedging studies.

Sarassoro and Leuthold (1988) suggested a potentially easier estimation procedure than the one in Thompson and Bond. They found that the task of computing several variances and covariances can be replaced with a series of simple regressions, since many of the parameters of the optimal hedge ratio for the offshore traders as well as the domestic traders can be determined by simple regression analysis.

Fackler and McNew (1994) attempted to deal with the increased complexity of the analysis and the difficulties involved in properly interpreting cointegration tests. They assert that many of the techniques designed to examine issues of parameter instability are currently not well developed for systems of equations, and those techniques that are available are considerably more complex and difficult to interpret than their single equation counterparts. Therefore, they suggest estimating hedge ratios in a single equation context. However, it is doubtful if the single equation estimation can be used beyond situations in which the cash commodities are always held in fixed proportions, such as Fackler and McNew's representative central Illinois soybean processor case.

The traditional theory of hedging suggests that the hedger should assume a futures position equal and opposite to the spot market position. But in the early 1960s Johnson and

Stein used modern portfolio theory to demonstrate that it may be reasonable for hedgers to hedge only partially. Both of the above approaches are criticized by Brown's (1985) study which shows that estimated hedge ratios for three popular agricultural commodities are not significantly different from one. In his reformulated model, the hedge ratio is estimated as the ratio of the total value of the futures position to the total value of the spot position rather than as the ratio of the units of each as in the Johnson's approach. He suggests that better hedge ratio estimates will be obtained using returns or price changes (percentage) rather than price levels.

Cost also affects the determination of optimal hedging ratio, as Howard and D'Antonio (1994) point out. For determining this cost (reducing expected return by the amount of the fixed cost plus the spot risk premium), arbitrage activity between the spot and futures market plays an important role. The hedging cost equation can be derived by incorporating both fixed and variable components. With an increasing marginal cost of hedging, the actual hedge ratio will be substantially less than the risk minimizing hedge ratio which ignores costs.

Table 2.1 shows some optimal hedge ratios estimated by researchers for a range of commodities and financial instruments.

TABLE 2.1

REPORTED OPTIMAL HEDGE RATIOS

Study	**Data**	**Optimal Hedge Ratio**
Peck, 1975	U.S. egg producers	0.75-0.95
Rolfo, 1980	Four cocoa producing countries	0.60-0.94
Berck, 1981	California cotton producers	negative-0.11
Bond, Thompson and Geldard 1985	Australian wheat exports	-0.08-0.76
Brown, 1985	Chicago Board of Trade	
	wheat	0.78
	corn	0.88
	soybeans	0.967
Hartzmark, 1987	Oat traders, 1980	0.45
	Wheat traders, 1980	0.49
Lecchetti, Cumby, Figlewski, 1986	Treasury bonds	0.54-0.91
Peck and Nahmias, 1989	U.S. Flour miller, 1964-79	0.76
Thompson and Bond, 1987	Offshore commodities	0.17-0.33
Sarassoro and	Cote D'Ivoire	
Leuthold, 1988	exporting cocoa	-0.05--0.50
	exporting coffee	-3.14-1.90
Hauser and Neff	Soybeans in Illinois	0.89-0.945
1993	Corn in Illinois	0.937-0.957
Sephton, 1993	Winnipeg Commodity Exchange	1.0295-1.688
Fackler Mcnew	Soybeans in central Illinois	1.171
1994	Soybean oil	1.107
	Soybean meal	1.279
Lapan & Moschini 1994	Soybean production in Iowa, 1974-93	0.51-0.74

The research of Bond and Thompson (1985) on the effect of basis risk on hedging strategies for Australian wheat exports reveals that the optimal hedge ratio may vary substantially over time, and from situation to situation. In the Australian case, the optimal hedge ratio ranges from zero to 76 percent of the cash position. In general, the longer the time period of observations used by the decision makers to form estimates of parameter risk, the more stable the hedge ratio becomes.

In the case of treasury bonds hedges studied by Cecchetti, Cumby and Figlewski (1986), any short position in bond futures increased returns on an overall hedged position. The larger the hedge ratio, the higher the ex post return. Accurate hedge design can increase expected utility by a significant amount, with a pay-off over the long run. The authors asserted that relative performance ex post is entirely dominated by the direction of price change in the underlying asset. The smaller the hedge ratio, the better, as the market rises. The larger the hedge ratio, the greater the profit, as the market falls.

Expected Utility

Expected utility is a reasonable objective for choice problems in the face of uncertainty. However, the focus of the applied hedging literature has been on minimum-variance hedges (MVH) rather than on expected-utility maximizing hedges, with few exceptions (e.g. Cechettii, Cumby, and Figlewski, 1986) (Lence, 1995). MVHs are easy to estimate with econometric methods, but are required to hold certain conditions to obtain expected-utility maximization.

Despite the increased economic sophistication of the minimum variance hedge (MVH) estimations, Lence (1995) argues that some basic assumptions are still heavily relied on, such as neglecting contract "lumpiness", preventing the agent from investing in other activities, and not allowing for borrowing or lending.

By relaxing some unrealistic but standard MVH assumptions: the agent is allowed to borrow, lend and invest in risky alternatives other than cash and futures, Lence found that the potential economic value of substituting sophisticated econometric technique for simple and more intuitive hedging models is small and can be negligible. In this more realistic unconstrained scenario, MVHs are not expected-utility maximizing hedges and hence are suboptimal. Therefore, Lence suggests that the analysis should rely on the expected-utility-maximization paradigm.

As Cecchetti, Cumby and Figlewski (1988) suggested, the optimal futures hedge is the one which maximizes expected utility. An accurate hedge design is to increase expected utility by a significant, but fairly modest amount, over a long run. The mean-variance model may well serve as a reasonable approximation to the expected utility model, in which the amount of risk reduction is inherently measured by its variation (or standard deviation).

Here, optimal hedging is defined as the activity which maximizes expected utility. Minimizing risks without any regard to the effect on expected returns is considered suboptimal.

In addition, since the effectiveness of the hedge is measured by the extent to which the trader believes at the beginning of the trade that the variance of return of holding a position of one commodity in a market is reduced by simultaneously holding a position of certain size of this commodity in another market, the effectiveness of the hedge is considered only in subjective terms.

Since no "ideal" marketing strategy can be found in real world because market participants have different expectations and risk preferences, Adam et al. (1993) suggest a practical measure of utility in a neighborhood around the utility maximizing point for a range of hog price scenarios. Strategies outcomes within 2% of the maximum certainty equivalent are identified for different risk preferences and price scenarios. They are near-optimal, hence are identified as "robust" marketing strategies. Adam et al. found several strategies are quit robust across varying price mean and volatility expectations. Although some specific assumptions may be required for different agencies and market situations to apply these robust strategies, the study provides insight into the development of more general marketing strategies that can be effective under varying market conditions.

Summary

This review has shown that many authors have contributed their effort to rich the hedge menu, which provides various alternatives for producers and traders to manage risks in trade.

The review suggested that the motivation of hedging in futures markets is not only to reduce the risk of price changes, but also to profit from favorable changes in basis. The intelligent hedger may know basis trends, and be able to select the types and degrees of risk he is willing to bear. Rational traders and producers will prefer a portfolio containing minimum expected deviation of returns about the mean. But, the effectiveness of the diversification can only achieved when the portfolio is composed of products or commodities that do not fluctuate in a similar fashion.

This review also traced the development over the last three decades of theoretical and empirical approaches to commodity hedging by risk averse agents. Noticeably, the naive hedge, routine hedge, direct hedge, single commodity hedge, simple hedge, complex hedge, cross hedge, and multiproduct hedge, are not necessarily listed in order of effectiveness. The potential risk reduction varies over time and is not always realized. For example, complex hedges or cross hedges do not necessarily perform better than naive or simple hedges. Some definitions of hedges (e.g. complex hedge and multiproduct hedge) are still unclear, although definitions were proposed here.

The review further outlined the works contributed to the estimation of hedge ratios. The optimal hedge ratio is determined by the firm's objective function selected, and it may be reasonable for hedgers to hedge only partially. The optimal hedge ratio may vary substantially over time, and from situation to situation. Furthermore, the optimal futures hedge is the one which maximizes expected utility.

While some authors try to identify the "robust" or the "general" marketing strategies, some others try to investigate the applications in numerous specific situations. Undoubtedly, both of the above two research directions will benefit this study on a new area, rice and wheat hedge in Asia, which is be described in later chapters.

CHAPTER III

RESEARCH PROCEDURES

In order to determine the potential for using the wheat futures market as a cross hedge for rice trade, this chapter investigates the price movement in several cash and futures markets for rice and wheat, and identifies the characteristics of rice and wheat marketing activities. Market investigation consists of cash market activity analysis and futures market activity analysis for both rice and wheat, and analysis of price patterns for both commodities. A range of prices for different varieties and grades of rice is evaluated. Cash price movements are analyzed graphically and statistically. Since seasonality is one of the most important characteristics of rice and wheat marketing activities, a dummy variable technique is used to capture discrete shifts in the underlying price relationships through a marketing year.

Volume and annualized price volatility are examined for futures prices. Trade volume indicates the presence of currently active sellers and buyers. Open interest assures that there will be traders in the future and is useful in assessing the liquidity of a market. Liquidity is usually greater in markets with more participants and more trading. Determining if liquidity is a problem for large rice traders is necessary since low trading volume was a characteristic of the rice futures market in past years. Volatility is a measure of the dispersion of prices. The higher the volatility, the greater the likelihood that the price will rise or fall substantially.

If liquidity is still a problem for the rice futures market, using a more heavily traded market, such as wheat futures market, to help hedge cash transactions for rice, will be useful to grain traders, especially those trading with Asian countries.

Four procedures are used to evaluate the potential for rice-wheat cross hedging: (1) correlation analysis of futures prices with cash prices; (2) analysis of basis patterns; (3) market integration analysis; and (4) modeling trading in an expected utility framework. The ability to hedge in a futures market depends on how closely the futures and the cash prices are related. The relationship between a set of cash rice prices and futures rice and wheat prices is initially graphically analyzed for two possible trading periods, August through September, and December through January. Then, the relationship between log price changes in futures and cash markets of milled rice, rough rice, and wheat is statistically measured. The covariance between two price series is a measure of the association between them. The larger the absolute value of the correlation, the more nearly the values of the two series of price changes are linearly related.

To further examine if the relationships are sensitive to the season of the year, hedge/cross hedge model estimates for milled rice and soft red winter wheat in the August-September period using November rough rice futures and December wheat futures are compared with similar estimates in the December-January period using March rough rice and wheat futures contracts. The estimates are obtained from simple regression equations. The estimated slope coefficients are price risk minimizing hedge ratios. The intercept term can be viewed as the average allowance for processing costs, grade premiums or discounts, and transport costs. The standard error of the estimated equation is the distribution error about the expected cash price. It can be used to measure hedging effectiveness, the proportional reduction of cash price variance. The relationships of cash price changes for four types of U.S.- based milled rice with wheat futures price changes and with rice futures price changes during the two different trading periods are evaluated, using the regression R^2.

Next, basis patterns are evaluated. The basis, the difference between cash price and futures price for a particular market, is usually much more stable than the price level and hence more reliably predicted. Since a predictable basis is essential for effective hedging, this study uses basis behavior as an indicator of efficiency of a futures contract for hedging. The basis should be predictable and vary little day to day. The trend in the basis should reflect storage costs over the marketing year. The analysis described here compares world and Houston milled rice prices, and New Orleans rough rice cash prices, with the January, March, May, September and November CBOT rough rice futures prices. The marketing year is assumed to start in July. Graphs compare a basis averaged from three different rice price series with a wheat basis. To examine whether the basis behaves in an orderly fashion during a marketing year in selected delivery areas, this study regresses the basis over time, using weekly cash price in the specified area less the nearby contracts futures price and a time counter. The analysis of basis indicates ability to hedge in the rice futures markets and suggests particular contracts that may possess greater hedging potential.

Third, the degree of market integration is determined. This analysis investigates whether rice price movements in the Chicago rice and wheat futures markets reflect price movements in the world spot rice market and U.S. spot rice markets for evaluating cross hedging potential. Since the contracts closest to expiring are usually more heavily traded than more distant contracts and should reflect cash prices most closely, nearby futures contracts are used in this analysis. The models regress the log price changes in nearby rice and wheat futures markets against log price changes in the four cash rice markets. A statistically significant coefficient close to one would support the argument that the futures market offers a good hedge for rice in the delivery area. Other factors, such as foreign exchange rate risk in Asian rice and wheat trade, are also considered.

Based on the information from the above investigations, an expected utility trading model is specified for alternative strategies for rice and wheat trade. This study evaluates four strategies: cash rice trade, hedging rice utilizing rice futures market, hedging rice utilizing wheat futures market, and hedging rice using both rice and wheat futures market. The rice season is divided in this analysis into the following four trading periods: August-October, November-January, February -April and May-July.

Optimal hedge positions are estimated by simple regression on returns. The agency is assumed to maximize expected revenue subject to a certain level of risk, where risk is measured by the variance of the revenue. A formalized objective function is maximized. To compare with a no-hedging marketing strategy, the hedging strategies are evaluated using a hedging efficiency criterion.

In expected utility models, it is assumed that a trader's preferences among alternative trade strategies are based on expected income and associated income variance. In this paper, it is assumed the utility function is of the exponential form, and income Y is normally distributed. The trade agency will then rationally trade in order to achieve higher expected income and lower variances of income. Consistent with this, the E, V decision rule is used to determine optimal strategies for trading agencies and firms.

These four procedures will provide comprehensive insight into the potential for the wheat futures market to be used as a cross-hedge to minimize risk of international trade in rice and wheat.

Market Investigation

Data

The scarcity of the price data and the range of prices for different varieties and grades of rice complicate analysis of rice markets. Daily cash rice prices are unavailable, while weekly cash rice price series are scarce. Nevertheless, given the increasing volume of the international rice trade, and the potential contribution of a rice futures market, analysis using the best available data is worth while.

Rice is classified in the United States by grain length: long, medium, and short grain, depending on an average length and average length/width ratio of the kernel. In world markets, most rice trade is in milled rice of the indica type (Setia et al., 1994). Indica rice is referred to as long-grain rice, produced mostly in tropical climates, including southern China, south and southeast Asia, and the southern United States. Japonica rice is referred to as short-grain rice, and the international trade of this variety of rice is limited and accounts for only 13 percent of world trade (1986-87 average) (Setia et al., 1994). Rough rice is much less frequently traded internationally, since hulls have little value and shipments of rough rice over long distances are uneconomical. Therefore, the rice prices used in this analysis are mainly long grain milled rice prices.

Regular milled white rice is the rice product produced after the hull, brain layers, and germ have been removed (Setia et al., 1994). Well-milled long grain rice has less than 10 percent brokens. Prices for U.S. #2 long grain milled rice (less than 4 percent brokens) and for Thai 100 percent, grade B (up to 5 percent short grain rice and up to 5 percent brokens), long-grain milled rice prices are the two most frequently cited rice prices in the international markets (Herrmann, 1994).

In the United States, free-on-board (f.o.b.) U.S. #2 milled long-grain rice prices are available for Southwest Louisiana, Houston, Texas, and Arkansas. U.S. #2 milled medium-grain rice prices are available for Southwest Louisiana, Arkansas, and California, while U.S. #1 short-grain milled rice prices are available only for California. Weekly average cash prices of milled rice per hundredweight for Texas, Louisiana, and Arkansas rice are available in USDA Agricultural Marketing Service "Rice Market News".[1] These three series of U.S. milled rice prices will be compared in this analysis.

In the international rice markets, the most commonly used world price is the Thailand export rice price for 100 percent second grade (grade B) f.o.b. milled rice, Bangkok. Thailand f.o.b. prices for first grade, second grade, and 5 percent brokens are posted weekly by the Thai Board of Trade, and serve as the reference price that private exporters charge buyers. Normally, the actual transaction price may be as much as 10 percent above or below the posted price (Siamwalla and Haykin, 1983), depending on the current market conditions. Further discounts are generally negotiated. U.S. f.o.b., No.2, 4 percent broken (high-quality long-grain) rice is similar to Thai 100 percent (grade B) rice, and offer quotes from Houston are available (USDA, ERS, Rice, Situation and Outlook Report, E-mail printout, Oct.12, 1995).

USDA-announced rice prices are also important in the world markets. The USDA collects information about actual sales rather than nominal quotes or posted prices for

[1] These data were provided by Dr. Marvin L. Hayenga of Iowa State University.

different classes of rice traded in all markets. Price analysts digest the information and try to offer a benchmark price series for U.S. rice exporters to be competitive in the world markets. The Secretary of Agriculture announces the so called world market prices every Tuesday afternoon. The price series is adjusted to reflect equivalent values for U.S. Number 2, 4 percent brokens, f.o.b. Houston (Herrmann, 1994).

Therefore, prices of long-grain milled rice from of Houston, USDA-announced world market long-grain milled rice, and Thai Grade B f.o.b. milled rice are chosen as the typical cash price series in this study.

The rough rice futures contract traded on the CBOT provides daily futures closing prices for U.S. Number 2 long-grain rough rice, in cents per hundredweight. This data series ranged from the period August, 1986 to December, 1993, and was obtained from Chicago Board of Trade,

Soft red winter is the major class of wheat imported by China (People's Republic), the largest wheat importer in the world. In the crop year June 1993 to May 1994, China imported 66,509 thousand bushels of wheat from the United States, more than 76 percent of which, i.e., 50,961 thousand bushels, was soft red winter (Grain and Feed Market News, Agricultural Marketing Service, USDA). This volume also accounted for more than thirty one percent of total soft red winter wheat exported by the United States in the 1993 marketing year (USDA, ERS, Wheat, Situation and Outlook Report, October 1994). Hence, wheat futures prices and wheat cash prices used in this analysis are for soft red winter wheat quoted by the Chicago Board of Trade, purchased from Technical Tools.

In Asia, Hong Kong is an important grain trade center. Hong Kong has served as a stepping-stone to mainland China for Chinese imports during the last decade. According to the Census and Statistics Department of Hong Kong (1993), an increasing number of countries used Hong Kong as a conduit to China in the 1980s. The increased transshipment through Hong Kong is primarily attributed to its status as a free trade area, sophisticated harbor facilities, a well developed financial and banking network, and closeness to the concentrated area of joint ventures in south China (S. Webb, 1992). Starting from 17 October 1983, the Hong Kong dollar was linked to the U.S. dollar through a new arrangement in the note-issue mechanism at a fixed exchange rate of HK$7.80 = US$1.00 (Hong Kong Census and Statistics Department, 1993). Therefore, foreign exchange rate risk in Asian rice and wheat trade is not a factor in this study.

Analysis of Cash Markets Activity

Average Prices and Variance of Prices. Preliminary graphical analysis for Thailand cash prices movement of 1st grade, 2nd grade and 5% brokens rice is provided by Figures 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6. Cash price trends for Texas milled long grain rice and world market long grain cash rice are shown in Figures 3.7, 3.8, and 3.9. Figures 3.10 and 3.11 exhibits the trends of Chicago number 2 soft red winter wheat.

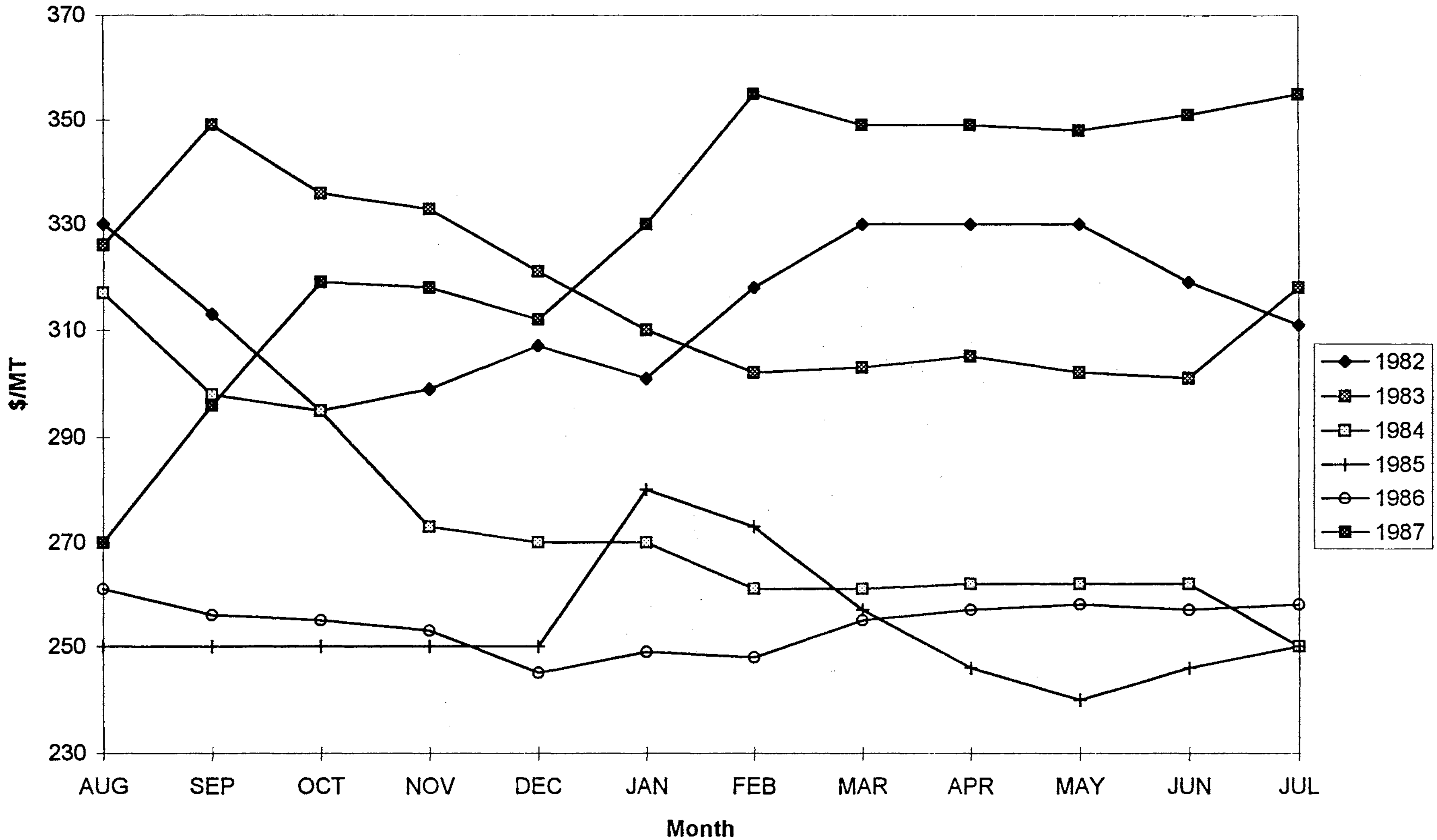


Figure 3.1. Thailand Monthly Cash Rice Prices
100% 1st Grade, Aug1982 - July 1988

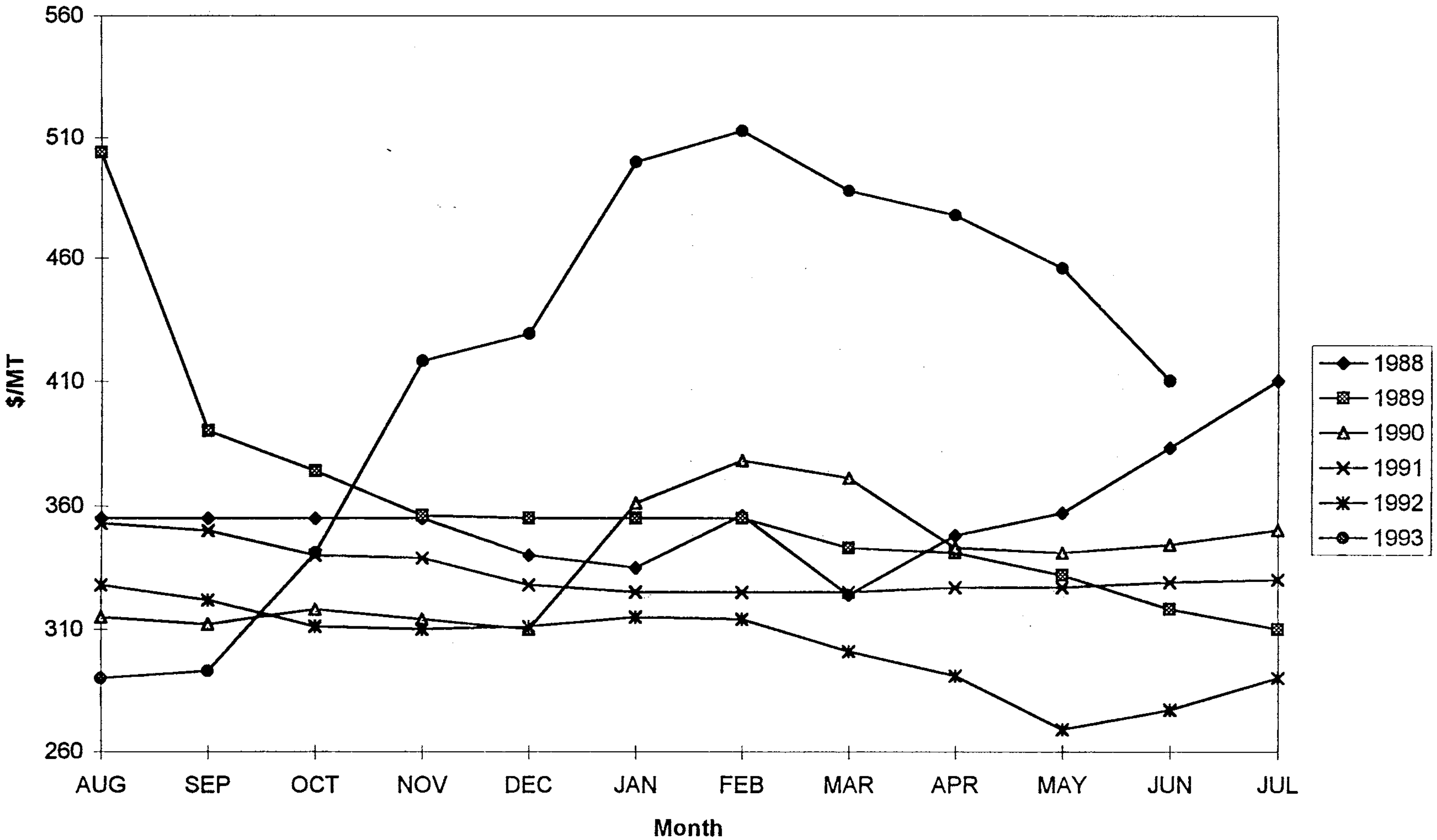


Figure 3.2. Thailand Monthly Cash Rice Prices
100% 1st Grade, Aug.1988 - June 1994

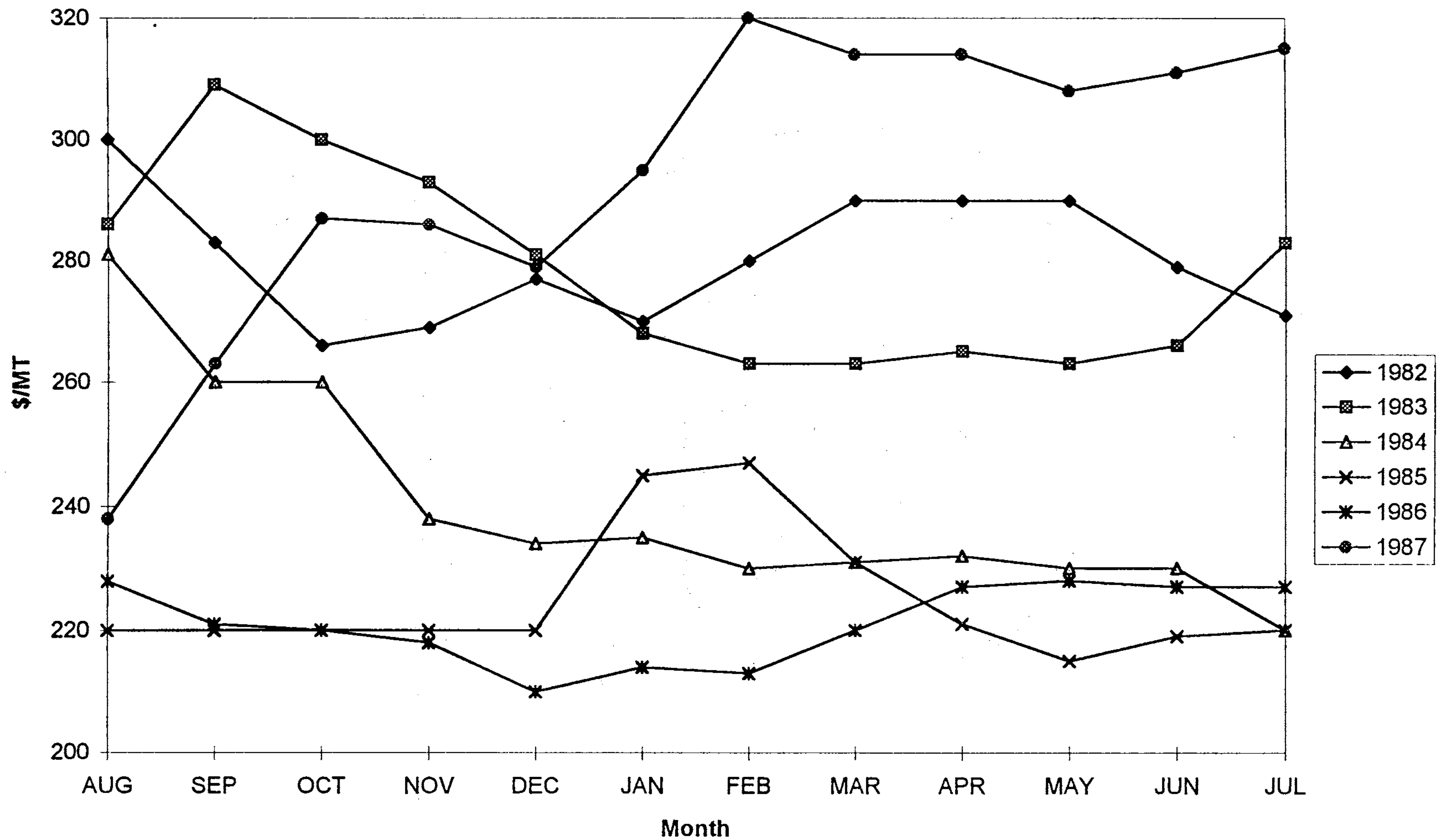


Figure 3.3. Thailand Monthly Cash Rice Prices 100% 2nd Grade, Aug.1982 - July 1988

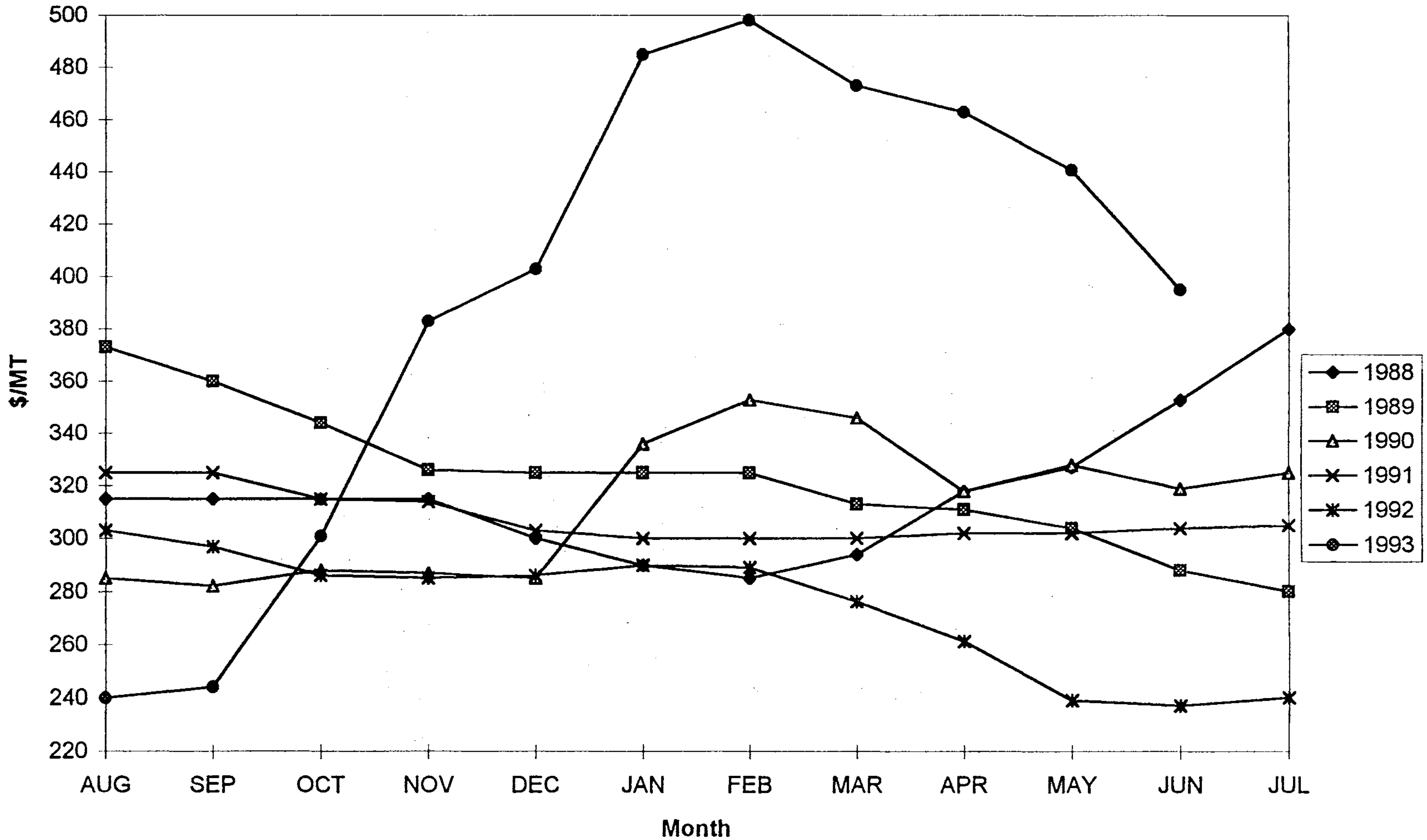


Figure 3.4. Thailand Monthly cash Rice Prices
100% 2nd Grade, Aug.1988 - June 1994

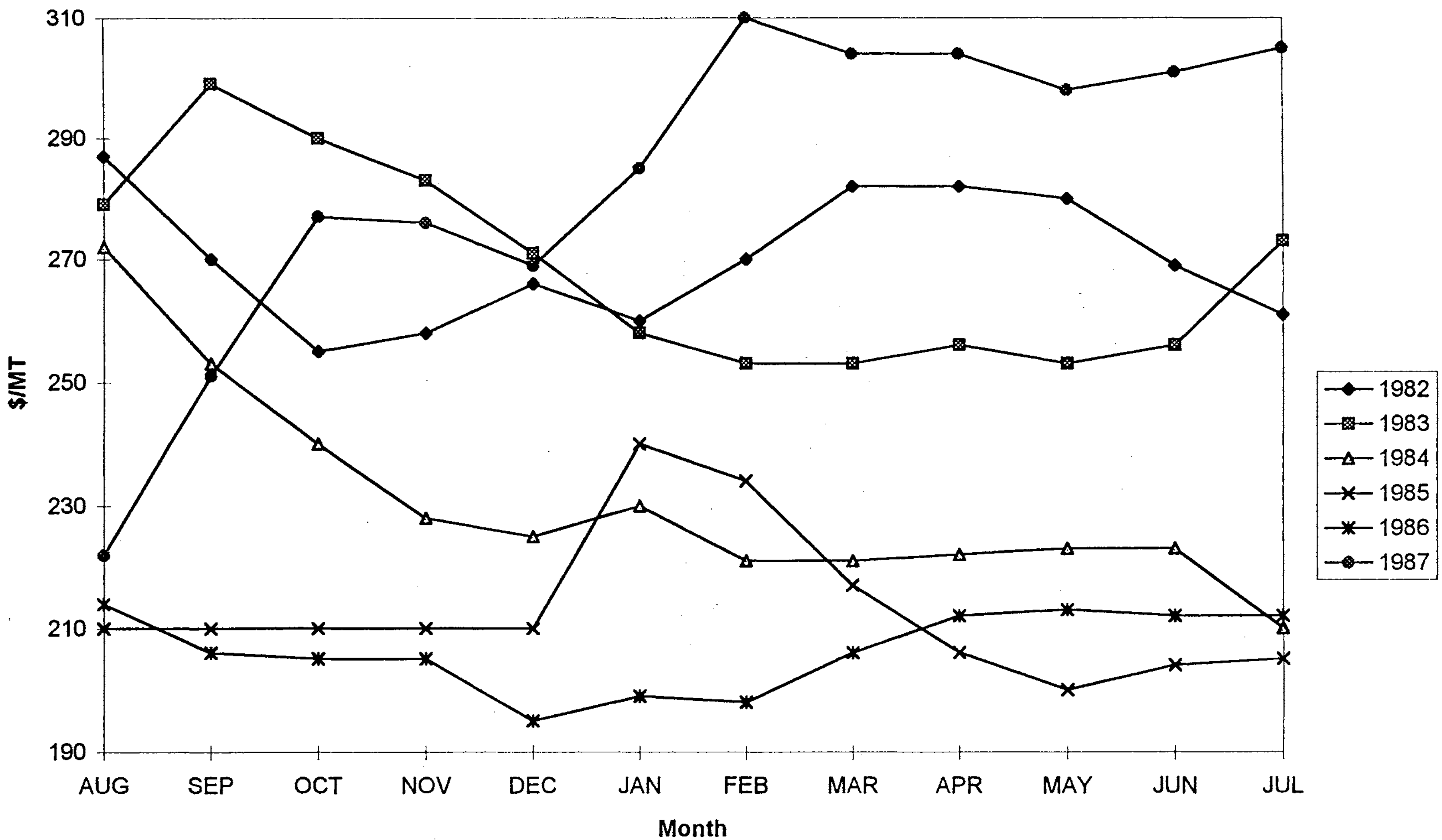


Figure 3.5. Thailand Monthly Cash Rice Prices
5% Brokens, Aug. - July 1988

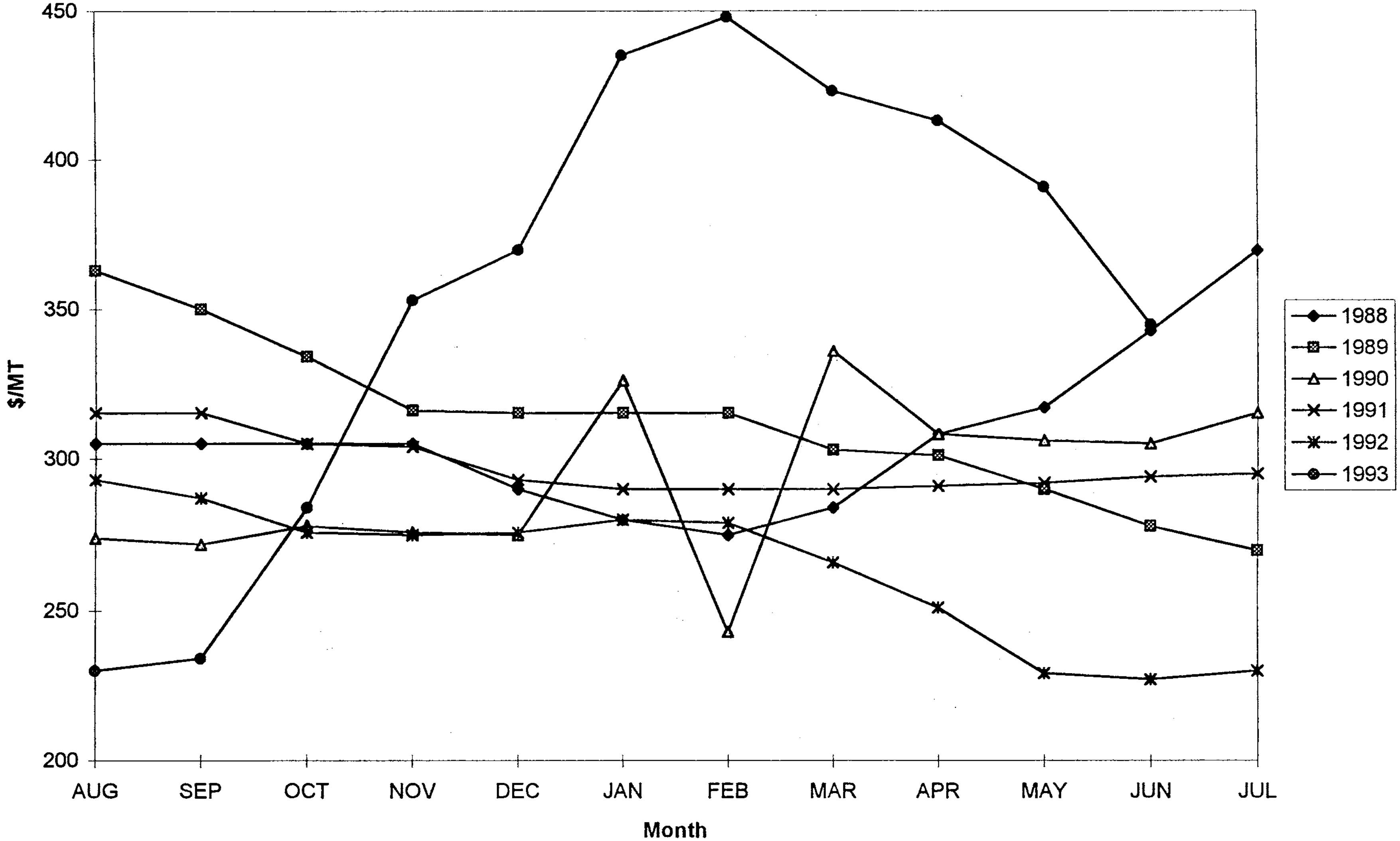


Figure 3.6. Thailand Monthly Cash Rice Prices
5% Brokens, AUG. 1988 - June 1994

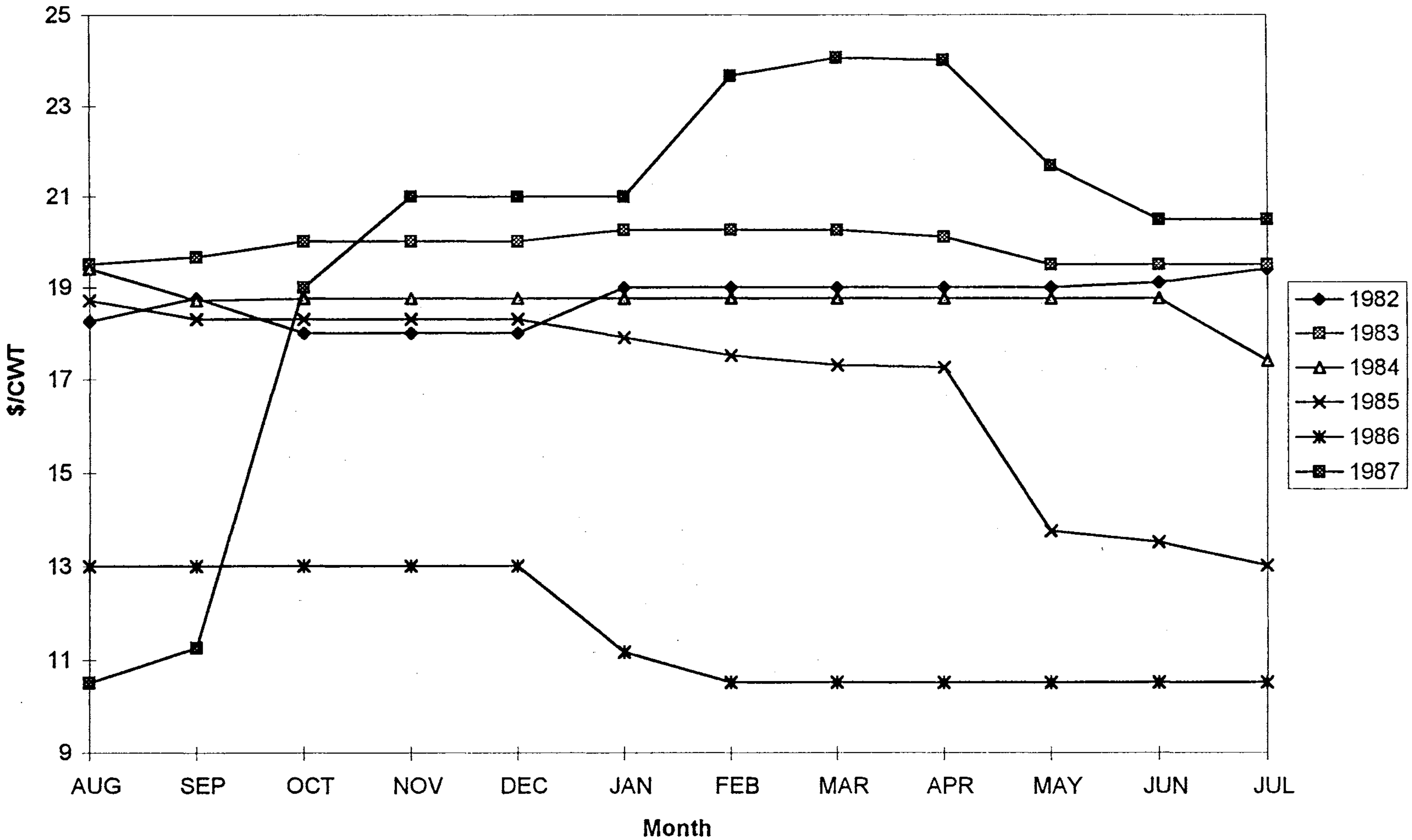


Figure 3.7. Texas Monthly Cash Rice Prices
Long Grain, f.o.b. mills, Aug.1982 - July 1988

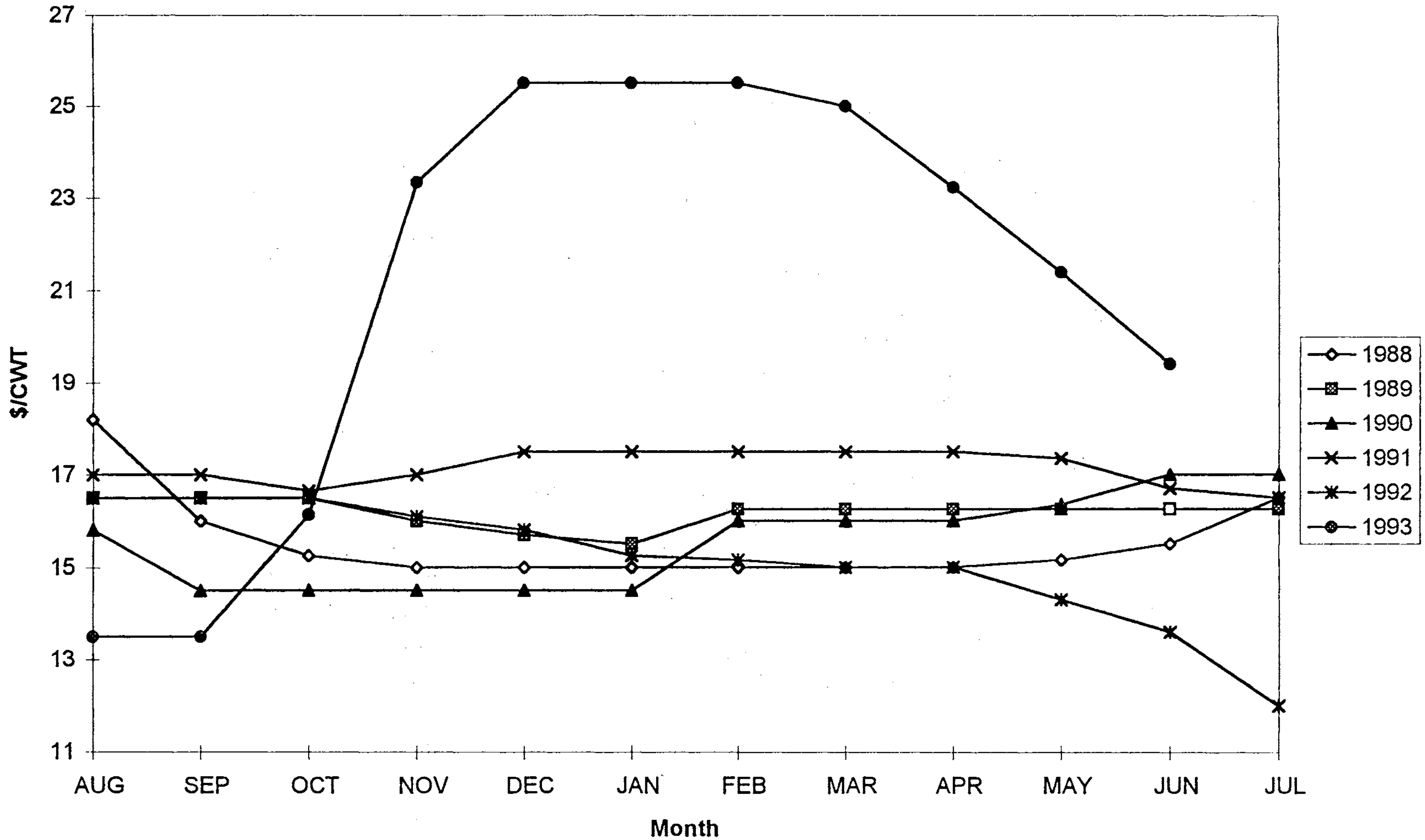


Figure 3.8. Texas Monthly Cash Rice Prices
Long Grain, f.o.b. mills, Aug.1988 - June 1994

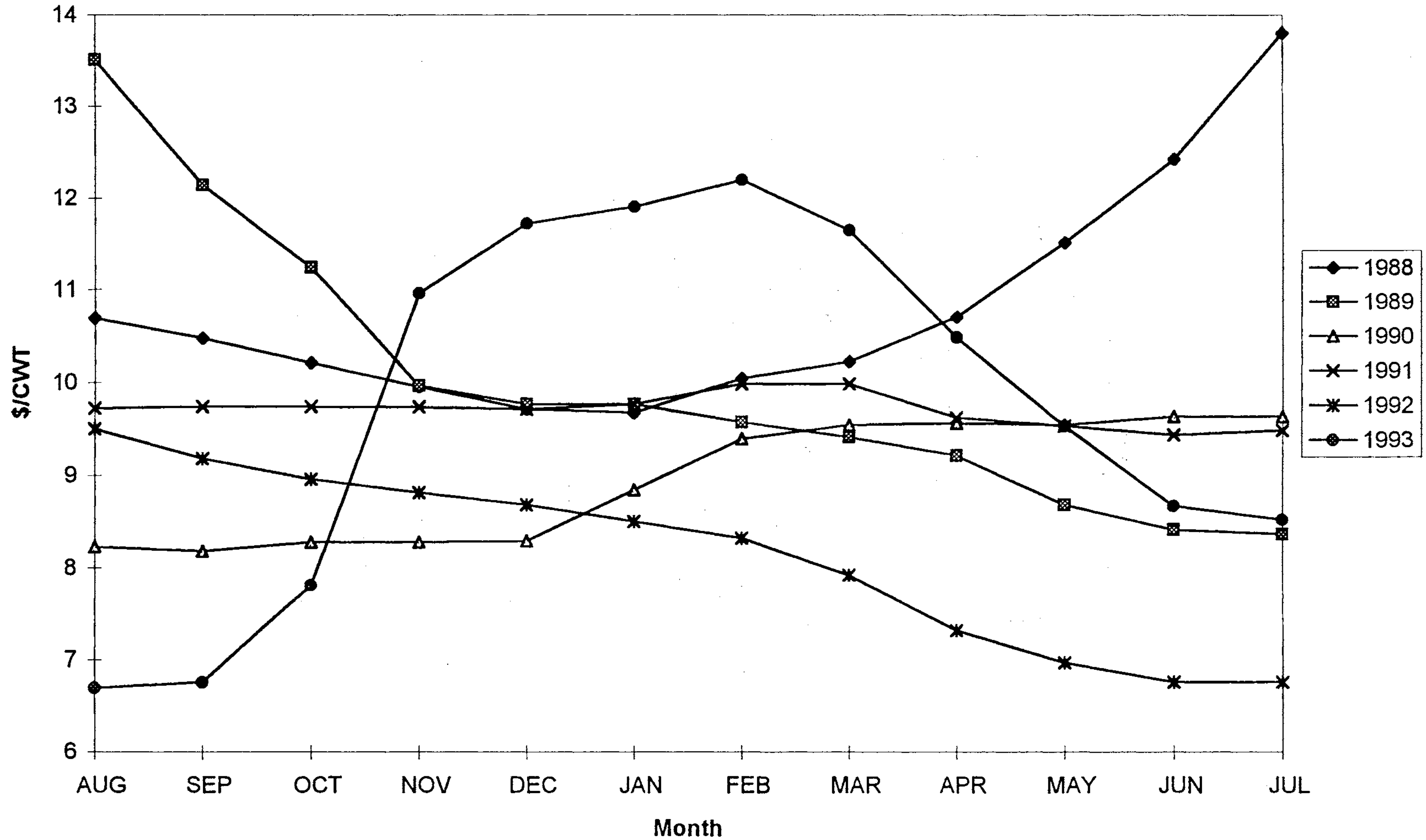


Figure 3.9. World Market Monthly Cash Rice Prices
Loan Rate Basis, Long Grain, Aug.1988 - July 1994

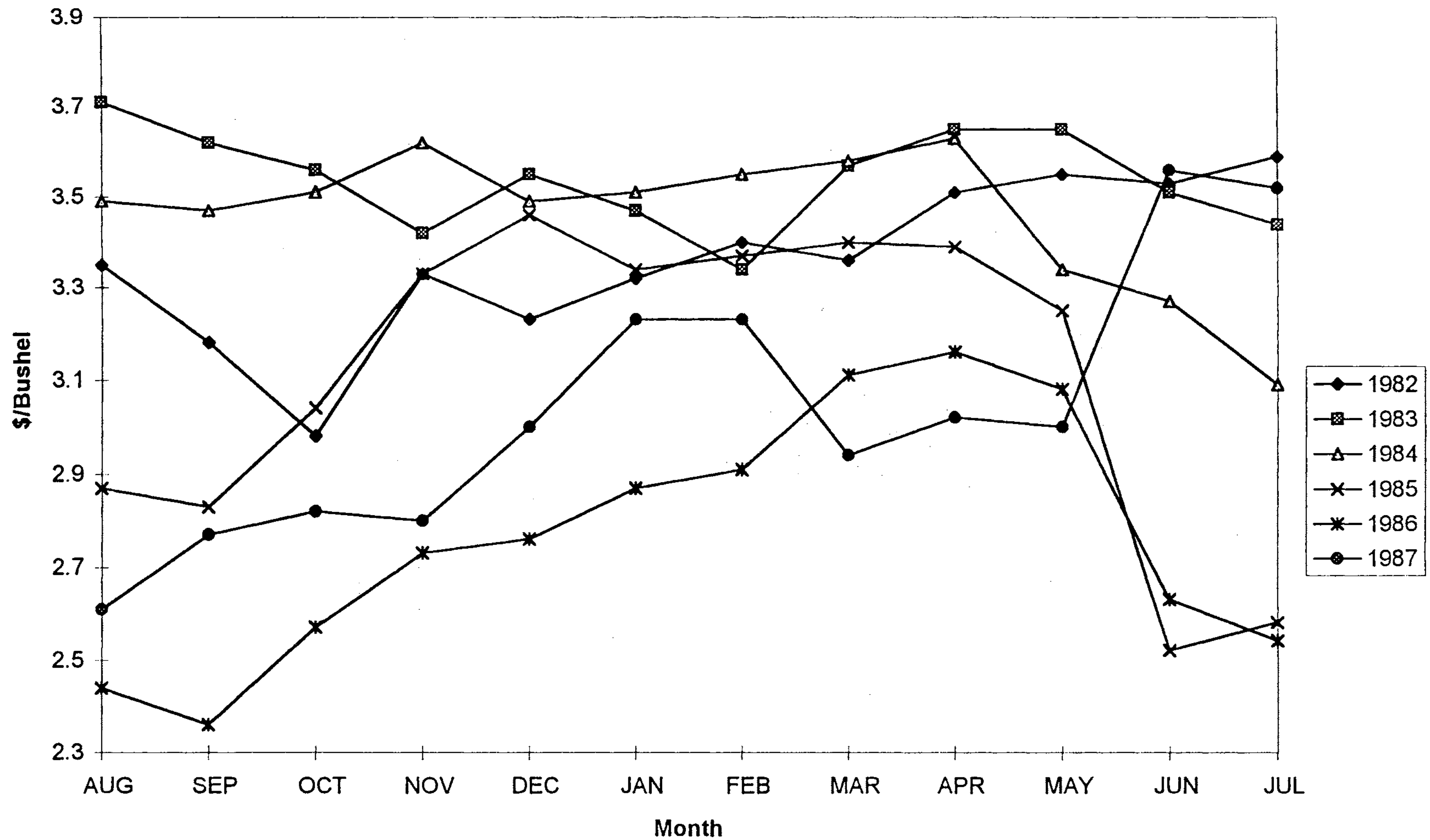


Figure 3.10. Wheat Monthly Cash Prices, Aug.1982 - July 1988
Chicago, No.2 Soft Red Winter

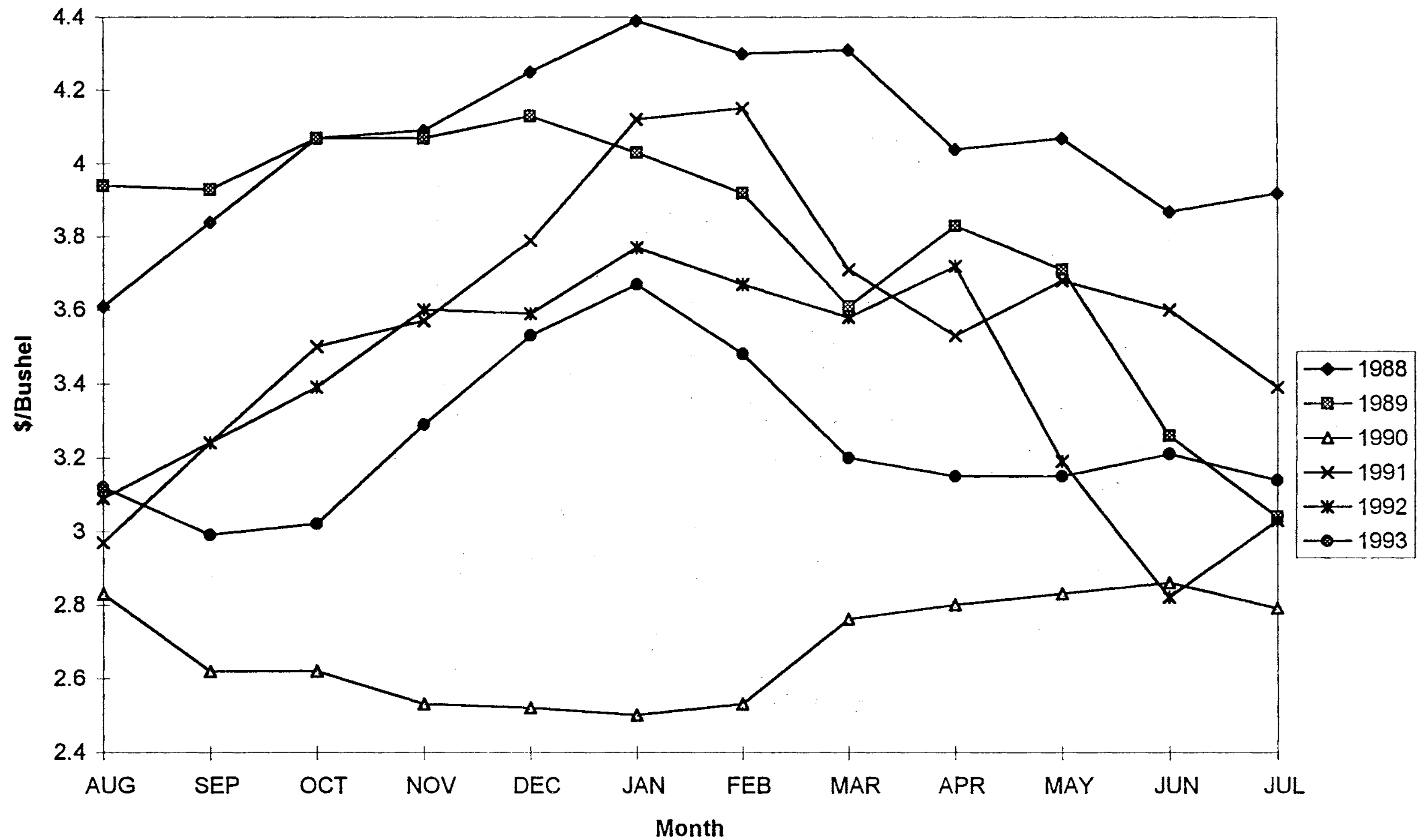


Figure 3.11. Wheat Monthly Cash Prices, Aug.1988 - July 1994
Chicago, No.2 Soft Red Winter

Although the yearly cash price movement of Thailand rice follows no fixed pattern, there are several apparent seasonal trends: First, rice prices decline following August, and the decline lasts three to four months; Second, rice cash prices start to increase in January, and the increase lasts one to two months. Monthly cash prices for Chicago No.2 soft red winter wheat, however, increase following September, and the increase lasts about four months to January when greater price fluctuation is associated with a declining trend.

The above observations are supported by the simple average of monthly prices of rice and wheat from August, 1981 to June, 1994 in table 3.1. The trends of cash prices of rice and wheat are shown in Figure 3.12.

TABLE 3.1

MONTHLY AVERAGE CASH PRICES OF RICE AND WHEAT, AUGUST 1981 - JUNE 1994, $/CWT

Month	World[1/]	Thailand[2/]	Texas[3/]	Chicago Wheat[4/]
Aug.	9.72	13.63	17.07	5.35
Sep.	9.41	13.54	16.81	5.37
Oct.	9.37	13.5	17.39	5.53
Nov.	9.62	13.52	17.97	5.70
Dec.	9.65	13.24	18.08	5.78
Jan.	9.74	13.64	17.93	5.90
Feb.	9.92	13.74	18.10	5.82
Mar	9.79	13.59	17.98	5.73
Apr.	9.48	13.44	17.82	5.78
May	9.29	13.23	17.15	5.63
Jun.	9.22	13.03	16.85	5.38
Jul.	9.42	12.71	16.36	5.32

Note: 1/ World market long grain rice price, Aug.1988-Juy 1994. 2/ Thai 2nd grade rice price.
3/ Texas f.o.b. long grain rice price. 4/ Chicago soft red winter wheat price.
Source: USDA, ERS, Situation and Outlook Report, Rice, RCS-70, July 1994.
USDA, ERS, Situation and Outlook Report, Wheat, WHS-308, October 1994.

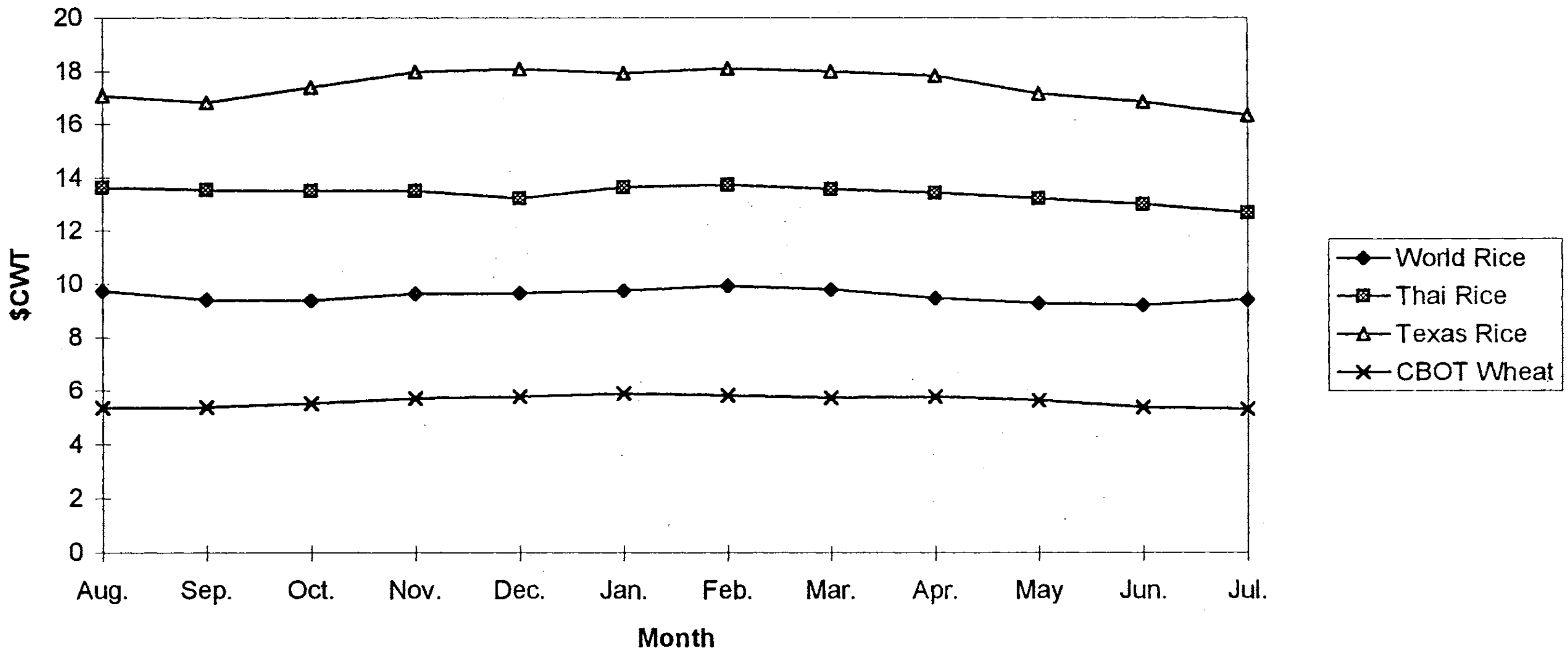


Figure 3.12. Monthly Average Cash Prices of Rice & Wheat
Aug. 1981 - June 1994

In the last thirteen years, the lowest monthly average Thai rice price is in July, and the highest monthly average rice price is in February. Interestingly, the lowest monthly average price for No.2 soft red winter wheat in this period is also in July, but the highest monthly average price for wheat is in January, one month ahead of that for Thai rice. (A possible interpretation for that lag of higher Thai rice price may be that Asian rice has a second harvest in November.) However, although the months of lowest and highest prices for rice and wheat are nearly the same, the direction of wheat price movement is different from that of rice after August.

Seasonality. Prices often vary seasonally. In seasonality models, dummy variables are usually used to capture discrete shifts in the regression function. The simple use of zero-one dummy variables could reflect the shifts in the underlying relationships as prices change across months. This chould be achieved, for example, by specifying a dummy variable (d = 1) for January and zero for other months. In this analysis, eleven monthly dummy (0/1) variables are introduced for individual months, attempting to account for seasonal variations in monthly cash prices. The dummy variables are denoted Mi; M1 for January, M2 for February, and so on. Monthly log cash price returns of rice and wheat are used as the dependent variables:

$$\text{Log}\,(P_t/P_{t-1}) = \text{Log}\,P_t - \text{Log}\,P_{t-1} \qquad (3.1)$$

Eleven monthly dummy variables are used as independent variables. The seasonality analysis covers the period from August 1981 to June 1994, except that the cash rice prices series in world markets start from August 1988. December log price returns are used first as the base. Then, July log price returns are used as the base.

Analysis of Futures Markets Activity

Volume Analysis. Volume refers to the number of futures contracts that are either bought or sold during a selected period of time, such as a day or a month. A CBOT rough rice futures contract is specified as 2,000 hundredweight of U.S. Number 2 or better long grain rough rice. The number of registered contracts is a measure of trading activity that occurs during that period. High volume indicates the presence of currently active sellers and buyers. Open interest measures the number of futures contracts that remain "open" at a particular point in time, usually at the close of trading. High open interest indicates the presence of sellers and buyers already holding positions and therefore assures that there will be traders in the future. Open interest can also be useful in assessing the liquidity of a market. Liquidity is usually greater in markets with more participants and more trading.

Low traded volume has been a character of the rice futures market over years (Hoffman, 1990). The term "low volume contract" is defined by the Commodity Futures Trading Commission as "any commodity futures contract in which the trading volume in all futures listed for trading falls below 1,000 contracts per calendar month during at least four of any six consecutive calendar months" (Federal Register, 1982, pp.29,515-23). The rough rice contract had fallen into this criterion of a "thin" market. Since August 1986, however, the trading volume has grown to the extent that that the number of rough rice contracts traded exceeds a "low volume" designation. Still, the volume of rice trading is very low, if compared with the volume registered for other heavily traded commodities such as corn, soybeans, and wheat. As a result, liquidity is still a problem for large rice traders (Lee, Hayenga, and Lence, 1995).

Rice futures market volume varies from season to season, and from contract month to contract month. Activity in the rice futures market for each contract two months before its delivery period is summarized in Table 3.4. Although there are six contract months in each year (January, March, May July, September, And November), only five contract months are analyzed in this study, since few people trade rice futures using the July futures contract.

TABLE 3.2

TRADED VOLUME OF ROUGH RICE FUTURES CONTRACTS,
SELECTED MONTHS, 1986-94

Futures Contract	Trading Period	Average Daily Volume	Open Interest
1986 Nov	08/20/86--09/30/86	28.6	149.6
1987 Jan	10/01/86--11/28/86	13.7	127.7
Mar	12/01/86--01/30/87	17.7	156.5
May	02/02/87--03/31/87	10.9	118.8
Sep	04/01/87--07/31/87	14.6	187.6
Nov	08/03/87--09/30/87	83.7	550.7
1988 Jan	10/01/87--11/30/87	167.5	1,275.7
Mar	12/01/87--01/29/88	143.4	1,383.5
May	02/01/88--03/31/88	166.8	1,301.0

TABLE 3.2

TRADED VOLUME OF ROUGH RICE FUTURES CONTRACTS, SELECTED MONTHS, 1986-94 (Continued)

Sep	04/04/88--07/29/88	60.1	858.0
Nov	08/01/88--09/30/88	35.4	1019.7
1989 Jan	10/03/88--11/30/88	52.5	794.7
Mar	12/01/88--01/31/89	51.0	1010.7
May	02/01/89--03/31/89	47.4	732.4
Sep	04/03/89--07/31/89	86.4	951.4
Nov	08/01/89--09/29/89	96.7	1229.7
1990 Jan	10/02/89--11/30/89	101.7	1007.7
Mar	12/01/89--01/30/90	111.5	1146.7
May	02/01/89--03/30/90	120.0	1748.0
Sep	04/02/90--07/31/90	58.5	621.0
Nov	08/01/90--09/28/90	79.4	1091.3
1991 Jan	10/01/90--11/30/90	80.8	1247.5
Mar	12/03/90--01/31/91	91.3	1262.0
May	02/01/91--03/28/91	87.8	1132.7
Sep	04/01/91--07/31/91	48.3	587.6
Nov	08/01/91--09/30/91	48.4	842.2
1992 Jan	10/01/91--11/29/91	57.6	814.6
Mar	12/02/91--01/31/92	34.1	629.4
May	02/03/92--03/31/92	55.2	657.5
Sep	04/01/92--07/31/92	25.8	411.6
Nov	08/03/92--09/30/92	44.4	927.8
1993 Jan	10/01/92--11/30/92	25.5	569.8
Mar	12/01/92--01/29/93	34.6	800.5
May	02/01/93--03/31/93	44.0	644.5
Sep	04/01/93--07/30/93	63.8	949.0
Nov	08/02/93--09/30/93	84.5	1199.2
1994 Jan	10/01/93--11/30/93	267.1	1568.7
Mar	12/01/93--01/30/94	180.3	1829.0
May	02/01/94--03/31/94	167.7	1467.9
Sep	04/04/94--07/29/94	109.6	1461.7
Nov	08/01/94--09/30/94	188.5	1380.7

Source: Authors' calculation using CBOT rough rice futures volume data purchased from Technical Tools.

The greatest marketing activity was during the first six months of the crop year (from August to January), using the November, January and March contracts. The average number of contracts traded daily in this time period is 80.5, 7.6 more than in the remaining months of the crop year (February through July). The largest and second largest average daily volumes (267.1 and 188.5) were achieved on the November and January contracts, respectively, during August through November. The smallest average daily volume (10.9) was registered on the May contract during February through March.

Volumes traded in the various rice futures contracts is consistent with actual production activities. In most rice producing areas, rice is harvested in August and September; in Asia, rice is also harvested in November. Afterwards, the rice is out of the hands of most farmers by January. Hence, the time from harvest (August) through January is likely the period of greatest liquidity in the cash market.

Volatility Analysis. Cox and Rubinstein (1985, p34) stated that volatility is a measure of the dispersion of possible future stock prices. We extend this concept to rice and wheat prices, to evaluate the dispersion of the expected rate of returns of the prices of the commodities.

To estimate the annual volatility, Cox and Rubinstein first assumed that the natural logarithm of the price relative (final price divided by initial price) over any period (e.g. a week, a month) has a normal distribution, that is, the prices are lognormally distributed. The mean and variances are proportional to the length of the period. Then, Cox and Rubinstein apply standard statistical techniques to estimate the parameters of a normal distribution with unknown mean and variance. The sample mean and variance are given by:

$$\mu = (\textstyle\sum_{k=1}^{n} \log R_k)/n \qquad (3.2)$$

$$\sigma^2 = (\Sigma_{k=1}^{n} (\log R_k - \mu)^2)/n \qquad (3.3)$$

where R_k is the price relative for the k_{th} time period, and n is the number of price relatives in the sample series.

However, the estimators of the standard deviation and variance may be biased. To correct for this, Cox and Rubinstein multiply their original estimators by a correction factor n/(n-1) for the variance. The following estimator of sample variance is approximately the population variance hence is unbiased:

$$\sigma^2 = (\Sigma_{k=1}^{n} (\log R_k - \mu)^2)/n-1$$

$$= (\Sigma_{k=1}^{n} ((\log R_k)^2 - \mu^2)/n-1 \qquad (3.4)$$

The more price relatives in the sample, the less likely the calculated estimate will be different from the true variance. In another words, as n increases, the variance of the estimator decreases, and the estimate approaches the true value. In this analysis, seven cash price series from the most active part of the cash rice marketing year, August through January, are used. California medium grain milled rice prices, California long grain milled rice prices, Texas long grain milled rice prices, and USDA announced world market long grain milled rice prices are weekly average prices; Thailand 100% 1st grade milled rice prices, Thailand 100% 2nd grade milled rice prices, and Thailand 5% brokens milled rice prices are monthly average prices. (If weekly prices are used, weekly standard deviation is multiplied by $\sqrt{52}$ to annualize).

Next, daily closing prices for CBOT rough rice and soft red winter wheat are collected through the contract lifetime. For example, for March 1993 rice futures contract, observations from August 4, 1992 through March 22, 1993 were used, whiile for March

1993 wheat contract, observations from December 20, 1991 through March 22, 1993 were used. Although there are six futures contracts traded year-round, only four contracts for rice and wheat futures are chosen here for volatility analysis. They are: March, May, September, and November contracts for rice futures, and March, May, September, and December contracts for wheat futures. These two sets of contract months are nearly the same, so prices can be compared. To annualize the daily volatility, the daily standard deviation is multiplied by $252^{1/2}$.

Procedures for Evaluating Cross-Hedging Potential

Correlation of Futures Prices with Cash Prices.

The relationship between a set of cash rice prices and futures rice and wheat prices is initially graphically analyzed for two periods, August through September, and December through January. Data used are monthly average prices covered from 1982 to 1993. In the period August through September, November rice futures contracts and December wheat futures contracts are used, while March rice and wheat futures contracts are used for the period December through January. All the prices are converted to a cents per bushel basis.

In Figure 3.13, November futures prices of CBOT rough rice and December futures prices of CBOT soft red winter wheat are compared with cash prices of three types of Thailand f.o.b. rice.

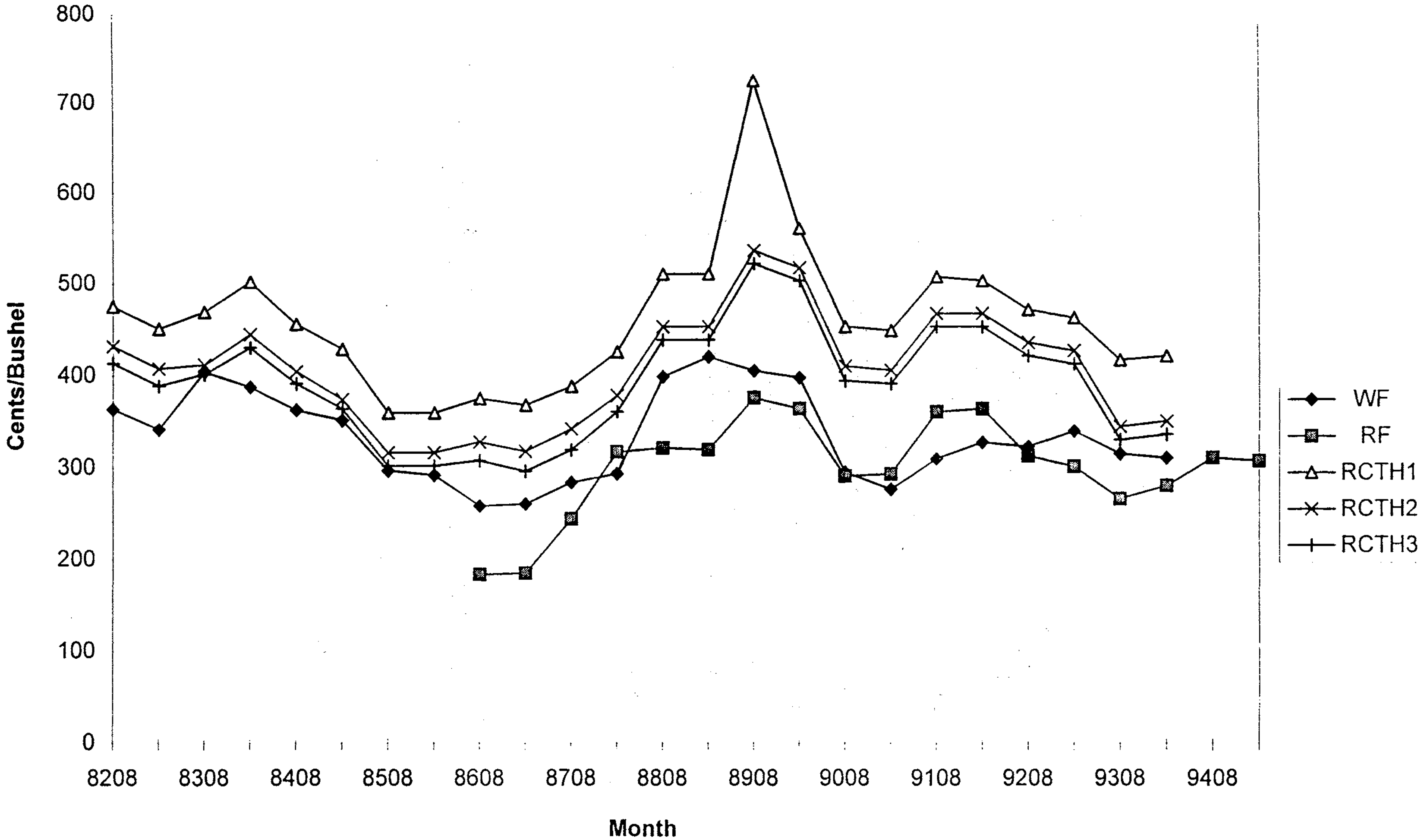


Figure 3.13. Nov/Dec futures Prices of Rice & Wheat vs. Cash Prices of Thailand Rice

In Figure 3.14, the above two sets of futures prices in CBOT are compared with cash prices of California medium-grain milled rice, Texas long-grain milled rice, and USDA announced world market long-grain milled rice. Figure 3.15 provided the graphical relationship between the futures prices and the cash prices of soft red winter rice.

Graphical comparisons among the above mentioned cash prices and March futures prices of CBOT rough rice and CBOT soft red winter wheat are shown in Figure 3.16, Figure 3.17, and Figure 3.18.

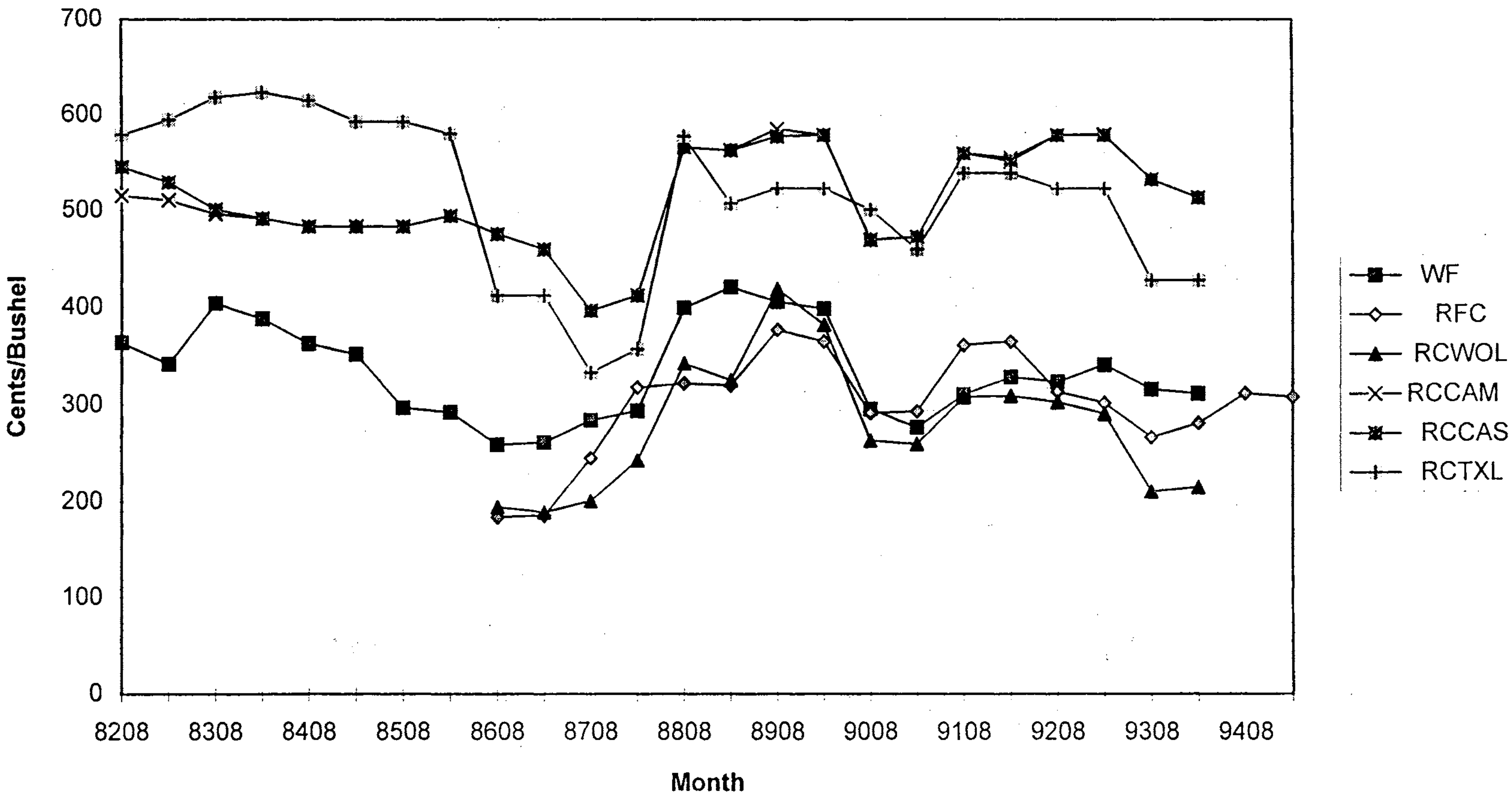


Figure 3.14. Nov/Dec Futures Prices of Rice & Wheat vs. Cash Prices of CA, TX & World Market Rice

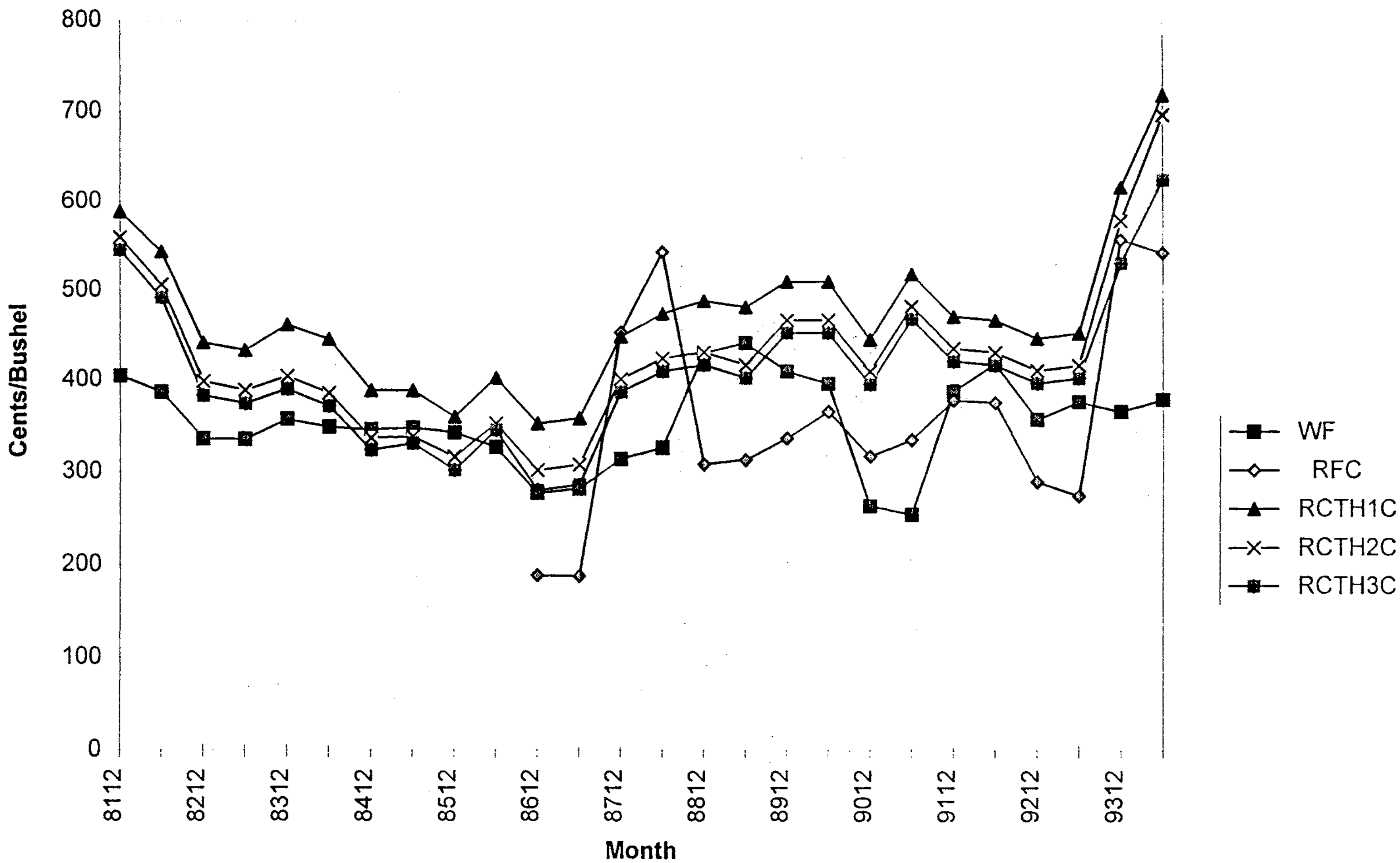


Figure 3.15. March Futures Prices of Rice & Wheat vs. Cash Prices of Thailand Rice

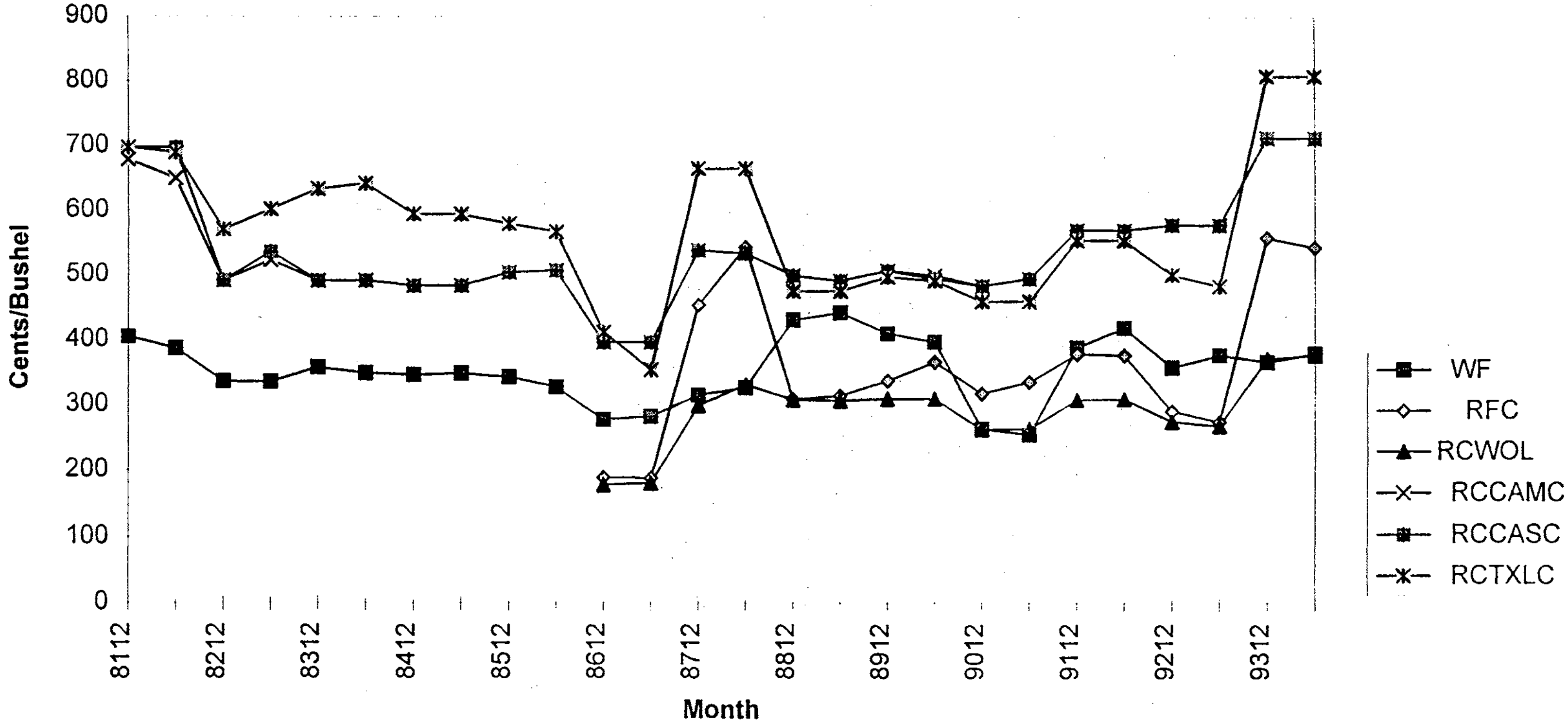


Figure 3.16. March Futures Prices of Rice & Wheat vs. Cash Prices of CA, TX & World Market Rice

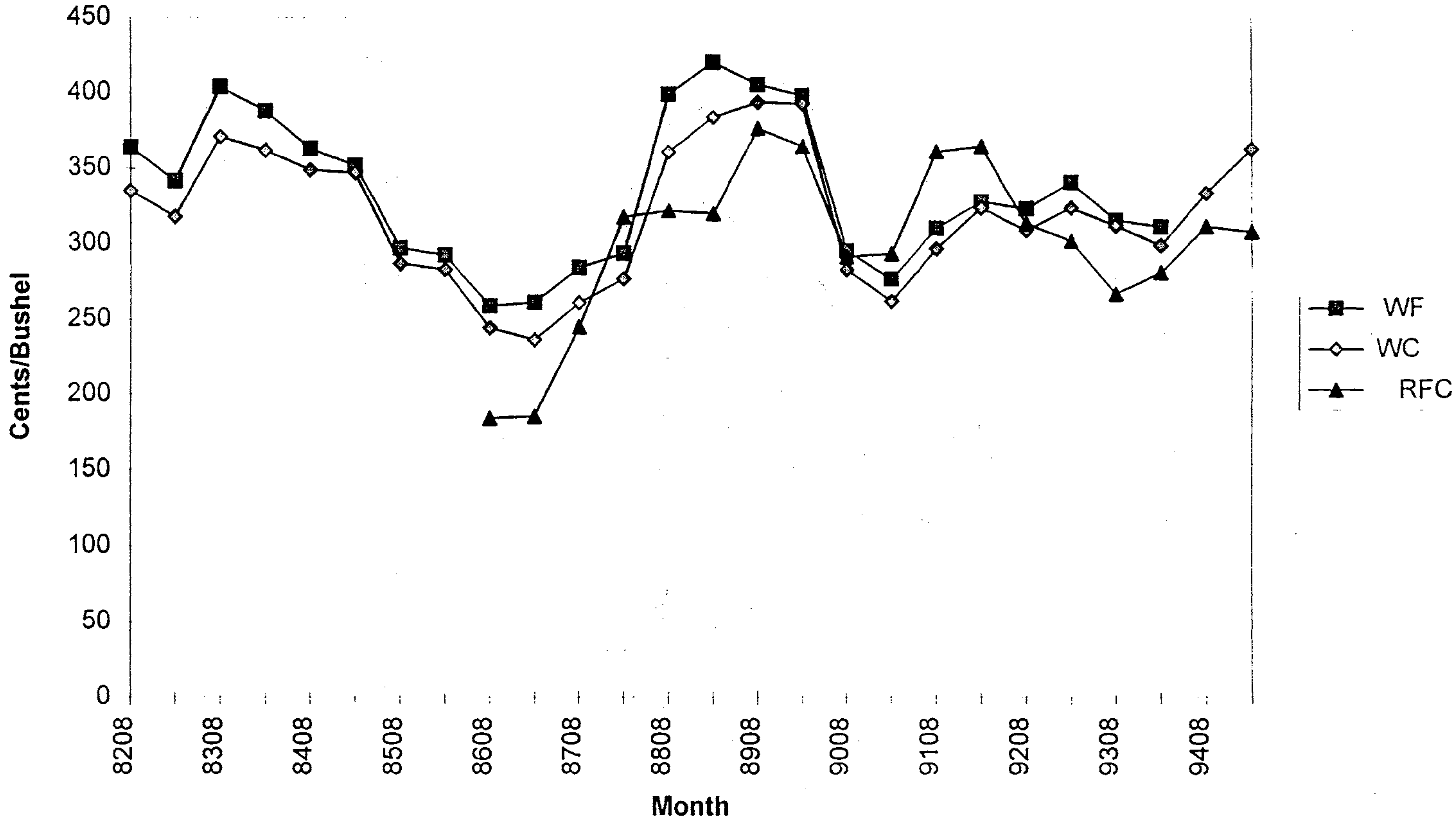


Figure 3.17. Nov/Dec Futures Prices of Rice Wheat vs. Cash Prices of CBOT Soft Red Winter Wheat

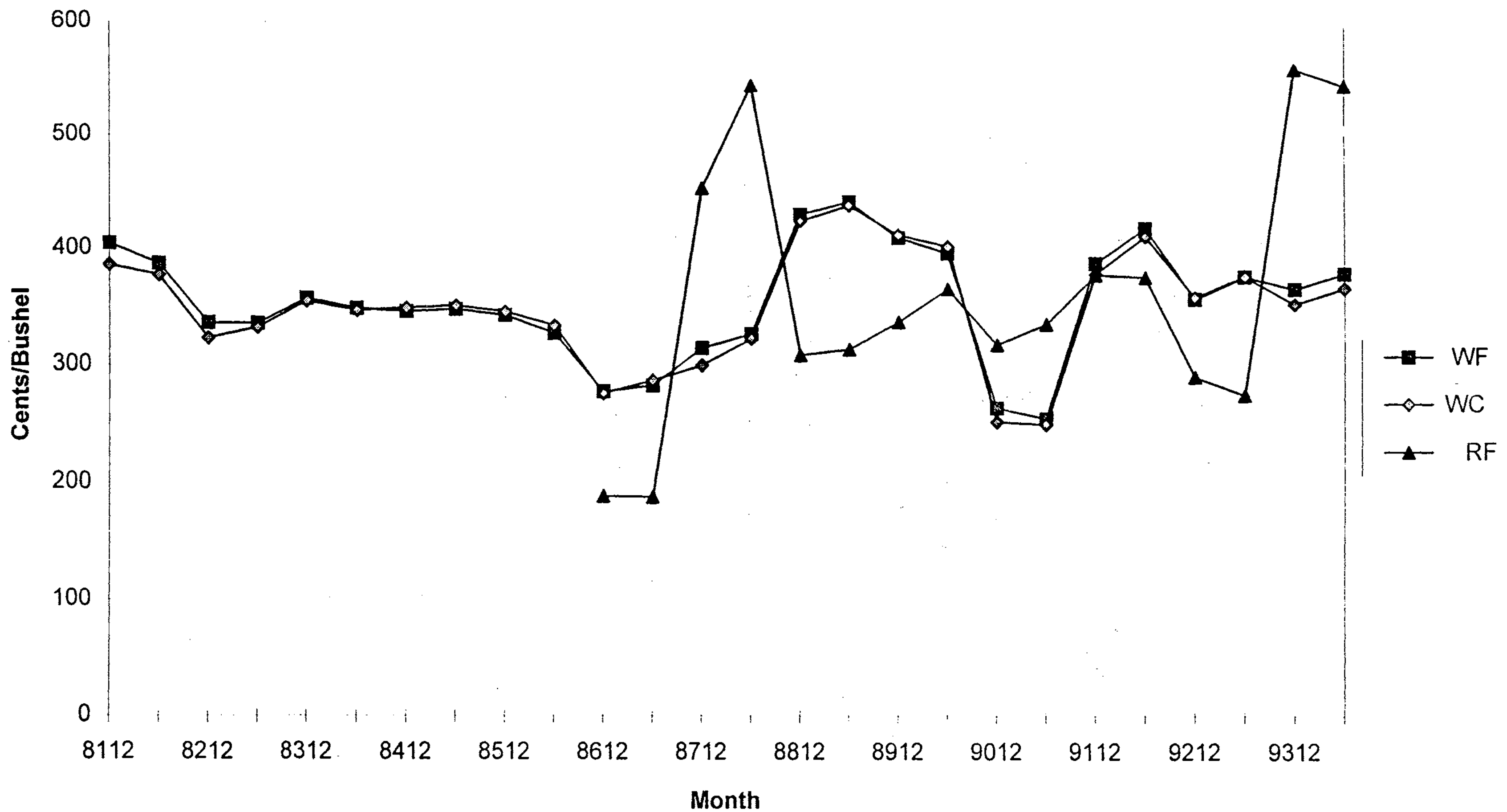


Figure 3.18. March Futures Prices of Rice & Wheat vs. Cash Prices of Wheat

Next, the relationship between log price changes in futures and cash markets of milled rice, rough rice, and wheat is statistically measured. Variance, covariance, and the correlation coefficients of eight sets of cash prices and two sets of futures prices for the period August through September will be provided. The variance of a price is a measure of the dispersion of the probability mass of this price about its mean. The covariance between two series of prices is a measure of the association between them. The correlation between two series of prices is a pure number and falls between -1 and 1. If the two sets of data are independent, the correlation coefficient equals to zero. The larger the absolute value of the correlation, the more nearly the values of the two series of price changes are linearly related. To determine if these results are sensitive to the season of the year, the same procedures are also performed for the December-January period.

To further examine the above observations, hedge/cross hedge model estimates for milled rice and soft red winter wheat in August-September period using November rough rice futures and December wheat futures are provided. The estimates are obtained from the simple regression equations of futures prices of Chicago Board of Trade and cash prices of rice and wheat:

$$\text{Ln } \Delta CP = a + \text{Ln } \Delta FP + e \qquad (3.5)$$

where

Ln ΔCP = Log cash price changes, that is Ln (P_t/P_{t-1}).

Ln ΔFP = Log futures price changes.

a = Intercept term.

e = error term.

Separate equations are estimated for seven type of milled rice (World market long grain rice, Texas long grain rice, California medium grain rice, California short grain rice, Thai 1st grade, Thai 2nd grade, Thai 5% brokens) and also for CBOT soft red winter wheat. Since seasonality has been a concern in this analysis, hedge/cross hedge model estimates for milled rice and soft red winter wheat in December-January period using March rough rice and wheat futures contracts are provided.

The estimated slope coefficients are price risk minimizing hedge ratios in In this period. The intercept term can be viewed as the average allowance for processing costs, grade premiums or discounts, and transport costs. The standard error of the estimated equation is the distribution error about the expected cash price. It can be used to measure the hedging effectiveness, the proportional reduction of cash price variance.

Analysis of Basis Patterns

A benefit of a liquid futures market is that potential buyers and sellers of the commodity can find trading partners efficiently, minimizing search and transaction costs. International trade in rice, however, is not as liquid as wheat trade. Often, prices in rice futures markets are not strongly correlated with prices in cash markets.

Since a predictable basis, the difference between cash price and futures price for a particular contract, is essential for effective hedging, Herrmann (1994) suggested that basis behavior is an indicator of efficiency of a futures contract. The analysis described here compares world and Houston milled rice prices, and New Orleans rough rice cash prices with the January, March, May, September and November CBOT rough rice futures prices. The marketing year is assumed to start in July. Daily CBOT futures closing prices for rough rice (in cents per hundredweight) for the period August, 1986 to December, 1993, are used. Weekly average cash prices of long grain milled rice (kernel rates) in world market, in loan rate basis (cents per pound), are from USDA, ERS "Rice, Situation and Outlook report". Weekly average cash (f.o.b.) prices of long grain milled rice (U.S. dollars per hundredweight) in Houston, Texas are from USDA Agricultural Marketing Service "Rice Market News". Weekly average cash (f.o.b.) prices (U.S. dollars per hundredweight) of No.2 long grain rough rice in New Orleans, Louisiana for the period January 1991 to December 1993 were from "Creed Rice Market Report".[1] Weekly average futures price series are calculated by the authors to coincide with the weekly cash prices.

The ability to hedge in a futures market depends on how closely the futures and the cash prices are related. The basis, the difference between the two sets of prices at a delivery point, should be predictable and vary little day to day. In addition, the trend in the basis should reflect storage costs over the marketing year.

Figures 3.19 and 3.20 show that in 1990 the basis generally rose following harvest in July, then dropped sharply to its lowest points in October and November. For all contracts, basis is lowest in October and November, reflecting the second rice harvest in Asia. Seasonal change of basis in October and November is more obvious than other months in the graphs. This trend reveals the effect of second rice crop in Asia in October and November on rice prices in world markets, including U.S. markets. In this period, there exists little return to storage.

After November, basis generally rises by the approximate cost of storage. However, since there are some variables of demand and supply other than storage cost, the basis does

[1] These data were provided by Dr. Marvin L. Hayenga of Iowa State University.

not necessarily move smoothly upwards. Also, since these cash markets are not futures delivery points[1], basis does not necessarily approach zero.

[1] The delivery point for the CBOT rice futures contract is in eastern Arkansas.

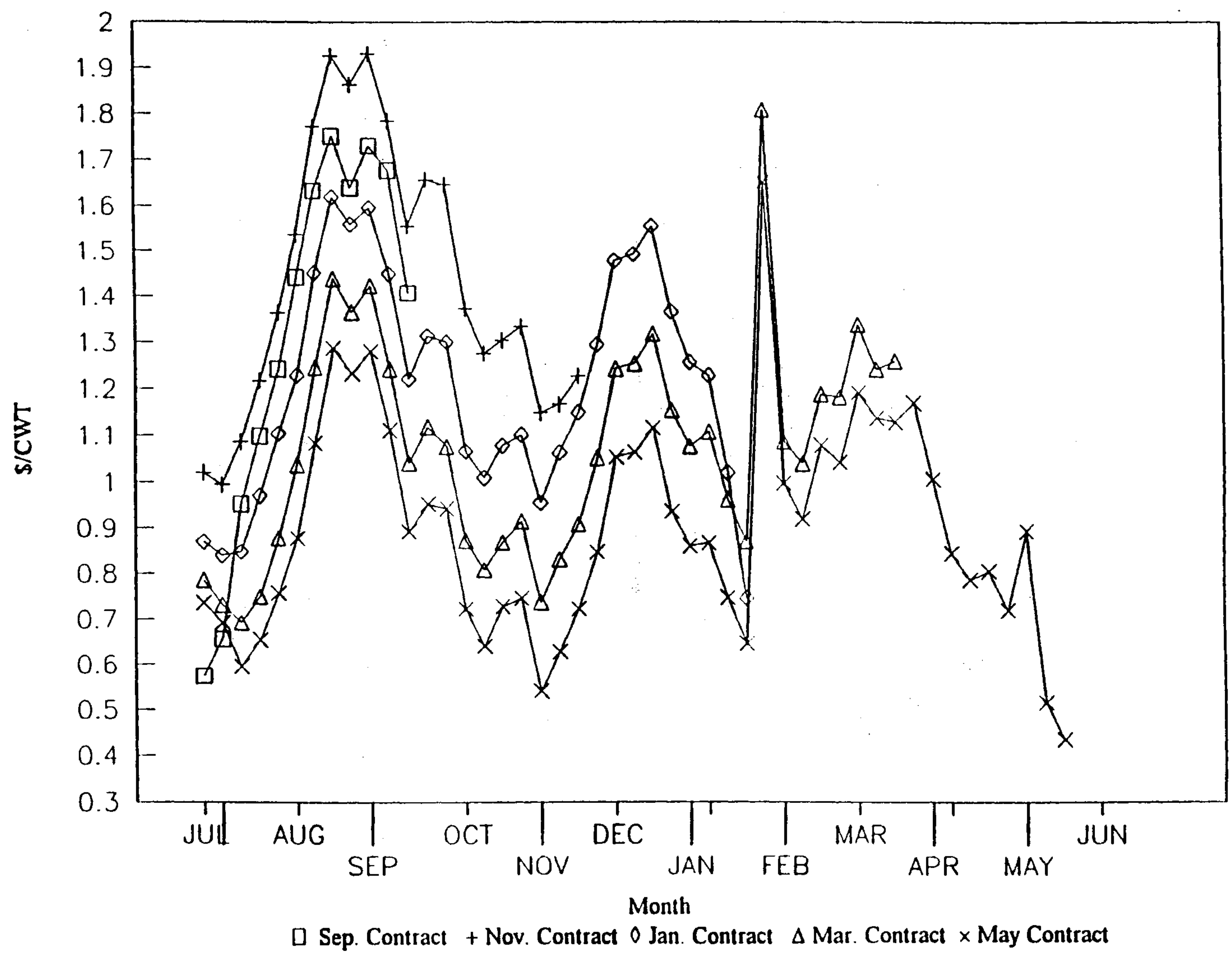


Figure 3.19. World Rice Basis, 1990, Long Grain, Milled

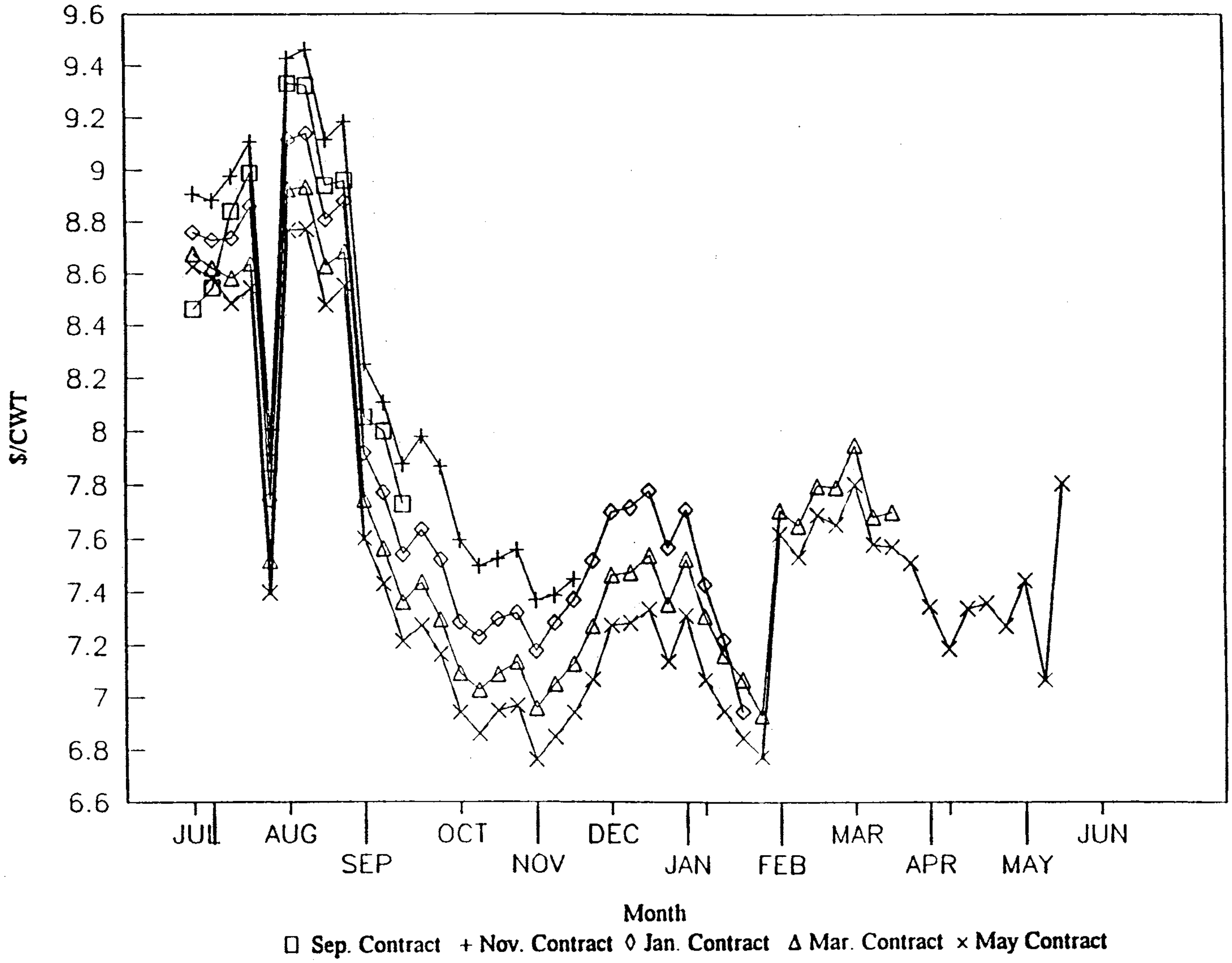


Figure 3.20. Texas Rice Basis, 1990, Long Grain, f.o.b. Mills

Longer-term average rice basis from three different price series (USDA-announced world market prices for long milled kernel rates, Texas prices for long grain milled rice, and New Orleans rough rice price) show basis patterns more clearly than yearly figures (Figures 3.21 through 3.23). The common pattern of the longer-term average rice basis movement was: 1) Basis rose slightly from second week of July to September, then dropped sharply to the lowest point of the year by November. After November, basis rose again to a plateau with fluctuations in January. Around March, basis reached its highest point of the year and then fluctuated again until May; 2) The influence of the second Asian rice harvest was stronger on world rice price than on the Texas and New Orleans prices.

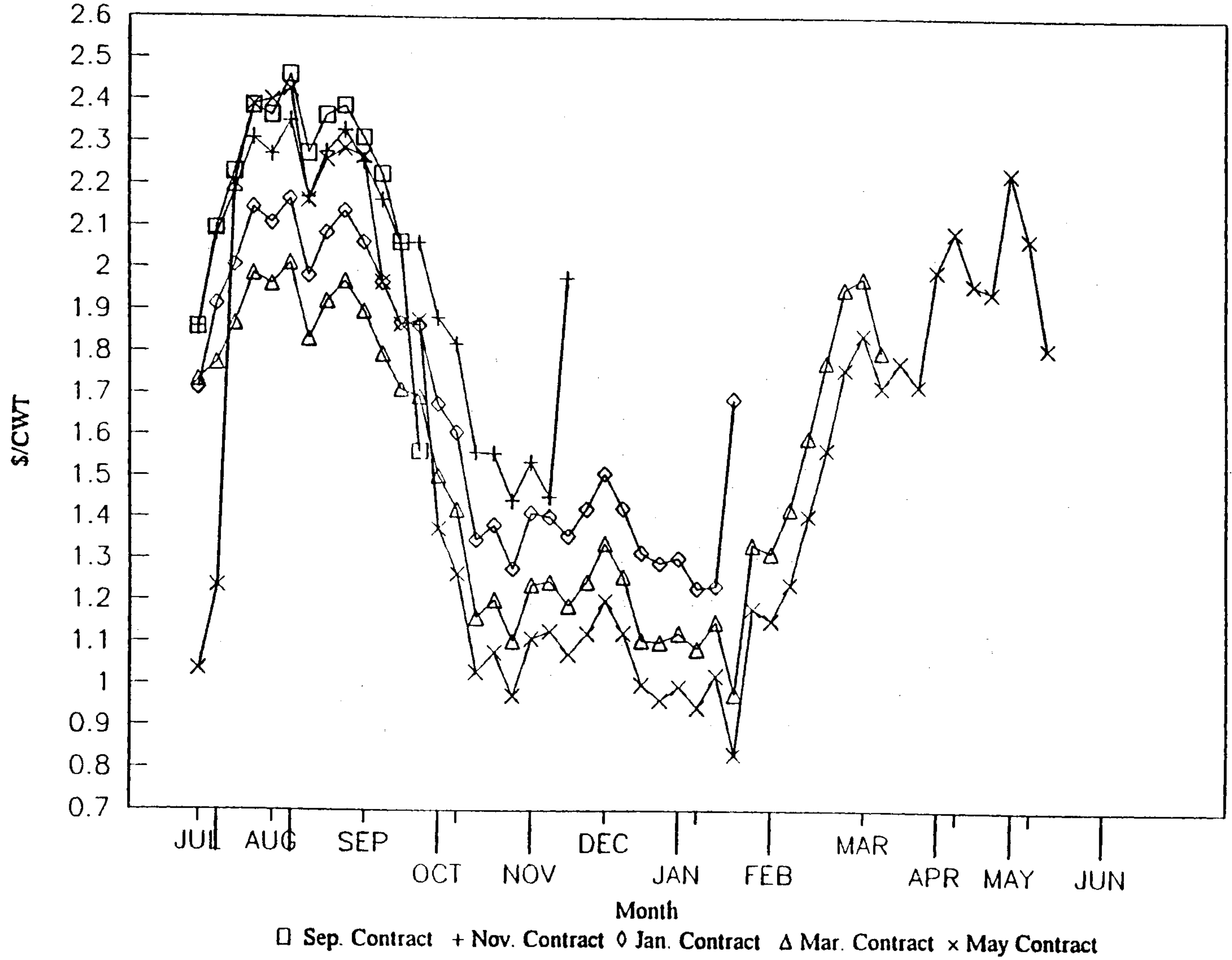


Figure 3.21. Average World Rice Basis, 1997 - 93, Long Grain, Milled

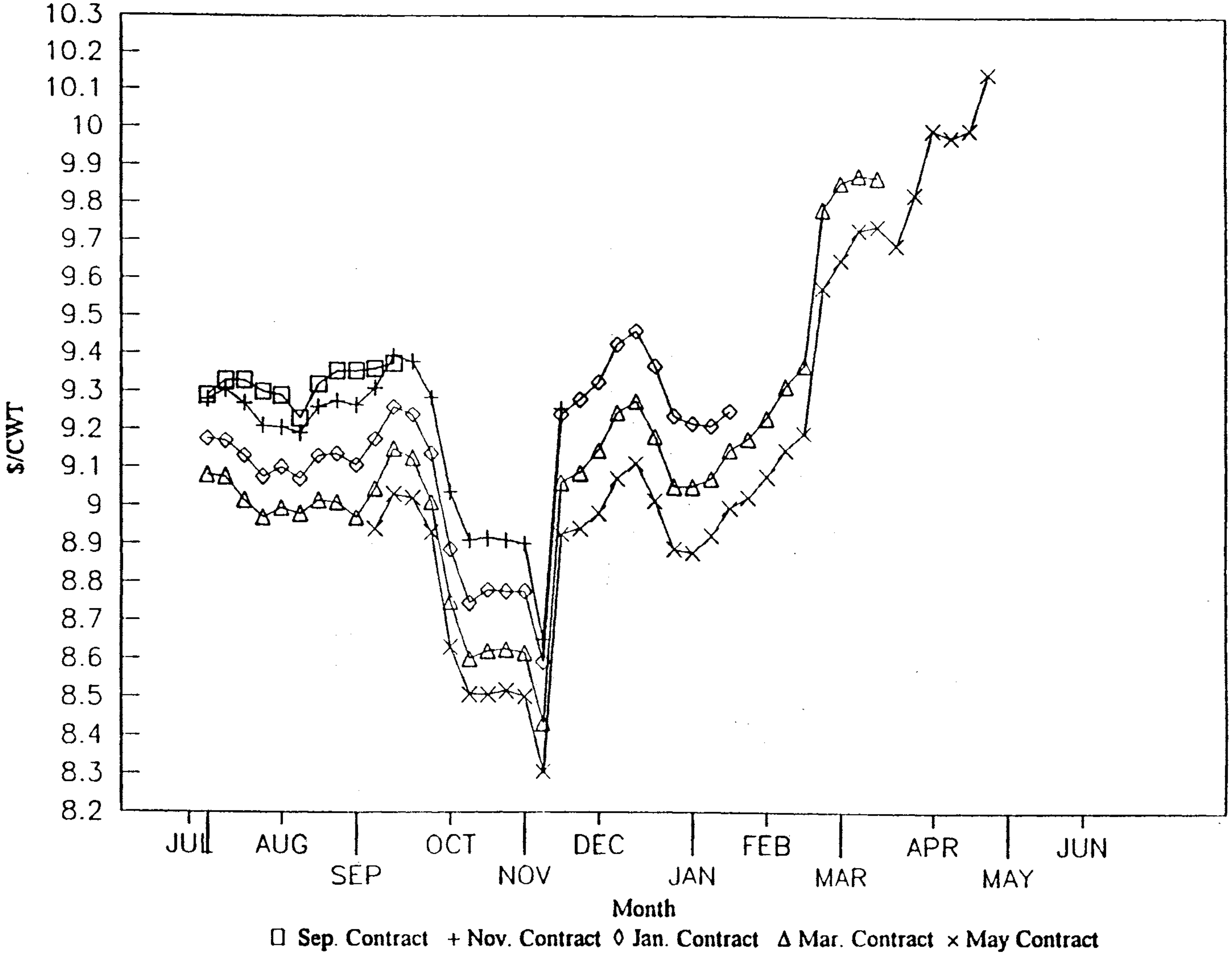


Figure 3.22. Average Texas Rice Basis, 1991 - 92, Long Grain, f.o.b. Mills

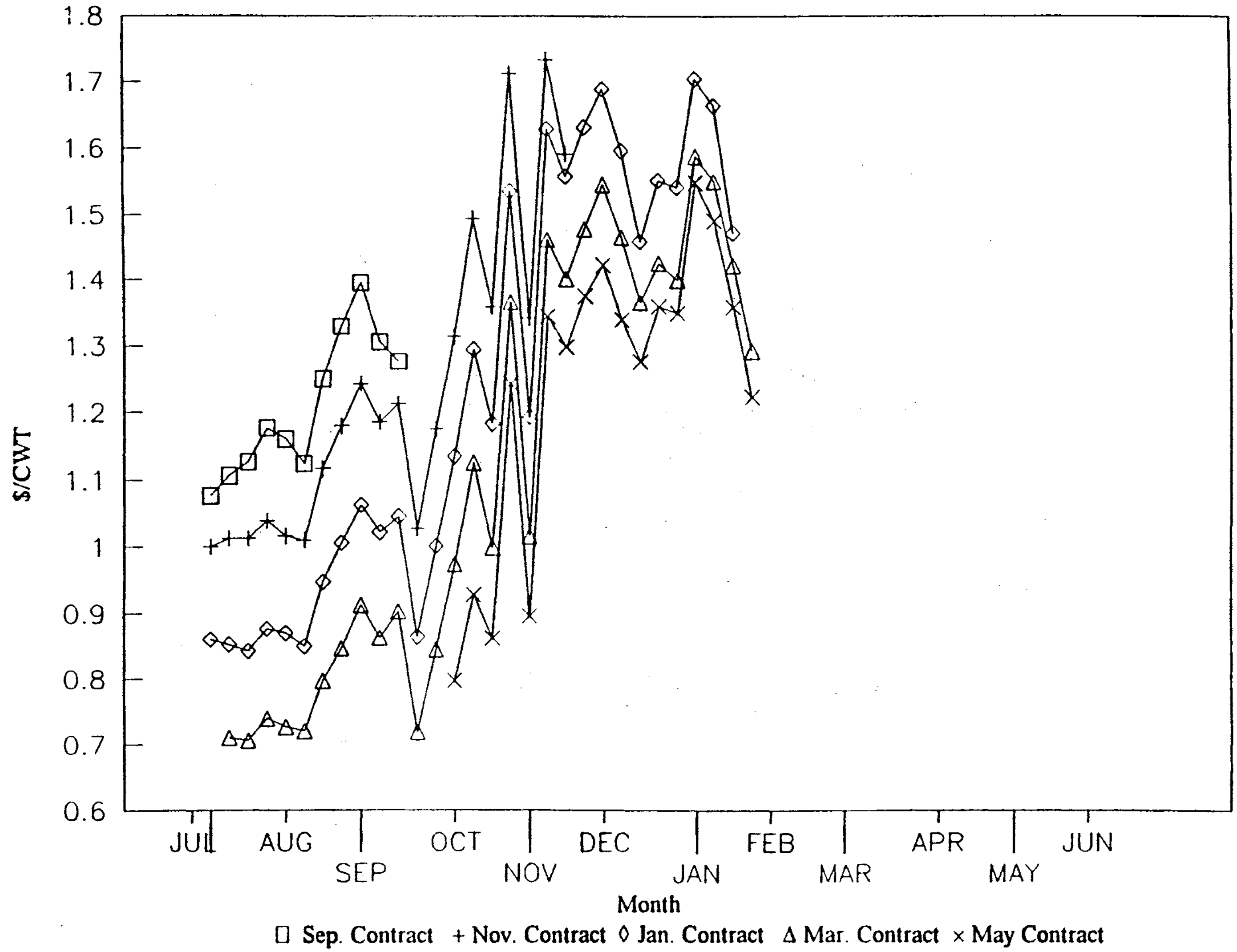


Figure 3.23. Average New Orleans Rice Basis, 1991 - 93, #2 Long Grain, f.o.b. Rough

The Chicágo wheat basis is different than the rice basis. The general movement of wheat basis (Figure 3.24 and 3.25) was in a direction opposite that of the rice basis. The basis rose after September, and dropped after January. The likely reason for this difference in basis direction is different harvest patterns, but this is a question for further research.

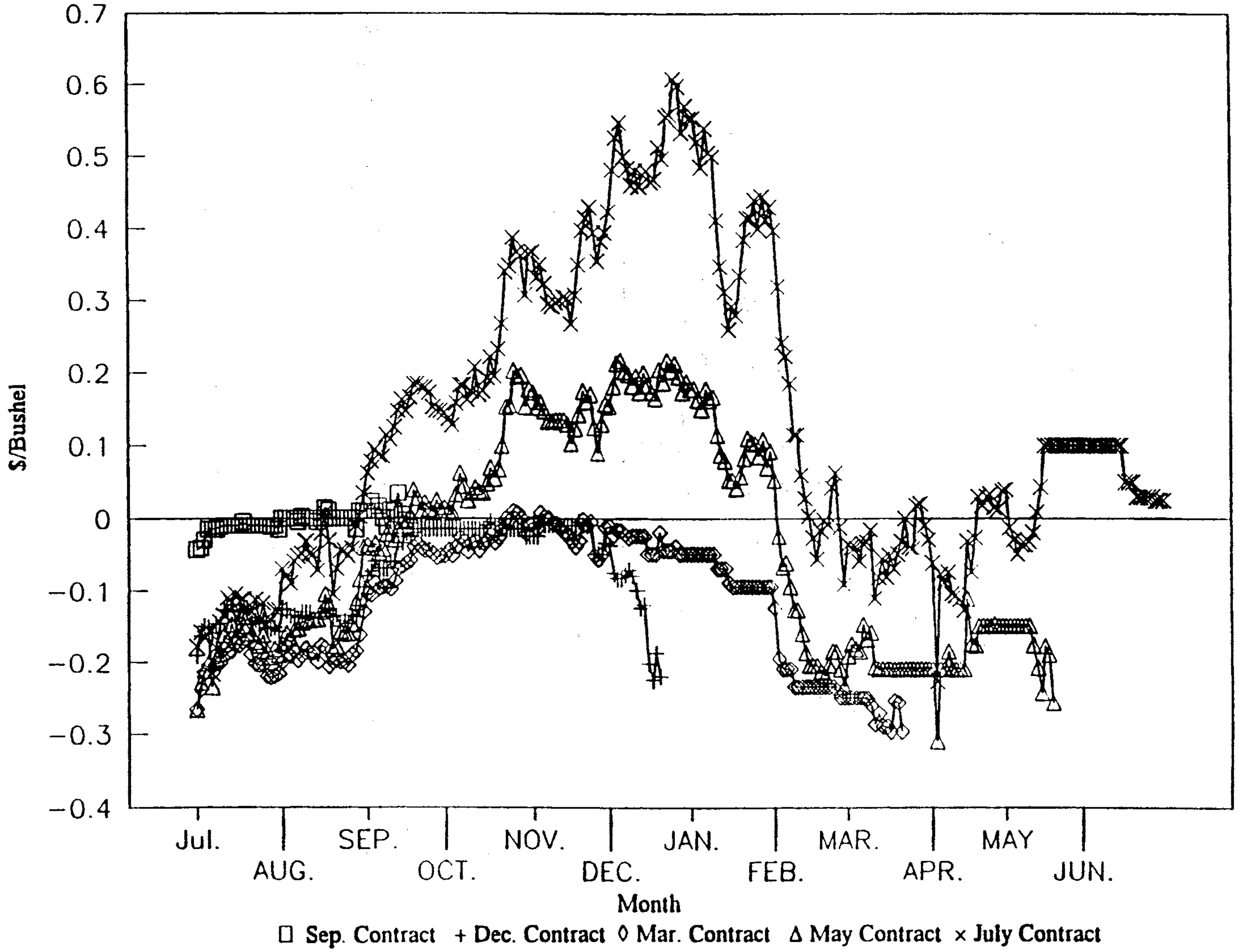


Figure 3.24. Chicago Wheat Basis, 1991.7 - 92.6, No.2 Soft Red Wheat

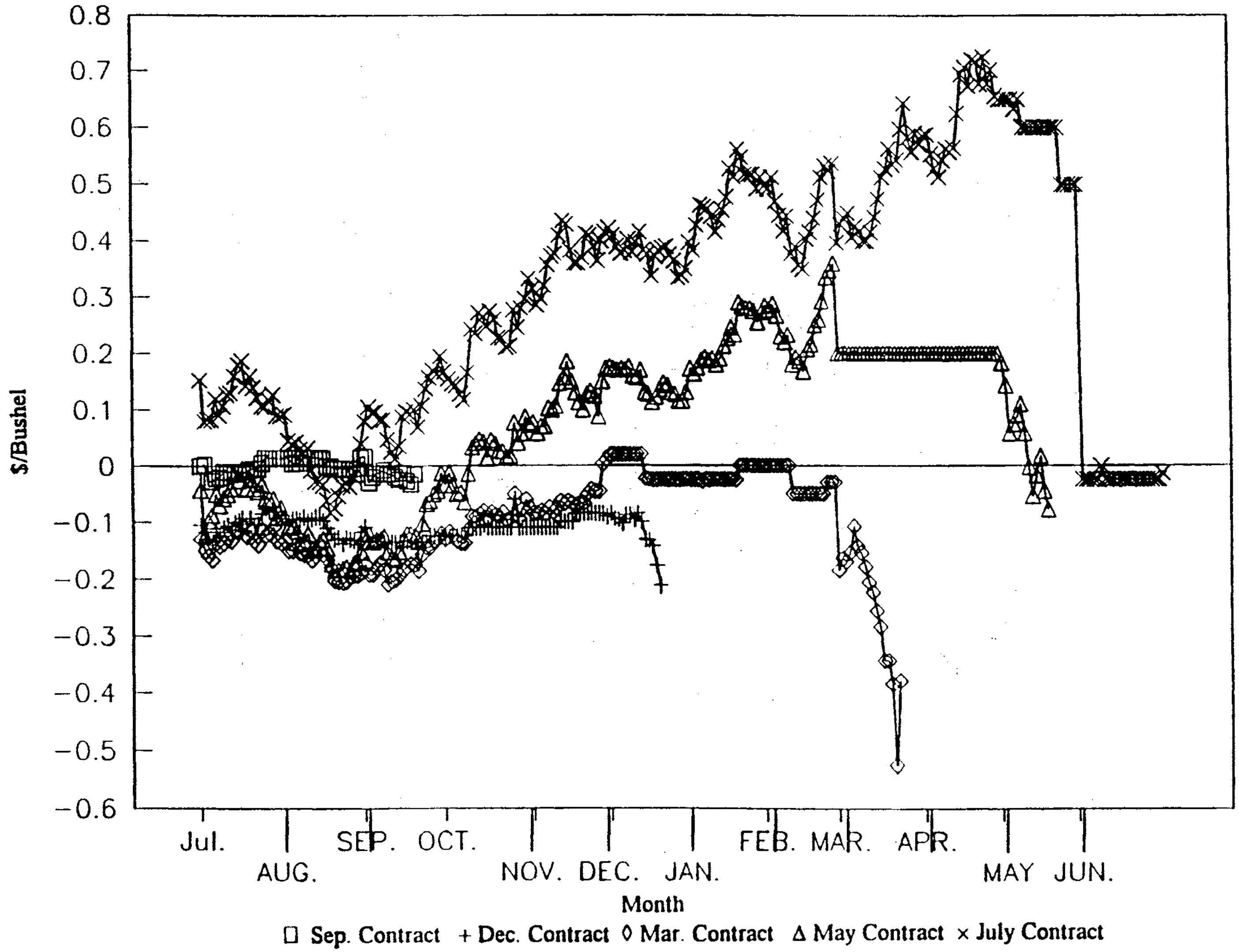


Figure 3.25. Chicago Wheat Basis, 1992.7 - 93.6, No.2 Soft Red Wheat

To examine whether the basis behaves in an orderly fashion during a marketing year in selected delivery areas, this model, based on Herrmann, regresses the basis over time:

$$BASIS = (CP_t - FP_t) = \beta_0 + \beta_1 WEEK, \quad (3.6)$$

where BASIS is the weekly cash price in the specified area less the nearby contract's futures price at time t. WEEK is a time counter. This model is applied to the data from 1991 to 1993.

Integration of Markets

Herrmann (1994) explored the potential of a rice futures market for hedging price risks. She tested the relationship between rice prices in futures and cash markets by regressing the changes in the price of the nearby future against changes in the announced world price and in the Louisiana, Arkansas, and Brinkley cash prices. For all three crop years tested (1986--1988), the model shows a statistically significant relationship between changes in the futures price and changes in the Arkansas cash price. In all cases, the regression coefficient is positive, and appears to increase over the three years. A statistically significant coefficient close to one would support the argument that the futures market offers a good hedge for rice in the delivery area.

Following Herrmann, this analysis investigates if rice price movements in the Chicago rice and wheat futures markets reflect price movements in the world spot rice market and U.S. spot rice markets. The general regression model is:

$$(FP_t - FP_{t-1}) = a_0 - a_1(CP_t - CP_{t-1}), \quad (3.7)$$

where Fp_t is the rice and/or wheat futures price at time t, FP_{T-1} is the rice and/or wheat futures price the week before time t, and CP_t and CP_{T-1} are the comparable cash prices of USDA announced world market prices, Texas, Louisiana, and Arkansas long grain milled rice pries.

Specifically,

$$(RFP_t - RFP_{t-1}) = a_0 - a_1(WOLCP_t - WOLCP_{t-1}) \quad (3.8)$$
$$(RFP_t - RFP_{t-1}) = a_0 - a_1(TXLCP_t - TXLCP_{t-1}) \quad (3.9)$$
$$(RFP_t - RFP_{t-1}) = a_0 - a_1(LOLCP_t - LOLCP_{t-1}) \quad (3.10)$$
$$(RFP_t - RFP_{t-1}) = a_0 - a_1(ARLCP_t - ARLCP_{t-1}) \quad (3.11)$$

for the change in the price of rice futures market, and

$$(WFP_t - WFP_{t-1}) = a_0 - a_1(WOLCP_t - WOLCP_{t-1}) \quad (3.12)$$
$$(WFP_t - WFP_{t-1}) = a_0 - a_1(TXLCP_t - TXLCP_{t-1}) \quad (3.13)$$
$$(WFP_t - WFP_{t-1}) = a_0 - a_1(LOLCP_t - LOLCP_{t-1}) \quad (3.14)$$
$$(WFP_t - WFP_{t-1}) = a_0 - a_1(ARLCP_t - ARLCP_{t-1}) \quad (3.15)$$

for the change in the price of wheat futures market.

In the rice producing area in United States, most rice is harvested in August and is out of the hands of most farmers by January. In most of the Asian rice producing areas, rice is harvested in August and also in November.

Correspondingly, the greatest marketing activity is in the first five months of the marketing year in the futures markets, as described previously in the discussion of trade volume of futures contracts. Hence, prices in the period of August through January are used to test the integration level, since that is presumably the period of greatest liquidity in the rice market. Data for 1986 through 1992 crop years are used in these models.

Since the contracts closest to expiring are usually more heavily traded than more distant contracts and should reflect cash prices most closely, nearby futures contracts are used in this analysis. The nearby futures is the next contract to expire. Nearby contract rolls to the next contract seventh business day before expiration, when the previous contract was delivered. For example, the November 1992 contract for rice is defined as the nearby contract between September 22,1992 and November 18, 1992. But, when the seventh business day before the end of the month when the previous contract was delivered is not Tuesday, the nearest coming Tuesday price is used, since the Tuesday settlement price for the rice futures is chosen as the weekly futures price in this analysis.

All the prices of milled rice are converted to rough rice prices by dividing them by 0.0453 and 31. All the prices in per hundredweight terms are converted to prices per bushel by dividing them by 2.222[1].

Next, the models regress the log price changes in nearby rice and wheat futures markets against log price changes in the four cash rice markets, to verify the observations from the regression model for price changes.

The models are then applied in a shorter period, August through October, to determine if there is any seasonal difference. The November contract for rice and the December contract for wheat, rather than the nearby futures contracts, are used because those are the ones that would most likely be used by hedgers. The results of price change regressions and regression of log price changes are reported separately.

Expected Utility Trading Model

Model Specification

The United States competes primarily with Thailand in the high-quality rice market, which distinguishes from low-quality rice by the percentage of broken rice.

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[1] Conversion table in USDA, ERS, Rice, Situation and Outlook Report, July 1994:
1 cwt = 2.22 bushes = .0453 metric tons; 1 metric ton milled = 31 cwt rough.

China, the largest grain importer in the world, is projected to increase import demand for high-quality rice in 1995 (USDA, ERS, Situation and Outlook Report, Rice, 1994). Hong Kong is an important grain trade center in Asia, especially for mainland China. Since U.S. dollar is linked with Hong Kong dollar at a fixed exchange rate of HK$7.80 = US$1.00, foreign exchange rate risk in Asia is not an consideration in this study.

Thailand Board of Trade posts a price but discounts of 10 to 15 percent usually in the competitive world rice market. Since U.S. rice industry services a large, high-valued domestic market, U. S. rice price is well above the international price. The disadvantage of higher U.S. rice price is remedied by selling at a premium compared to major competitors. The premium is often measured by the difference between offer price quotes for the U.S.'s No.2, 4 percent milled long-grain rice, f.o.b. Gulf ports, and Thailand's 100 percent grade B milled long-grain white rice, f.o.b. Bangkok. Traditionally, U.S. rice prices compete very well with a $30 to $50 premium (USDA, ERS, Rice). Sometime the premium was much higher. For example, in late July, 1994, the U.S. export premium for high-quality rice was $92. In addition, U.S. rice is generally believed to be of a higher quality. However, higher U.S. exports and a larger U.S. share in Asian market are mainly conditional on whether U.S. prices are competitive. The USDA-announced world market prices are then designed to provide benchmark prices for U.S. exporters who are trying to be competitive in the international market. Since price information about actual sales of Thailand rice is tightly guarded (Herrmann), and the USDA-announced world market prices are weighted prices after reviewing actual sales rather than nominal quotes (e.g. nominal price quotes, Bangkok) or posted prices (e.g. Thailand's posted Board of Trade prices), USDA-announced world market prices are used in this study as reference prices in Asian markets.

Alternative Strategies Four strategies: cash rice trade, hedging rice utilizing rice futures market, hedging rice utilizing wheat futures market, and hedging rice using both rice and wheat futures market are evaluated in this paper.

In this analysis, the rice season is divided into the following four trading periods: August-October, November-January, February -April and May-July.

Assuming the best forecast of futures returns are the average of past returns, the specific marketing strategies evaluated over 1986 through 1993 are: At the end of the previous period, the agency takes a position, and reverses it at the end of this period. For example, the agency takes a short cash position in rice and a long futures position in rice on the last business day before August, July 31. On November 31. the agency takes a long cash position and a short futures position in rice. In a few cases, when the price data is not available for the end of a month, the price for the first business day of next month is used.

Prices of November rice contract and December wheat contract are used in the analysis for the August-October period, prices of March rice and wheat contracts are used in November-January period, prices of May rice and wheat contacts are used in February-April period. and Prices of September rice and wheat contracts are used in May-July period.

Daily futures closing prices for rough rice (in cents per hundredweight) for the period August, 1986 to December, 1993 are from the Chicago Board of Trade. Daily futures closing prices for soft red winter wheat (in dollar per bushel) for the period 1982 to 1995 are also provided by the Chicago Board of Trade. Weekly average Texas cash prices of long grain milled rice (in dollars per hundredweight) for the period 1981 to 1993 are from USDA Agricultural Marketing Service "Rice Market News", provided by Hayenga of Iowa State

University. Weekly world market long grain milled rice prices for the period April, 1986 to July, 1994 in loan rate basis (see detailed explanation of the data), are from USDA Economic Research Service "Rice, Situation and Outlook Report". All the prices for rough rice are converted to milled rice prices by dividing them by 0.032 and 22.046 [1]. All the prices measured in bushel are converted to prices in per hundredweight by multiplying them by 100/60.

Hedging Models Optimal hedge positions are estimated by simple regression on returns. The agency is assumed to maximize expected revenue subject to a certain level of risk where risk is measured by the variance of the revenue. The following objective function is thus formalized to be maximized:

$$E_t(Y_{t+1}) - 1/2\,\delta\,VAR_t(Y_{t+1}) \qquad (3.16)$$

where E_t is the expectation operator, is the risk aversion parameter ($\delta >= 0$), VAR_t is the variance operator, and Y_{t+1} is the revenue in period t+1, and

$$Y = R_r + Hr\,R_r^f \qquad (3.17)$$

were R_r is the revenue of cash rice (wheat) activities, R_r^f is the return from the activities in rice (wheat) futures markets, and Hr is the level of the commodity (rice and/or wheat) hedges.

The variance of the revenues can be obtained by

$$VAR(y) = VAR(Rr) + Hr^2 VAR(R_r^f) + 2H_r COV(Rr, R_r^f) \qquad (3.18)$$

To compare with no hedging strategies, the hedging strategies are evaluated by using the hedging efficiency criteria, $e = 1 - VAR(Y_h)/VAR(y_{uh})$, where $VAR(Y_h)$ and $VAR(y_{uh})$ are the variances of the revenue from the hedged and unhedged portfolios

1

respectively.

Taking first derivatives of the objective function to be maximized with respect to the decision variables Hr and Hw , and set it equal to zero, get

$$dE(U(Y))/dH_r = E(R_r^f) - \delta * (HrVAR(R_r^f) + COV(Rr,R_r^f)) = 0 \quad (3.19)$$

Dividing equations through by VAR(Rr), leads to

$$E(R_r^f)/ VAR(Rr) - \delta H_r - \delta COV(Rr,R_r^f)/ VAR(R_r) = 0 \quad (3.20)$$

Then the optimal commodity hedging position is

$$H_r = E(R_r^f)/ \delta VAR(Rr) - COV(Rr,R_r^f)/ VAR(R_r) \quad (3.21)$$

Expected Utility Models The most established decision theory in economics is the expected utility theory (or the Bernoulli principle) developed by Von Morgenstern (1944). It is assumed that a trader's preferences among alternative trade strategies are based on expected income and associated income variance. Some functional forms of expected utility are suggested in literature. In this paper, it is assumed the utility function is of the exponential form, and income Y is normally distributed, then

$$E[U(Y)] = E(Y) - 1/2\ \delta\ VAR(Y) \quad (3.22)$$

The trade agency will then rationally trade with higher expected income and lower variances of income. In another words, for a given level of mean income the agency will prefer the trade that has the lowest variances of income. This is referred to as the E, V decision rule.

In general, given a set of efficient strategies, the acceptability of any particular strategy to an individual trade agency will depend on his preferences among various expected income and associated variance levels as described by his E, V utility function.

When this functional relationship can be determined, a unique trade strategy can be rigorously identified which offers the trader higher utility.

Noticeably, risk aversion parameter, also known as the Pratt-Arrow absolute risk aversion coefficient, can significantly affect the feasibility of a trade strategy in any year. The values of risk aversion coefficient reflect traders' risk attitude toward each trade activity conducted by his/her firm. Therefore, in seeking to find better trade strategies in relation to a trader's income objectives, the analyst must be sure that the strategy will also be feasible at an acceptable risk level. In this analysis, the value of risk parameter is selected in the interval from 10^{-3} for fairly low risk aversion to 10^{5} for very high risk aversion, to draw meaningful implications on the decision maker's risk attitude.

Expected Results

Food grain traders in Asia have available to them two major futures markets, wheat and rice futures markets. Whether and how grain traders in Asia can use the available futures markets to manage multiple risks simultaneously is a concern of many decision makers.

First, traders can not afford to ignore the effects of seasonal difference on both cash and futures markets. In Asian grain market, Using CBOT November/December futures contracts is expected to be more appropriate than using March contracts, while in the United States using March contracts is expected to be more appropriate than using November/December contracts.

Second, utilizing a more heavily traded market, most likely wheat futures market, to help to increase the hedging or price forecast benefit of rice market, a relatively "thin" market, will be applauded by grain traders, especially those trading with Asian countries. To maximize their expected utility, CBOT wheat futures market may be utilized as an alternative market in a rice-wheat cross hedge portfolio for food grain traders to obtain substantial risk reduction opportunity in Asia.

Summary

Seasonality is one of the most important characteristics of rice and wheat marketing activities. Seasonal differences have effects not only on rice and wheat cash price movements, but also on the effectiveness of available futures contracts. A dummy variable technique is used to capture discrete shift in the underlying price relationships through a marketing year. Volume and annualized price volatility are examined for futures markets to determine if liquidity is a problem for large rice traders. If liquidity is still a problem for the rice futures markets, using a more heavily traded market, such as wheat futures market, to help hedge cash transactions for rice, will be useful to grain traders in Asian markets.

To evaluate the potential for rice-wheat cross-hedging, four procedures were conducted: (1) measuring correlation of futures prices with cash prices; (2) analyzing basis patterns; (3) investigating market integration; (4) modeling trading in an expected utility framework.

Having determined the potential of the wheat futures market as a cross hedge for rice trade, four strategies: cash rice trade, hedging rice utilizing rice futures market, hedging rice utilizing wheat futures market, and hedging rice using both rice and wheat futures market are evaluated in next chapter. For practical reasons, the rice season is divided into four trading periods: August-October, November-January, February-April and May-July. Given a set of efficient strategies, the acceptability of any particular strategy to an individual trader will depend on his preferences among various expected income and associated variance levels.

CHAPTER IV

RESULTS AND FINDINGS

Procedures were described in Chapter III for investigating price movements in several cash and futures markets for rice and wheat to determine the potential for using the wheat futures market as a cross-hedge for rice trade. This investigation consists of cash market activity analysis and futures market activity analysis for rice and wheat, and analysis of price patterns for both commodities. Price movements, including seasonality in price change, were analyzed graphically in Chapter III and are analyzed statistically here. The results of statistical analysis of seasonality and volatility are reported in tables 4.1 through 4.4.

To further evaluate the potential for rice-wheat cross hedging, four additional procedures were used: (1) correlation analysis of futures prices with cash prices; (2) analysis of basis patterns; (3) market integration analysis; and (4) modeling trading in an expected utility framework. The results are provided in tables 4.5 through 4.13.

Statistics of simulations based on equations 3.16, 3.17, 3.18, 3.21, and 3.22, are presented in tables 4.14 through 4.27 for rice and wheat traders in four scenarios: (1) cash trade; (2) hedging rice utilizing rice futures market; (3) hedging rice utilizing wheat futures market; and (4) hedging rice using both rice and wheat futures markets. The simulation results refer to not only the differences created by the four alternative trading strategies, but also to the differences due to the four trading periods: August-October, November-January, February -April and May-July. Therefore, the results reported in tables 4.14 through 4.27 refer to sixteen different circumstances and will be analyzed in returns from unhedged positions, returns from direct hedging, and returns from cross hedging respectively. The alternative strategies will be compared not only statistically, but graphically as well.

Cash Markets Activity

To measure effect of seasonal differences on rice and wheat cash price movements, this study use dummy variable technique to catch the shifts in the underlying relationships as prices change across months. First, December log price returns are used as the base. The results provided by the single equation model are summarized in table 4.1.

TABLE 4.1

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING DECEMBER PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994

Variable	Coefficient	Std. Deviation	T-ratio
Rice:			
Thai 1_{st} Grade			
R-Square	0.0987		
Intercept	-0.019	0.014	-1.322
Monthly Dummies			
January	0.046	0.020	2.239**
February	0.015	0.010	1.425
March	0.0004	0.007	0.060
April	0.002	0.005	0.463
May	0.0006	0.004	0.157
June	0.002	0.003	0.685
July	0.004	0.003	1.298
August	0.006	0.003	2.405**
September	-0.0003	0.002	-0.111
October	0.002	0.002	0.803
November	0.002	0.002	0.913

TABLE 4.1

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING DECEMBER PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994 (Continued)

Variable	Coefficient	Std. Deviation	T-ratio
Thai 2_{nd} Grade			
R-Square	0.0572		
Intercept	-0.019	0.014	-1.350
Monthly Dummies			
January	0.045	0.020	2.227**
February	0.013	0.010	1.25
March	0.003	0.007	0.519
April	0.002	0.005	0.474
May	0.0007	0.004	0.18
June	0.001	0.003	0.395
July	0.003	0.003	1.161
August	0.004	0.003	1.499
September	0.002	0.002	0.721
November	-0.002	0.002	0.969
Thai 5% Brokens			
R-Square	0.0598		
Intercept	0.126	0.019	6.518
Monthly Dummies			
January	0.047	0.027	1.730*
February	0.015	0.014	1.082
March	0.001	0.009	1.295
April	0.003	0.007	0.368
May	0.001	0.005	0.186
June	0.003	0.005	0.722
July	0.005	0.004	1.284
August	0.008	0.003	2.231**
September	0.002	0.003	0.682
October	0.002	0.003	0.722
November	0.002	0.002	0.754

TABLE 4.1

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING DECEMBER PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994 (Continued)

Variable	Coefficient	Std. Deviation	T-ratio
Texas Long Milled			
R-Square	0.0896		
Intercept	0.004	0.019	0.212
Monthly Dummies			
January	-0.017	0.027	-0.632
February	0.002	0.013	0.14
March	-0.003	0.009	-0.365
April	-0.003	0.007	-0.422
May	-0.008	0.005	-1.479
June	-0.003	0.004	-0.743
July	-0.003	0.004	-0.833
August	0.0002	0.003	0.067
September	-0.002	0.003	-0.651
October	0.004	0.003	1.441
November	0.002	0.002	0.935
World Long Milled			
R-Square	0.0957		
Intercept	0.001	0.026	0.042
Monthly Dummies			
January	0.009	0.037	0.241
February	0.008	0.019	0.434
March	-0.005	0.012	-0.383
April	-0.008	0.009	-0.911
May	-0.005	0.007	-0.663
June	-0.002	0.006	-0.398
July	0.003	0.006	0.505
August	-0.001	0.005	-0.205
September	-0.003	0.004	-0.735
October	0.0004	0.004	0.112
November	0.003	0.003	0.752

TABLE 4.1

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING DECEMBER PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994 (Continued)

Variable	Coefficient	Std. Deviation	T-ratio
Wheat:			
CBOT No.2 Soft Red			
R-Square	0.1641		
Intercept	0.016	0.015	1.096
Monthly Dummies			
January	0.002	0.021	0.097
February	-0.01	0.01	-1.308
March	-0.01	0.007	-1.381
April	-0.002	0.005	-0.289
May	-0.009	0.004	-2.062**
June	-0.01	0.003	-3.136**
July	-0.004	0.003	-1.299
August	-0.003	0.003	-1.153
September	-0.001	0.002	-0.595
October	0.001	0.002	0.54
November	0.001	0.002	0.738

Notes: 1). Observation number = 155.
2). T-ratios with * are significant at 10% level or above.
T-ratios with ** are significant at 5% level or above.

The January dummy variable for Thailand 1st and 2nd grade rice is statistically significant at the 95-percent confidence level, while for Thai 5% brokens it is significant at the 90-percent confidence level. The August dummy variable for Thailand 1st and 5% brokens rice is significant at the 95-percent confidence level. For USDA announced world market long grain rice and Texas milled long grain rice prices, none of the months was significant at the 90% confidence level.

The most statistically significant seasonality at the 95-percent confidence level for CBOT soft red winter wheat is found in May and June, which is the harvest season for wheat and about a month before rice harvest season.

Second, July log price returns are used as the base. The single equation models provide the following results:

TABLE 4.2

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING JULY PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994

Variable	Coefficient	Std. Deviation	T-ratio
Rice:			
Thai 1_{st} Grade			
R-Square	0.0987		
Intercept	0.008	0.015	0.529
Monthly Dummies			
January	0.019	0.021	0.896
February	0.001	0.010	0.098
March	-0.009	0.007	-1.239
April	-0.004	0.005	-0.844
May	-0.005	0.004	-1.144
June	-0.002	0.003	-0.627
August	0.003	0.003	1.086
September	-0.003	0.002	-1.406
October	-0.001	0.002	-0.512
November	-0.0007	0.002	-0.403
December	-0.002	0.002	-1.298
Thai 2_{nd} Grade			
R-Square	0.0572		
Intercept	0.005	0.015	0.313
Monthly Dummies			
January	0.021	0.021	1.021
February	0.0007	0.010	0.063
March	-0.004	0.007	-0.653
April	-0.004	0.005	-0.696
May	-0.004	0.004	-0.985
June	-0.003	0.003	-0.775
August	0.0009	0.003	0.331

TABLE 4.2

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING JULY PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994 (Continued)

Variable	Coefficient	Std. Deviation	T-ratio
September	-0.001	0.002	-0.455
October	-0.0001	0.002	-0.071
November	-0.0004	0.002	-0.212
December	-0.002	0.002	-1.161
Thai 5% Brokens			
R-Square	0.0598		
Intercept	0.161	0.02	8.042
Monthly Dummies			
January	0.011	0.028	0.411
February	-0.003	0.014	-0.224
March	-0.0001	0.009	-0.015
April	-0.006	0.007	-0.923
May	-0.006	0.006	-1.101
June	-0.003	0.005	-0.576
August	0.003	0.004	0.929
September	-0.002	0.003	-0.615
October	-0.002	0.003	-0.576
November	-0.001	0.003	-0.544
December	-0.003	0.002	-1.284
Texas Long Milled			
R-Square	0.0896		
Intercept	-0.019	-0.019	-0.952
Monthly Dummies			
January	0.006	0.027	0.214
February	0.013	0.014	0.970
March	0.004	0.009	0.476
April	0.003	0.007	0.419
May	-0.003	0.005	-0.616
June	0.0005	0.005	0.105
August	0.003	0.004	0.883
September	0.0006	0.003	0.195
October	0.006	0.003	2.244**
November	0.004	0.002	1.749*
December	0.002	0.002	0.833

TABLE 4.2

TESTS FOR SEASONALITY OF RICE AND WHEAT LOG CASH PRICE RETURNS, USING JULY PRICE RETURNS AS THE BASE, AUG.1981 - JUNE 1994 (Continued)

Variable	Coefficient	Std. Deviation	T-ratio
World Long Milled			
R-Square	0.0957		
Intercept	0.021	0.029	0.722
Monthly Dummies			
January	-0.011	0.039	-0.275
February	-0.002	0.019	-0.092
March	-0.011	0.001	-0.870
April	-0.013	0.010	-1.373
May	-0.009	0.008	-1.137
June	-0.006	0.006	-0.884
August	-0.003	0.005	-0.680
September	-0.005	0.004	-1.206
October	-0.002	0.004	-0.398
November	0.0008	0.004	0.212
December	-0.002	0.003	-0.505
Wheat:			
CBOT No.2 Soft Red			
R-Square	0.1641		
Intercept	0.011	0.015	-0.749
Monthly Dummies			
January	0.030	0.021	1.394
February	0.0002	0.011	0.018
March	-0.0004	0.007	-0.053
April	0.005	0.005	1.017
May	-0.003	0.004	-0.721
June	-0.006	0.004	-1.773
August	0.0004	0.003	-0.144
September	0.002	0.002	0.717
October	0.004	0.002	1.829
November	0.004	0.002	2.022**
December	0.002	0.002	1.299

Notes: 1). Observation number = 155.

2). T-ratios with * are significant at 10% level or above.
T-ratios with ** are significant at 5% level or above.

For all the three types of Thailand rice, seasonality in log price returns is not statistically significant when using July price returns as a base. However, for the Texas long grain milled rice, October and November dummy variables are significant at the 95 and 90 percent confidence levels respectively. For wheat, the June and November dummy variables are different at the 95 and 90 percent levels of confidence, respectively.

In this section, December price returns and July price returns are chosen in order to measure a typical month's effect and the results show that most month's price returns are not significantly different from the base month. This is especially true for world market rice price returns, for which no month is significant.

Compared with dummy variables in table 4.1 using December price returns as the base, dummy variables for Thailand rice price returns in table 4.2 using July price returns as the base exhibit smaller seasonal difference in August and January, which are one or two month after Asian rice harvest season. However, dummy variables for Texas rice price returns in table 4.2 show larger seasonal difference in October and November than it in table 4.1 using December price returns as the base. This comparison suggests that seasonality varies depending on the base and the region of study chosen.

Annual volatility of cash rice prices in U.S. dollar per hundredweight is calculated following Cox and Rubinstein. The results are summarized in table 4.3.

TABLE 4.3

ANNUALIZED VOLATILITY OF CASH RICE PRICES, 1986-94

	1986	1987	1988	1989	1990	1991	1992	1993	1994
RTH1	0.106	0.124	0.096	0.393	0.068	0.111	0.043	0.287	0.105
RTH2	0.106	0.139	0.109	0.173	0.078	0.126	0.046	0.361	0.109
RTH3	0.121	0.162	0.113	0.178	0.075	0.122	0.048	0.337	0.123
RCAM	0.089	0.226	0.147	0.130	0.107	0.135	0.022	0.250	0.129
RCAS	0.078	0.226	0.147	0.126	0.107	0.134	0.012	0.250	0.127
RTXL	0.231	0.555	0.247	0.082	0.109	0.110	0.041	0.473	0.110
RWOL	0.019	0.312	0.095	0.185	0.031	0.017	0.057	0.415	NA

Note: NA: Data not available.

Where: RTH1: Thailand 100% 1st grade milled rice price.
RTH2: Thailand 100% 2nd grade milled rice price.
RTH3: Thailand 5% brokens milled rice price.
RCAM: California medium grain milled rice price.
RCAL: California long grain milled rice price.
RTXL: Texas long grain milled rice price.
RWOL: World market grain milled rice price.

In six of the eight analyzed years, annual volatilities of world market cash rice prices were lower than the volatilities for Texas cash rice prices. The average annual volatility of Texas rice prices is 0.231, and the average annual volatility of world market rice prices is only 0.0896, about one third of the former. The annual volatilities of Thailand cash rice prices were lower than the volatilities for U.S. based cash rice prices in 1987, 1988, 1990, and 1994, but were higher in 1986, 1989, and 1992. It suggests that although Thailand rice prices used here are monthly average prices while California medium grain milled rice prices, California long grain milled rice prices, Texas long grain milled rice prices, and USDA announced world market long grain milled rice prices are weekly average prices, Thailand rice prices do not necessarily have lower annual volatility or lower risk.

Futures Markets Activity

Annualized volatilities of rice and wheat futures prices are evaluated for 1986 through 1994 and are summarized in table 4.4.

TABLE 4.4

ANNUALIZED VOLATILITY OF RICE AND WHEAT FUTURES PRICES FOR MARCH, MAY, SEPTEMBER AND NOVEMBER/DECEMBER CONTRACTS

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Rice Futures:									
Mar.	NA	0.107	0.320	0.279	0.162	0.149	0.114	0.111	0.307
May.	NA	0.103	0.321	0.214	0.175	0.140	0.111	0.137	0.347
Sep.	NA	0.260	0.386	0.145	0.161	0.146	0.109	0.189	0.314
Nov.	0.099	0.298	0.344	0.144	0.150	0.139	0.099	0.289	0.285
Wheat Futures:									
Mar	0.147	0.208	0.179	0.243	0.123	0.153	0.194	0.181	0.155
May	0.200	0.213	0.188	0.255	0.127	0.162	0.198	0.165	0.151
Sep.	0.213	0.166	0.259	0.143	0.140	0.186	0.196	0.139	0.150
Dec.	0.217	0.173	0.250	0.129	0.148	0.185	0.178	0.186	0.147

Note: NA: Data not available.

According to Cox and Rubinstein, the higher the volatility, the greater the likelihood that the price will rise or fall substantially. Among the four rice futures contracts, the November contract has the lowest annual price volatility in 1989, 1990, 1991, 1992, and 1994; hence, it is the contract most frequently having the lowest annual price volatility. Among the four soft red winter wheat futures contracts, however, the contract most frequently having lowest annual price volatility is the March futures contract, recorded in 1986, 1988, 1990, and 1991.

In six of the nine analyzed years, annual price volatility's for rice November contracts were higher than the volatilities for wheat November contracts. The average annual volatility of November rice futures prices is 0.2052, and the average annual volatility of November wheat futures prices is 0.1792. All the rest three futures prices for rice and wheat, neither have clear trend showing its superiority to other futures prices, nor have clear trend which can be used to identify the lower risk of futures prices between rice and wheat futures contracts.

In general, annual volatility of rice and wheat prices changes over time, depending on the year. As Cox and Rubinstein pointed out, we can measure past volatility without error, but we can not predict future volatility with certainty. In the real world, many factors that affect volatility are themselves uncertain.

Cross Hedging Potential

Cross hedging potential for rice and wheat is determined through evaluating correlation of futures prices with cash prices, analyzing basis patterns and integration of markets. All the following symbols will be used in table 4.5, 4.6, 4.7, and 4.8:

WF: CBOT No.2 soft red winter wheat futures closing prices.

WC: CBOT No.2 soft red winter wheat cash prices.

RF: CBOT rough rice futures closing prices.

RCTH1: Thailand milled rice prices, 100% 1st grade, f.o.b. Bangkok.

RCTH 2: Thailand milled rice prices, 100% 2nd grade, f.o.b. Bangkok.

RCTH 3: Thailand milled rice prices, 5% brokens, f.o.b. Bangkok.

RCCAM: California milled rice, Medium grain, f.o.b. mills.

RCCAS: California milled rice, short grain, f.o.b. mills.

RCTXL: Houston, Texas milled rice, long grain, f.o.b. mills.

RWOL: World market rice prices, loan rate basis, milled long kernel rates.

Correlation of Futures Prices with Cash Prices

The relationships among selected rice and wheat log price changes in August/September period using November/December futures contracts are showed in table 4.5.

TABLE 4.5

COVARIANCE/CORRELATION MATRIX OF LOG PRICE CHANGES IN AUGUST/SEPTEMBER PERIOD, NOVEMBER/DECEMBER FUTURES, 1982 - 93

Prices	WF	WC	RF	RCTH1	RCTH2	RCTH3	RCCAM	RCCAS	RCTXL	RWOL
WF	0.014	0.014	0.008	0.014	0.009	0.01	0.008	0.008	0.010	0.019
WC	0.973	0.015	0.011							
RF	0.487	0.583	0.021	0.014	0.014	0.015	0.004	0.004	0.003	0.020
RCTH1	0.540		0.661	0.017						
RCTH2	0.696		0.795		0.012					
RCTH3	0.723		0.798			0.013				
RCCAM	0.678		0.248				0.01			
RCCAS	0.659		0.234					0.01		
RCTXL	0.573		0.124						0.022	
RWOL	0.772		0.712							0.191

Note: 1) All prices are in cents/bushel.
2) Partial correlation coefficients are shown below the diagonal; covariance coefficients are shown above the diagonal.

The highest partial correlation coefficient (0.973) among all the observed series of price changes with wheat futures price changes is found in wheat cash price changes as expected. However, the highest partial correlation coefficient among all the observed series of rice price changes with wheat futures price changes is observed in world rice price changes (0.772). The highest partial correlation coefficient (0.798 for RCTH3 and 0.795 for RCTH2) with rough rice futures price changes is obtained from Thailand cash price changes, followed also by world rice price changes (0.712). Noticeably, all the U.S.-based cash rice price changes together with world market rice price changes (0.678 for RCCAM, 0.659 for RCCAS, for RCTXL, and 0.772 for RWOL) are more closely correlated with wheat futures price changes other than with CBOT rough rice futures price changes (0.248 for RCCAM, 0.234 for RCCAS, 0.124 for RCTXL, and 0.712 for RWOL) in the August-September period using November rice futures contract and December wheat contract.

To check if there is any seasonal difference in the relation between log prices changes in futures and cash markets of milled rice, rough rice, and wheat, December-January period is chosen in the analysis and the results is summarized in table 4.6.

TABLE 4.6

COVARIANCE/CORRELATION MATRIX OF LOG PRICE CHANGES IN DECEMBER/JANUARY PERIOD, MARCH FUTURES, 1982 - 93

Prices	WF	WC	RF	RCTH1	RCTH2	RCTH3	RCCAM	RCCAS	RCTXL	RWOL
WF	0.022	0.023	0.003	0.004	0.004	0.005	0.006	0.007	0.007	0.012
WC	0.988	0.024	-0.002							
RF	0.043	-0.031	0.120	0.028	0.031	0.031	0.031	0.031	0.081	0.054
RCTH1	0.237		0.761	0.014						
RCTH2	0.213		0.752		0.017					
RCTH3	0.237		0.755			0.018				
RCCAM	0.373		0.778				0.013			
RCCAS	0.353		0.776					0.015		
RCTXL	0.220		0.946						0.042	
RWOL	0.375		0.917							0.169

Note: 1) All prices are in cents/bushel. 2) Partial correlation coefficients are shown below the diagonal; covariance coefficients are shown above the diagonal.

In this period, The highest partial correlation coefficient (0.988) among all the observed series of price changes with wheat futures price changes is also found in wheat cash price changes, while the highest correlation coefficient among all the observed series of rice price changes with wheat futures price changes is observed in world rice price changes (0.375). However, the highest partial correlation with rough rice futures price changes among all the data series is achieved by Texas cash rice price changes (0.946), which is much higher than it in August-September period (0.124). World rice price changes has the second highest correlation with rice futures price changes (0.917), which is also higher than it in August-September period (0.712). Moreover, all the other U.S. based rice price series obtained higher partial correlation coefficient in this period (0.778 for RCCAM and 0.776 for RCCAS) than it in August- September period (0.248 for RCCAM and 0.234 for RCCAS). But it is not true for the typical Asian rice prices quotes, the Thailand rice prices. The level of correlation between Thailand rice price changes and the CBOT rice futures price changes is basically remain the same for the two periods, although the correlation between Thailand rice price changes and the CBOT wheat futures price changes is now (0.237 for RCTH1, for RCTH2, and 0.237 for RCTH3) much lower than it in August-September period (0.540 for RCTH1, 0.696 for RCTH2 and 0.723 for RCTH3).

Several observations can be drawn from the above tests. First, CBOT wheat futures price changes can be even more closely related with some type of cash rice price changes than CBOT rice futures price changes in certain time period. Second, there is seasonal difference in a marketing year for the relation among the ten cash and futures rice and wheat price changes. Third, there are regional differences in the relative strength of the relationships between cash rice price changes and CBOT rice and wheat futures price changes.

Table 4.7 provides hedge/cross hedge model estimates for milled rice and soft red winter wheat in the August-September period using November rough rice futures and December wheat futures. These results will be used to compare with the results (reported in table 4.8) from the December-January period using March rough rice and wheat futures contracts.

TABLE 4.7

HEDGE/CROSS-HEDGE MODEL ESTIMATES FOR MILLED RICE AND WHEAT: NOVEMBER ROUGH RICE FUTURES AND DECEMBER WHEAT FUTURES, AUGUST-SEPTEMBER PERIOD

Region	Type	Estimates	August-September Rough Rice Futures	August-September Wheat Futures
Thailand	1st grade	Intercept	-0.01136	-0.001192
		Slope	0.67474	0.58749
		Std.Error	0.2123	0.2000
		R Square	0.4373	0.2913
	2nd grade	Intercept	-0.01413	-0.004675
		Slope	0.65979	0.63616
		Std.Error	0.1395	0.1431
		R Square	0.6323	0.4849
	5% brokens	Intercept	-0.01379	-0.004156
		Slope	0.69865	0.69698
		Std.Error	0.1465	0.1451
		R Square	0.6362	0.5234
California	Medium	Intercept	-0.000758	0.003688
		Slope	0.20836	0.56426
		Std.Error	0.2257	0.1336
		R Square	0.0615	0.4592
	Short	Intercept	-0.000405	0.001137
		Slope	0.19587	0.55243
		Std.Error	0.2262	0.1374
		R Square	0.0545	0.4349
Texas	Long	Intercept	-0.00142	-0.008193
		Slope	0.13919	0.72567
		Std.Error	0.3093	0.2263
		R Square	0.0153	0.3287
World Market	Long	Intercept	-0.020	-0.008
		Slope	0.932	1.166
		Std.Error	0.255	0.266
		R Square	0.507	0.596

TABLE 4.7

HEDGE/CROSS-HEDGE MODEL ESTIMATES FOR MILLED RICE AND WHEAT: NOVEMBER ROUGH RICE FUTURES AND DECEMBER WHEAT FUTURES, AUGUST-SEPTEMBER PERIOD (continued)

Region	Type	Estimates	August-September	
			Rough Rice Futures	Wheat Futures
CBOT Wheat	Soft Red	Intercept	-0.001	0.001
		Slope	0.515	0.987
		Std.Error	0.199	0.070
		R Square	0.340	0.939

TABLE 4.8

HEDGE/CROSS-HEDGE MODEL ESTIMATES FOR MILLED RICE AND WHEAT: MARCH ROUGH RICE FUTURES AND MARCH WHEAT FUTURES, DECEMBER-JANUARY PERIOD

Region	Type	Estimates	December-January	
			Rough Rice Futures	Wheat Futures
Thailand	1st grade	Intercept	0.031	0.009
		Slope	0.231	0.189
		Std.Error	0.070	0.162
		R Square	0.454	0.056
	2nd grade	Intercept	0.037	0.009
		Slope	0.261	0.188
		Std.Error	0.076	0.180
		R Square	0.473	0.046
	5% brokens	Intercept	0.035	0.006
		Slope	0.261	0.216
		Std.Error	0.074	0.181
		R Square	0.463	0.056
California	Medium	Intercept	0.021	0.003
		Slope	0.259	0.288
		Std.Error	0.038	0.149
		R Square	0.783	0.139

TABLE 4.8

HEDGE/CROSS-HEDGE MODEL ESTIMATES FOR MILLED RICE AND WHEAT: MARCH ROUGH RICE FUTURES AND MARCH WHEAT FUTURES, DECEMBER-JANUARY PERIOD (Continued)

Region	Type	Estimates	December-January	
			Rough Rice Futures	Wheat Futures
	Short	Intercept	0.210	0.002
		Slope	0.258	0.293
		Std.Error	0.038	0.162
		R Square	0.776	0.125
Texas	Long	Intercept	-0.002	0.007
		Slope	0.672	0.301
		Std.Error	0.055	0.279
		R Square	0.920	0.048
World Market	Long	Intercept	0.018	0.043
		Slope	0.448	0.346
		Std.Error	0.054	0.237
		R Square	0.841	0.141
CBOT Wheat	Soft Red	Intercept	0.020	-0.002
		Slope	-0.017	1.029
		Std.Error	0.153	0.044
		R Square	0.001	0.977

The estimated hedge ratios vary over types of commodity. Hedged with November rice futures contracts in August-September period, Thailand rice has the slope coefficients ranged from 0.66 to 0.699, U.S. based rice has the slope coefficients ranged from 0.139 to 0.208, world market rice obtained a slope coefficient of 0.932, and the CBOT cash wheat has a slope coefficient of 0.515. These results mean that the proportional change in the cash price of world market milled rice to the rough rice futures price is close to one in this period, while the proportional change for U.S. based milled rice is only about twenty percent. But, if the underlying commodities are hedged with December wheat futures contracts, the hedge ratio for California medium grain rice is 0.564, for California short grain rice is 0.552, for Texas long grain rice is 0.726, all more than double the proportion for hedging with rice futures.

The slope coefficients for the above cash commodities also vary over time periods, suggesting that seasonal differences exist in the relationship between cash grain prices and futures grain prices. Thailand rice has much lower slope coefficients when hedged with March rice contracts in December-January period than when hedged in August-September, ranging from 0.231 to 0.261, instead of 0.660 to 0.699. Texas rice has a much higher slope coefficient (0.672) than in the previous period. Chicago cash wheat has a negligible slope coefficient of -0.0171, which suggests that variation in rice futures prices has little to do with cash wheat in this period. However, if hedged with Chicago wheat futures, all seven types of milled rice have low slope coefficients, while cash wheat has a hedge ratio of 1.029.

In the period August-September, five of the seven milled rice price changes have larger standard errors if hedged with rough rice futures than hedging with wheat futures. The higher standard errors reflect greater risk that a potential rice hedger may face hedging with rice futures than cross-hedging with wheat futures. However, in the period December-January, which is after harvest season, all of the seven milled rice price changes have much lower standard errors using rice futures than using wheat futures.

As evidenced by the higher R^2, cash price changes for the four types of U.S. based milled rice have a stronger relationship with wheat futures price changes than with rice futures price changes in August-September period. However, Thailand rice price changes have lower R^2; Thailand rice price changes are less closely related with wheat futures than with rough rice futures in this period. For all seven types of milled rice, the relationship in the December-January period is stronger with rice futures than with wheat futures.

In general, the statistical results and the graphical relationship of milled rice cash prices in different rice producing regions and futures prices of rice and wheat show that:

1. In harvest season, CBOT rough rice futures price changes are more closely related to milled rice cash price changes in Thailand and in the world market than they are with milled rice cash price changes in California and Texas.

2. After harvest, the Texas and California milled rice price changes exhibit much higher correlation with March rice futures prices than with November rice futures prices.

3. Cash price changes for milled rice are more closely related with December wheat futures price changes than with March wheat futures price changes.

4. U.S. milled rice prices are more closely related to wheat futures prices than to rice futures prices in August and September.

These results suggest that December wheat futures prices may be able to substitute for rice futures prices in hedging same types of cash milled rice prices in same season of the year, particularly for U.S. rice prices during August-September.

The significant seasonal difference in the potential hedging effectiveness resulted from the difference in futures contract design and harvest time distribution. There are five wheat and six rice futures contracts traded, each with a different delivery date, starting from the current month and going out one to two years into the future. Delivery months for wheat futures are March, May, July, September, and December. Delivery months for rough rice futures are January, March, May, July, September, and November.

The reasons why futures contracts shortly after harvest (November contracts for rice futures, December contracts for soft red winter wheat futures) appear to be better than other contracts for hedging in Asia include:

1. In general, the differences between cash prices and futures prices of grain are linked through storage markets after harvest. Hence, the cash price at harvest is typically the lowest price of the crop year, increasing after harvest by approximately the cost of storage. In Asia, there are two harvest times, July/August and November. Between these two periods, futures prices are closely correlated to cash prices with little effect from storage cost. After December and before the following harvest, storage cost does not sufficiently account for the difference between the cash prices and the futures prices, likely because storage capacity is very low in many Asian countries. After December, prices of the cash grain and the futures contracts appear to diverge.

2. In the period from July to December, food grain supply can be anticipated since the size of the harvest can be evaluated at that time with confidence. In the period from December to the next harvest, weather conditions, such as the timing of the Asian monsoon, are much less predictable.

3. Benefited by advanced agricultural techniques, sophisticated transportation facilities, well developed financial and banking networks, stable agricultural policies, and large storage capacity, the supply of rice and wheat is much less affected by the harvest time factor in the U.S. than it is in Asia.

Basis Patterns

The results of model (3.6), which is applied to the data from 1991 to 1993 and regresses the basis over time, are provided in Table 4.9.

TABLE 4.9

GULF/CHICAGO BASIS REGRESSIONS: CBOT ROUGH RICE FUTURES, 1991 - 93

Basis & Year	Contract	Intercept	Coefficient (WEEK)	St. Error (from mean)	F Value	p-value	R^2
World							
July 91-June 92	Sep.	1.599	0.009	0.012	0.558	0.472	0.053
	Nov.	1.881	-0.037	0.007	29.372	0.000	0.607
	Jan.	1.488	-0.006	0.004	2.430	0.130	0.080
	Mar.	1.072	0.019	0.005	14.147	0.001	0.282
	May	0.682	0.047	0.004	143.691	0.000	0.804
July 92-June 93	Sep.	2.522	0.011	0.004	7.485	0.021	0.428
	Nov.	2.478	-0.003	0.003	0.860	0.366	0.046
	Jan.	2.298	0.002	0.003	0.417	0.524	0.015
	Mar.	2.031	0.013	0.004	12.36	0.001	0.256
	May	1.924	0.011	0.004	9.424	0.004	0.203
July 93-June 94	Sep.	0.735	0.021	0.015	1.856	0.203	0.157
	Nov.	1.181	-0.101	0.022	20.354	0.000	0.531
	Jan.	0.500	-0.048	0.013	12.835	0.001	0.322
	Mar.	-0.566	0.027	0.014	3.801	0.059	0.098
	May	-1.800	0.121	0.010	143.225	0.000	0.822
Houston							
July 91-June 92	Sep.	9.001	-0.004	0.012	0.133	0.723	0.013
	Nov.	9.325	-0.056	0.013	20.104	0.000	0.514
	Jan.	8.601	0.010	0.010	1.038	0.317	0.036

TABLE 4.9

GULF/CHICAGO BASIS REGRESSIONS: CBOT ROUGH RICE FUTURES, 1991 - 93 (Continued)

Basis & Year	Contract	Intercept	Coefficient (WEEK)	St. Error (from mean)	F Value	p-value	R^2
	Mar.	8.214	0.033	0.008	18.902	0.000	0.344
	May	7.794	0.070	0.006	133.411	0.000	0.792
July 92-June 93	Sep.	9.398	0.042	0.011	14.994	0.003	0.600
	Nov.	9.388	0.025	0.007	12.188	0.003	0.404
	Jan.	9.472	-0.000	0.005	0.000	0.991	0.000
	Mar.	9.272	0.004	0.004	1.162	0.288	0.031
	May	9.071	0.011	0.005	4.597	0.039	0.111
New Orleans							
July 91-June 92	Sep.	1.667	-0.02	0.009	4.897	0.051	0.329
	Nov	1.619	-0.01	0.004	6.924	0.016	0.267
	Jan.	1.212	0.022	0.004	27.070	0.000	0.492
	Mar.	1.023	0.028	0.003	87.623	0.000	0.709
	May	1.147	0.024	0.003	58.998	0.000	0.628
July 92-June 93	Sep.	1.365	0.025	0.012	3.983	0.074	0.285
	Nov.	1.335	0.007	0.006	1.759	0.201	0.089
	Jan.	1.115	0.018	0.004	20.448	0.000	0.431
	Mar.	1.035	0.012	0.003	21.528	0.000	0.374
	May	1.000	0.006	0.003	6.179	0.018	0.143
	Sep.	0.170	0.058	0.017	11.340	0.007	0.531
July 93 June 94	Nov.	-0.336	0.108	0.013	71.441	0.000	0.799
	Jan.	-0.150	0.062	0.010	37.088	0.000	0.579
	Mar.	-0.247	0.061	0.010	34.661	0.000	0.562
	May	0.995	0.016	0.021	0.568	0.463	0.037

Source: Authors' calculations.

For world rice prices from July 1993 to June 1994, statistical significance is obtained for May and November futures contracts. But a negative relationship between time and the basis for the November and January contracts is observed, implying a negative return to storage. Also, the regression coefficient for the basis for the September and March contracts is not significantly different from zero. These findings suggest that basis is not well-behaved for the maturing September and March contracts in the 1993 marketing year, while the maturing November and May contracts in the same marketing year exhibit a well-functioning basis.

In the 1991 and 1992 marketing years, the basis regression for the May contract shows a lower level of statistical significance than in 1993. As in 1993, the WEEK coefficient for the November and January contracts is negative in July 1991 to June 1992 marketing year. This negative sign reinforces the above suggestion that there are little or no regular returns to storage in the early half of the marketing year.

The Houston basis for the May contract in the 1991 marketing year behaved as expected. The general trend in the basis was upward and significant. But, the WEEK coefficient for the September and November contracts declines from positive to negative, suggesting a negative return to storage. All other regression coefficients except for the January contract in the 1992 marketing year were of the right sign but were not significant.

The trend in the New Orleans rice basis for November contract in 1993 marketing year is significant and in the right direction. However, basis for November contract is insignificant in 1992 marketing year and in the wrong direction for 1991 marketing year. That is, cash price began above the futures in that marketing year and fell towards the futures price. In 1991, the trend in the New Orleans rice basis for September contract is also negative, with only the later three contracts showing a positive sign for the WEEK coefficient. Since no data are available for New Orleans rough rice prices after February 1994, the basis for May and March contracts in 1993 marketing year is only analyzed up to January 25, 1994. However, the weakness for these two cases did not affect the overall evaluation.

The analysis of basis suggest that the ability to hedge in the rice futures markets is limited. The basis has no significant trend in up to three of the five contracts and tended to move the wrong direction in ten of the forty observed cases. Most of the regression coefficients for WEEK regardless of the sign, are not significant at the one percent level. However, the May and November contracts in general have a more reliable basis than the other three contracts did. Also, their year-by-year improvement in statistical significance suggests an increasing degree of confidence. Hence, basis for May and November contracts could be more predictable than for the other three contracts, and these contracts may possess more attributes of an efficient futures market.

Nevertheless, with only three years estimate in each market, the regression coefficients for the five futures contracts do not permit a confident assessment.
More years of experience with available data in future will make such judgment more convincing.

Integration of Markets

The results of the investigation on whether rice price movements in the Chicago rice and wheat futures markets reflect price movements in the world spot rice market and U.S. spot rice markets are summarized in table 4.10.

TABLE 4.10

REGRESSION RESULTS OF RICE AND WHEAT PRICE CHANGES, AUGUST-JANUARY , NEARBY FUTURES CONTRACTS

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Rice Futures vs. World Spot						
1986	RFP=0.005+0.329WOL	0.301	1,20	1.194	0.287	0.056
1987	RFP=0.081+0.899WOL	0.478	1,22	3.537	0.073	0.139
1988	RFP=-0.005+0.783WOL	0.430	1,22	3.318	0.082	0.131
1989	RFP=-0.014+0.008WOL	0.281	1,22	0.001	0.979	0.000
1990	RFP=0.009+1.654WOL	1.473	1,22	1.260	0.274	0.054
1991	RFP=0.012+0.724WOL	1.965	1,22	0.136	0.716	0.006
1992	RFP=-0.023+0.003WOL	0.011	1,22	0.056	0.814	0.003
Rice Futures vs. Texas Spot						
1986	RFP=0.002+0.003TXL	0.043	1,20	0.005	0.943	0.0003
1987	RFP=0.069+0.515TXL	0.178	1,22	8.347	0.009	0.275
1988	RFP=-0.006+0.179TXL	0.079	1,22	5.168	0.033	0.190
1989	RFP=-0.016-0.111TXL	0.623	1,22	0.032	0.860	0.001
1990	RFP=0.008+0.022TXL	0.151	1,22	0.021	0.887	0.009
1991	RFP=0.016-0.532TXL	0.165	1,22	10.356	0.004	0.320
1992	RFP=-0.022+0.0529TXL	0.146	1,22	0.132	0.720	0.006
Rice Futures vs. Louisiana Spot						
1986	RFP=0.002-0.00597LOL	0.167	1,20	0.001	0.972	0.0001
1987	RFP=0.127+0.122LOL	0.257	1,22	0.224	0.641	0.010
1988	RFP=-0.008+0.240LOL	0.238	1,22	1.015	0.325	0.044
1989	RFP=-0.006+0.567LOL	0.320	1,22	3.133	0.091	0.125
1990	RFP=0.008+0.024OL	0.228	1,22	0.011	0.917	0.001
1991	RFP=0.017-0.378LOL	0.370	1,22	1.041	0.319	0.045
1992	RFP=-0.023+0.021LOL	0.162	1,22	0.017	0.897	0.001
Rice Futures vs. Arkansas Spot						
1986	RFP=0.002-0.330ARL	0.167	1,20	3.933	0.061	0.164
1987	RFP=0.096+0.411ARL	0.328	1,22	1.578	0.222	0.067
1988	RFP=-0.028-0.162ARL	0.192	1,22	0.713	0.407	0.031
1989	RFP=-0.006+0.469ARL	0.478	1,22	0.964	0.337	0.042
1990	RFP=0.009+0.133ARL	0.203	1,22	0.431	0.518	0.019
1991	RFP=0.013+0.063ARL	0.263	1,22	0.057	0.813	0.003
1992	RFP=-0.024-0.018ARL	0.140	1,22	0.016	0.900	0.001
Wheat Futures vs. World Spot						
1986	WFP=0.017+0.463WOL	0.726	1,20	0.407	0.531	0.020
1987	WFP=0.018+0.139WOL	0.122	1,22	1.303	0.266	0.056
1988	WFP=0.010-0.875WOL	0.376	1,22	5.406	0.030	0.197
1989	WFP=0.006+0.022WOL	0.156	1,22	0.020	0.889	0.001
1990	WFP=-0.014+0.069WOL	1.652	1,22	0.002	0.967	0.0001
1991	WFP=0.0585-2.438WOL	3.278	1,22	0.553	0.465	0.025
1992	WFP=0.035+0.0171WOL	0.024	1,22	0.526	0.476	0.023

TABLE 4.10

REGRESSION RESULTS OF RICE AND WHEAT PRICE CHANGES, AUGUST-JANUARY , NEARBY FUTURES CONTRACTS (Continued)

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Wheat Futures vs. Texas Spot						
1986	WFP=0.008-0.152TXL	0.095	1,20	2.536	0.127	0.113
1987	WFP=0.028-0.006TXL	0.051	1,22	0.014	0.908	0.001
1988	WFP=0.032+0.083TXL	0.078	1,22	1.133	0.299	0.049
1989	WFP=-0.005-0.710TXL	0.316	1,22	5.064	0.035	0.187
1990	WFP=-0.013+0.272TXL	0.154	1,22	3.112	0.092	0.124
1991	WFP=0.054+0.095TXL	0.337	1,22	0.080	0.781	0.004
1992	WFP=0.042+0.485TXL	0.288	1,22	2.840	0.106	0.114
Wheat Futures vs. Louisiana Spot						
1986	WFP=0.014+0.155LOL	0.393	1,20	0.156	0.697	0.008
1987	WFP=0.020+0.063LOL	0.061	1,22	1.057	0.315	0.046
1988	WFP=0.036+0.224LOL	0.216	1,22	1.071	0.312	0.046
1989	WFP=0.002-0.145LOL	0.190	1,22	0.586	0.452	0.026
1990	WFP=-0.023-0.345LOL	0.237	1,22	2.108	0.161	0.088
1991	WFP=0.051+0.321LOL	0.634	1,22	0.257	0.617	0.012
1992	WFP=0.047+0.615LOL	0.314	1,22	3.843	0.063	0.149
Wheat Futures vs. Arkansas Spot						
1986	WFP=0.015+0.435ARL	0.421	1,20	1.072	0.313	0.051
1987	WFP=0.038-0.091ARL	0.080	1,22	1.280	0.270	0.055
1988	WFP=0.015-0.188ARL	0.173	1,22	1.175	0.290	0.051
1989	WFP=0.004-0.047ARL	0.274	1,22	0.030	0.865	0.001
1990	WFP=-0.017-0.126ARL	0.222	1,22	0.324	0.575	0.015
1991	WFP=0.056-0.295ARL	0.438	1,22	0.454	0.508	0.020
1992	WFP=0.043+0.342ARL	0.284	1,22	1.451	0.241	0.062

The model shows a significant relationship between changes in the announced world price and changes in the CBOT rice futures price in 1987, 1988, 1990, and 1991. In addition, the regression approaches statistical significance in 1986. A similar level of significant relationship between announced world rice price and futures rice price in 1987 and 1988 was also found by Herrmann's research (1994, p436, Table 16-6) for the period 1986 through 1988.

The rice futures price movements do not show a strong relationship to movements in Texas rice prices and Louisiana rice prices. The regression approaches statistical significance only in 1987,1988, and 1991 for Texas rice price, and in 1988,1989 and 1991 for Louisiana rice price. This result is not consistent with the findings of Herrmann who found that the regression approaches statistical significance in 1987 for Louisiana rice price.

Arkansas rice price changes were related to changes in the rice futures price at the 10 percent significance level from 1986 through 1990, with a decreasing trend. However, Hermann (1994) showed a statistically significant relationship between changes in the futures rice price and changes in the Arkansas rice price, and the regression coefficient appears to increase over the period 1986-88. Such a favorable hedging scenario is not replicated in the longer term statistics for Arkansas rice price in this study.

Wheat futures price changes were not closely related to changes in the announced world rice price as rice futures price changes were, with statistical significance found only in the 1988 crop year. However, wheat futures price movements show a significant relationship to movements in the Texas rice prices in 1989 and 1992, and to movements in the Louisiana rice prices in 1992, when rice futures price movements failed to provide a significant relationship to movements in the Texas rice prices and the Louisiana rice prices. Moreover, the regression of wheat futures price changes to changes in the Arkansas rice price approaches statistical significance in 1991 and 1992, when rice futures price changes do not show a relationship to changes in the Arkansas rice price.

The regression model for the log price changes in nearby rice and wheat futures markets against log price changes in the four cash rice markets provides the following results:

TABLE 4.11

REGRESSION RESULTS OF RICE AND WHEAT LOG PRICE CHANGES, AUGUST-JANUARY , NEARBY FUTURES CONTRACTS

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Rice Futures vs. World Spot						
1986	RFP=-0.428+0.323WOL	0.307	1,20	1.114	0.304	0.053
1987	RFP=-1.057+0.477WOL	0.173	1,22	7.596	0.012	0.257
1988	RFP=-0.042+0.740WOL	0.444	1,22	2.780	0.110	0.112
1989	RFP=-0.744+0.050WOL	0.301	1,22	0.028	0.868	0.001
1990	RFP=0.851+1.447WOL	1.260	1,22	1.318	0.263	0.057
1991	RFP=-0.166+0.553WOL	1.638	1,22	0.114	0.739	0.005
1992	RFP=-0.806+0.0004WOL	0.020	1,22	0.042	0.839	0.002
Rice Futures vs. Texas Spot						
1986	RFP=-0.790+0.007TXL	0.087	1,20	0.005	0.942	0.0003
1987	RFP=-1.559-0.230TXL	0.400	1,22	0.329	0.572	0.015
1988	RFP=-0.457+0.301TXL	0.141	1,22	4.582	0.044	0.172
1989	RFP=-0.970-0.147TXL	0.875	1,22	0.028	0.868	0.001
1990	RFP=0.745+0.045TXL	0.241	1,22	0.035	0.854	0.002
1991	RFP=-1.660-0.761TXL	0.240	1,22	10.018	0.004	0.313
1992	RFP=-0.694+0.098TXL	0.257	1,22	0.147	0.705	0.007
Rice Futures vs. Louisiana Spot						
1986	RFP=-0.810-0.011LOL	0.289	1,20	0.001	0.970	0.0001
1987	RFP=-1.431+0.113LOL	0.243	1,22	0.215	0.647	0.010
1988	RFP=-0.436+0.321LOL	0.360	1,22	0.794	0.383	0.035
1989	RFP=0.053+0.749LOL	0.430	1,22	3.040	0.095	0.121
1990	RFP=-0.801-0.004LOL	0.345	1,22	0.000	0.991	0.000
1991	RFP=-1.453-0.579LOL	0.537	1,22	1.162	0.293	0.050
1992	RFP=-0.759+0.042LOL	0.253	1,22	0.027	0.871	0.001
Rice Futures vs. Arkansas Spot						
1986	RFP=-1.574-0.683ARL	0.338	1,20	4.072	0.057	0.169
1987	RFP=-1.601-0.120ARL	0.230	1,22	0.273	0.606	0.012
1988	RFP=-1.133-0.286ARL	0.329	1,22	0.758	0.393	0.033
1989	RFP=0.084+0.777ARL	0.678	1,22	1.314	0.264	0.056
1990	RFP=-0.551+0.215ARL	0.322	1,22	0.445	0.512	0.020
1991	RFP=-0.670+0.110ARL	0.381	1,22	0.084	0.775	0.004
1992	RFP=-0.818-0.010ARL	0.226	1,22	0.002	0.965	0.0001
Wheat Futures vs. World Spot						
1986	WFP=-4.245+0.311WOL	0.497	1,20	0.393	0.538	0.019
1987	WFP=-1.700+0.594WOL	0.238	1,22	6.255	0.020	0.221
1988	WFP=-5.399-0.700WOL	0.296	1,22	5.586	0.027	0.203
1989	WFP=-4.570+0.030WOL	0.154	1,22	0.037	0.848	0.002
1990	WFP=-4.527+0.074WOL	1.665	1,22	0.002	0.965	0.0001
1991	WFP=-8.080-3.069WOL	3.043	1,22	1.017	0.324	0.044
1992	WFP=-4.592+0.003WOL	0.004	1,22	0.555	0.464	0.025

TABLE 4.11
REGRESSION RESULTS OF RICE AND WHEAT LOG PRICE CHANGES, AUGUST-JANUARY, NEARBY FUTURES CONTRACTS (Continued)

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Wheat Futures vs. Texas Spot						
1986	WFP=-4.838-0.207TXL	0.131	1,20	2.518	0.128	0.112
1987	WFP=-2.525-1.190TXL	0.477	1,22	6.211	0.021	0.220
1988	WFP=-4.460+0.121TXL	0.106	1,22	1.31	0.265	0.056
1989	WFP=-5.629-0.898TXL	0.406	1,22	4.905	0.037	0.182
1990	WFP=-4.024+0.515TXL	0.289	1,22	3.180	0.088	0.126
1991	WFP=-4.421+0.149TXL	0.549	1,22	0.073	0.789	0.003
1992	WFP=-3.777+0.717TXL	0.422	1,22	2.859	0.103	0.116
Wheat Futures vs. Louisiana Spot						
1986	WFP=-4.394+0.181LOL	0.458	1,20	0.157	0.696	0.008
1987	WFP=-1.881+0.561LOL	0.305	1,22	3.387	0.079	0.133
1988	WFP=-4.301+0.260LOL	0.252	1,22	1.063	0.314	0.046
1989	WFP=-4.807-0.178LOL	0.232	1,22	0.592	0.450	0.026
1990	WFP=-5.339-0.637LOL	0.421	1,22	2.291	0.144	0.094
1991	WFP=-4.138+0.397LOL	1.041	1,22	0.146	0.706	0.007
1992	WFP=-3.694+0.789LOL	0.408	1,22	3.743	0.066	0.145
Wheat Futures vs. Arkansas Spot						
1986	WFP=-3.875+0.637ARL	0.574	1,20	1.232	0.280	0.058
1987	WFP=-2.206-0.071ARL	0.310	1,22	0.053	0.821	0.002
1988	WFP=-4.882-0.247ARL	0.229	1,22	1.157	0.294	0.050
1989	WFP=-4.691-0.076ARL	0.357	1,22	0.046	0.832	0.002
1990	WFP=-4.892-0.246ARL	0.414	1,22	0.353	0.558	0.016
1991	WFP=-4.991-0.353ARL	0.720	1,22	0.240	0.629	0.011
1992	WFP=-4.103+0.431ARL	0.384	1,22	1.263	0.273	0.054

The log price changes in nearby rice futures market are less closely related to changes in the announced world price than the price changes in rice futures, with significant coefficients more distant from one in all the years except 1989 and 1990. However, the relationship between the nearby rice futures market and all the three domestic rice cash markets (Texas, Louisiana, and Arkansas) is improved when log price changes are used in the regression. In six of the seven analyzed years, the rice futures price movements have better relationship to movement in the Texas rice price. In five of the seven analyzed years, the rice futures price movements have better relationship to movement in the Louisiana

(1986, 1988, 1989, 1991, and 1992) and Arkansas cash rice prices (1986, 1988, 1989, 1990, and 1991).

Log price changes in the nearby wheat futures market were more closely related to the announced world price in 1987, 1989, and 1990, but were less closely related than the rice futures prices in 1986, 1988, 1991, and 1992. However, in most of the years, changes in nearby wheat futures improved its relationship with Texas, Louisiana, and Arkansas rice cash price changes when log price changes are used. This is especially true for Texas and Louisiana rice price changes, where the regression coefficients in all seven years are at the 10 percent significance level.

The models are then applied to a shorter period, August through October, to check if there is any seasonal difference. The results of price change regressions and regression of log price changes are reported separately in tables 4.12 and 4.13.

TABLE 4.12

REGRESSION RESULTS OF RICE AND WHEAT PRICE CHANGES, AUGUST-OCTOBER, NOVEMBER CONTRACT OF RICE AND DECEMBER CONTRACT OF WHEAT

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Rice Futures vs. World Spot						
1986	RFP=0.014+0.571WOL	0.458	1,8	1.550	0.248	0.162
1987	RFP=0.152+0.308WOL	0.812	1,10	0.144	0.712	0.014
1988	RFP=0.001+0.853WOL	0.609	1,10	1.962	0.192	0.164
1989	RFP=-0.744+0.050WOL	0.286	1,11	0.478	0.504	0.042
1990	RFP=0.851+1.447WOL	1.611	1,11	1.422	0.258	0.115
1991	RFP=0.036-5.030WOL	5.184	1,11	0.941	0.355	0.086
1992	RFP=-0.031+0.002WOL	0.009	1,11	0.077	0.786	0.008
Rice Futures vs. Texas Spot						
1987	RFP=0.040+0.518TXL	0.132	1,10	15.372	0.003	0.606
1988	RFP=0.003+0.177TXL	0.025	1,10	5.357	0.043	0.349
1990	RFP=0.002-0.046TXL	0.148	1,11	0.098	0.761	0.009
1991	RFP=0.016-0.937TXL	0.454	1,11	4.258	0.066	0.299
1992	RFP=-0.031+0.042TXL	0.156	1,11	0.073	0.793	0.007
Rice Futures vs. Louisiana Spot						
1987	RFP=0.178+0.027LOL	0.313	1,10	0.007	0.933	0.001
1988	RFP=0.013+0.433LOL	0.361	1,10	1.435	0.259	0.126
1989	RFP=-0.052+0.601LOL	0.849	1,11	0.502	0.493	0.044
1990	RFP=0.012+0.218LOL	0.293	1,11	0.554	0.472	0.048
1991	RFP=0.036-2.011LOL	1.057	1,11	3.623	0.086	0.266
1992	RFP=-0.030+0.020LOL	0.232	1,11	0.008	0.931	0.001
Rice Futures vs. Arkansas Spot						
1986	RFP=0.007-0.353ARL	0.177	1,8	3.987	0.081	0.333
1987	RFP=0.067+0.522ARL	0.358	1,10	2.128	0.175	0.176
1988	RFP=-0.038-0.164ARL	0.233	1,10	0.495	0.498	0.047
1989	RFP=0.089-0.518ARL	0.544	1,11	0.907	0.361	0.076
1990	RFP=0.006+0.130ARL	0.238	1,11	0.299	0.596	0.026
1991	RFP=0.047+1.343ARL	0.683	1,11	3.862	0.078	0.279
1992	RFP=-0.033-0.269ARL	0.239	1,11	1.262	0.288	0.112

TABLE 4.11

REGRESSION RESULTS OF RICE AND WHEAT PRICE CHANGES, AUGUST-OCTOBER, NOVEMBER CONTRACT OF RICE AND DECEMBER CONTRACT OF WHEAT (Continued)

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Wheat Futures vs. World Spot						
1986	WFP=0.041+1.025WOL	0.759	1,8	1.827	0.213	0.186
1987	WFP=0.005+0.110WOL	0.195	1,10	0.321	0.584	0.031
1988	WFP=-0.001-0.652WOL	0.682	1,10	0.915	0.361	0.084
1989	WFP=0.013+0.183WOL	0.214	1,11	0.731	0.411	0.062
1990	WFP=-0.027-0.568WOL	1.660	1,11	0.117	0.739	0.011
1991	WFP=0.072-18.821WOL	5.617	1,11	11.227	0.007	0.529
1992	WFP=0.021+0.017WOL	0.020	1,11	0.732	0.412	0.068
Wheat Futures vs. Texas Spot						
1987	WFP=0.026-0.032TXL	0.050	1,10	0.417	0.533	0.040
1988	WFP=0.028+0.080TXL	0.098	1,10	0.665	0.434	0.062
1990	WFP=-0.028+0.183TXL	0.134	1,11	1.889	0.197	0.147
1991	WFP=0.050+0.282TXL	0.814	1,11	0.120	0.736	0.012
1992	WFP=0.020+0.312TXL	0.360	1,11	0.750	0.407	0.070
Wheat Futures vs. Louisiana Spot						
1987	WFP=0.009+0.030LOL	0075	1,10	0.154	0.703	0.015
1988	WFP=0.076+0.749LOL	0.339	1,10	4.893	0.051	0.329
1989	WFP=0.0003++0.147LOL	0.654	1,11	0.051	0.826	0.005
1990	WFP=-0.044-0.363LOL	0.271	1,11	1.797	0.207	0.140
1991	WFP=0.461+0.099LOL	1.861	1,11	0.003	0.958	0.000
1992	WFP=0.022+0.122LOL	0.550	1,11	0.049	0.829	0.005
Wheat Futures vs. Arkansas Spot						
1986	WFP=0.033+0.232ARL	0.354	1,8	0.431	0.530	0.051
1987	WFP=0.034-0.076ARL	0.092	1,10	0.673	0.431	0.063
1988	WFP=0.012-0.048ARL	0.255	1,10	0.035	0.855	0.004
1989	WFP=0.004+0.232ARL	0.422	1,11	0.304	0.369	0.027
1990	WFP=-0.028-0.056RL	0.235	1,11	0.057	0.815	0.005
1991	WFP=0.080+2.493ARL	0.923	1,11	7.296	0.022	0.422
1992	WFP=0.007-1.321ARL	0.438	1,11	9.117	0.013	0.477

Compared with the regression results for the period August through January, the relationship between the futures rice price movements and the movements of announced world rice price, Texas rice price, and Louisiana rice price in August-October period is stronger in some years but weaker in other years. Thus, a shorter hedging period does not imply a stronger relationship between futures price movement and cash price movement.

Arkansas rice price movements achieved stronger relationship with CBOT rice futures price movements in all seven years, when the model covers only from August through October, and excludes the second rice harvest. This suggests that CBOT rice futures markets offers a good hedge only in specific seasons. Even in Arkansas, which contains the delivery area for the rice futures contracts, hedging opportunity changes after first rice harvest.

The regression results for the wheat futures price movements and the movements of announced world rice price, Texas rice price, and Louisiana rice price in August-October period support the above observations that hedging potential varies seasonally.

When the rice and wheat price changes take log form in the regression, the relationship between futures and cash price changes, which is summarized in Table 4.12, exhibits a similar pattern.

TABLE 4.13

REGRESSION RESULTS OF RICE AND WHEAT LOG PRICE CHANGES, AUGUST-OCTOBER, NOVEMBER CONTRACT OF RICE AND DECEMBER CONTRACT OF WHEAT

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Rice Futures vs. World Spot						
1986	RFP=-0.115+0.593WOL	0.481	1,8	1.516	0.253	0.159
1987	RFP=-0.330+0.375WOL	0.574	1,10	0.427	0.528	0.041
1988	RFP=0.179+0.859WOL	0.657	1,10	1.709	0.220	0.146
1989	RFP=-0.203-1.054WOL	0.302	1,11	0.452	0.515	0.040
1990	RFP=1.167+1.726WOL	1.410	1,11	1.498	0.247	0.120
1991	RFP=-5.677-4.296WOL	4.351	1,11	0.974	0.347	0.089
1992	RFP=-0.808+0.0004WOL	0.002	1,11	0.075	0.790	0.008
Rice Futures vs. Texas Spot						
1987	RFP=-0.080+0.612TXL	0.172	1,10	112.636	0.005	0.558
1988	RFP=-0.445+0.340TXL	0.136	1,10	5.179	0.046	0.342
1990	RFP=-0.914-0.102TXL	0.281	1,11	0.131	0.725	0.012
1991	RFP=-2.300-1.323TXL	0.666	1,11	3.953	0.075	0.283
1992	RFP=-0.726+0.072TXL	0.265	1,11	0.074	0.791	0.007
Rice Futures vs. Louisiana Spot						
1987	RFP=-0.491+0.231LOL	0.391	1,10	0.349	0.568	0.034
1988	RFP=-0.086+0.624LOL	0.575	1,10	1.175	0.304	0.105
1989	RFP=0.193+0.884LOL	1.156	1,11	0.585	0.461	0.051
1990	RFP=-0.460+0.295LOL	0.461	1,11	0.408	0.536	0.036
1991	RFP=-4.074-2.887LOL	1.505	1,11	3.681	0.084	0.269
1992	RFP=-0.754+0.048LOL	0.355	1,11	0.018	0.896	0.002
Rice Futures vs. Arkansas Spot						
1986	RFP=-1.623-0.728ARL	0.360	1,8	4.097	0.078	0.339
1987	RFP=-0.174+0.518ARL	0.506	1,10	1.050	0.330	0.095
1988	RFP=-1.140-0.290ARL	0.405	1,10	0.511	0.490	0.049
1989	RFP=-1.589-0.673ARL	0.765	1,11	0.774	0.398	0.066
1990	RFP=-0.546+0.220ARL	0.389	1,11	0.320	0.583	0.028
1991	RFP=1.457+1.971ARL	0.986	1,11	3.999	0.073	0.286
1992	RFP=-1.313-0.443ARL	0.383	1,11	1.134	0.275	0.118
Wheat Futures vs. World Spot						
1986	WFP=-3.750+0.738WOL	0.537	1,8	1.888	0.207	0.191
1987	WFP=-4.497+0.093WOL	0.182	1,10	0.261	0.620	0.026
1988	WFP=-5.237-0.555WOL	0.561	1,10	0.979	0.346	0.089
1989	WFP=-4.339+0.230WOL	0.207	1,11	1.239	0.289	0.101
1990	WFP=-5.228-0.539WOL	1.578	1,11	0.116	0.739	0.011
1991	WFP=-26.221-19.014WOL	5.526	1,11	11.838	0.006	0.542
1992	WFP=-4.596+0.003WOL	0.003	1,11	0.681	0.429	0.064

TABLE 4.13

REGRESSION RESULTS OF RICE AND WHEAT LOG PRICE CHANGES, AUGUST-OCTOBER, NOVEMBER CONTRACT OF RICE AND DECEMBER CONTRACT OF WHEAT (Continued)

Markets & year	Regression Equation	Standard Error	F-statistic df	F-statistic Value	p	R^2
Wheat Futures vs. Texas Spot						
1987	WFP=-4.642-0.040TXL	0.081	1,10	0.242	0.634	0.024
1988	WFP=-4.465+0.117TXL	0.134	1,10	0.769	0.401	0.071
1990	WFP=-4.185=0.376TXL	0.276	1,11	1.858	0.200	0.145
1991	WFP=-4.069+0.458TXL	1.401	1,11	0.107	0.751	0.011
1992	WFP=-4.069+0.466TXL	0.563	1,11	0.684	0.428	0.064
Wheat Futures vs. Louisiana Spot						
1987	WFP=-4.535+0.059LOL	0124	1,10	0.227	0.644	0.022
1988	WFP=-3.494+0.960LOL	0.401	1,10	5.722	0.038	0.364
1989	WFP=-4.393+0.187LOL	0.893	1,11	0.055	0.828	0.005
1990	WFP=-5.344-0.635LOL	0.457	1,11	1.931	0.192	0.149
1991	WFP=-4.656-0.057LOL	3.153	1,11	0.000	0.986	0.000
1992	WFP=-4.404+0.171LOL	0.775	1,11	0.049	0.830	0.005
Wheat Futures vs. Arkansas Spot						
1986	WFP=-4.197+0.348ARL	0.487	1,8	0.510	0.495	0.060
1987	WFP=-4.739-0.128ARL	0.163	1,10	0.619	0.450	0.058
1988	WFP=-4.645-0.038ARL	0.344	1,10	0.012	0.914	0.001
1989	WFP=-4.269+0.294ARL	0.554	1,11	0.282	0.606	0.025
1990	WFP=-4.728-0.099ARL	0.416	1,11	0.057	0.816	0.005
1991	WFP=0.278+4.269ARL	1.594	1,11	7.174	0.023	0.418
1992	WFP=-6.810-1.939ARL	0.648	1,11	8.971	0.013	0.473

Expected Utility Trading Model

Unhedged Positions

Cash trade is a strategy of complete exposure to price risk, and is used to measure the relative effectiveness of the other strategies. Table 4.14 reports the expected returns and variances of returns from cash activities only and from futures activities only for a rice and wheat trader.

TABLE 4.14

EXPECTED RETURNS AND VARIANCES OF RETURNS FROM CASH AND FUTURES ACTIVITIES, 1986 - 93

	Expected returns from				Variances of returns from			
	cash activity		futures activity		cash activity		futures activity	
	WOL	TXL	RFP	WFP	WOL	TXL	RFP	WFP
Aug.--Oct.	0.096	-0.766	1.037	0.296	4.016	17.637	9.698	0.208
Nov.--Jan.	-0.645	-0.671	0.675	0.290	2.226	11.759	2.382	0.224
Feb.--Apr.	0.323	-0.219	-1.857	-0.190	0.960	1.444	7.062	0.119
May--Jul	-0.054	0.950	-0.192	-0.218	1.736	2.739	0.451	0.254

WOL denotes world market milled long grain rice, TXL is Texas milled long grain rice, RFP is CBOT futures rice contract, and WFP is CBOT futures wheat contract. These abbreviations are also used in the following tables.

Complete exposure to price risk results in either large losses or large profits for the rice and/or wheat trader. For example, the differences between the greatest profit and the greatest loss for a rice trader trading Texas long grain milled rice can be $1.716 (the difference between $-0.766 and $0.95) per hundredweight. In addition, returns from cash activities and futures market activities vary seasonally. In the period August through January, all returns from futures activities were larger than that from cash activities. However, from February through July, all the cash returns were larger than returns from futures activities, except for the return from wheat futures activity in the period February through April. The seasonal difference is so clear that a crop year can in general be divided into a harvest season (August through January) and a pre-harvest season (February through July).

The variances of returns from cash trade in the world long grain milled rice market were smaller than those from trade in the Texas long grain milled rice market for all four seasons, in part because the announced world market rice price is a weighted averaged price. Meanwhile, the variances of returns from wheat futures activities were smaller than that from rice futures markets throughout the year. A possible explanation is that the rice futures market is less heavily traded, and thus less stable.

Table 4.15 summarizes the relationships among returns using announced world rice prices, Texas rice prices, rice futures prices, and wheat futures prices.

TABLE 4.15

CORRELATIONS OF EXPECTED RETURNS FROM CASH AND FUTURES ACTIVITIES, 1986 - 93

	Aug.--Oct.	Nov.--Jan.	Feb.--Apr.	May--Jul.
WOL with RFP	-0.893	-0.405	-0.410	-0.510
WOL with WFP	-0.180	0.035	-0.056	0.198
TXL with RFP	-0.746	-0.207	-0.032	-0.422
TXL with WFP	0.039	-0.091	-0.239	0.295
RFP with WFP	0.174	-0.491	0.425	0.114

Returns from rice futures activities in general have much higher correlation with returns from world cash rice market and Texas cash rice market than returns from wheat futures activities did. However, in the period February through April, returns from Texas cash rice market are more closely related with wheat futures activities than with rice futures activities. In addition, only returns from wheat futures activities have positive correlations with returns from the two underlying cash markets.

Interestingly, the correlation of returns between the two futures activities was low in the August through October period, but much higher in the November through January period, with a negative sign. During the period of February to April, which is the most distant period to harvest either in the United States or in Asia, the correlation of returns from the two futures activities was as high as was in November through January, but with a positive sign.

Table 4.16 reports the ratios of the expected futures returns to variances for the rice and wheat futures markets in the four periods. Five of the eight ratios are less than absolute one, and the rest are larger than absolute one, suggesting the existence of good speculative opportunities. Comparatively, the ratios of expected futures returns to variances for wheat futures market are higher than those for rice futures market. The higher ratio is a signal of higher speculative opportunity (Sarassoro and Leuthold, 1988).

TABLE 4.16

RATIOS OF THE EXPECTED FUTURES RETURNS TO VARIANCES FOR THE RICE AND WHEAT FUTURES MARKETS, 1986 - 93

Period	Rice	Wheat
August------October	0.106977	1.424297
November--January	0.283302	1.291471
February----April	-0.262950	-1.598180
May---------July	-0.424500	-0.860010

Direct Hedging

The expected returns and variances of returns from direct hedging and hedging effectiveness are summarized in table 4.17.

TABLE 4.17

EXPECTED RETURNS AND VARIANCES OF RETURNS FROM DIRECT HEDGING AND HEDGING EFFECTIVENESS, 1986 - 93

	Aug.--Oct.		Nov.--Jan.		Feb.--Apr.		May--Jul.	
	initial short	initial long	initial short	initial long	initial short	initial long	initial short	initial long
Expected Returns								
WOL--RFP	1.134	-1.134	0.030	-0.030	-1.534	1.534	-0.245	0.245
TXL--RFP	0.271	-0.271	0.004	-0.004	-2.076	2.076	0.759	0.759
WOL--WFP	0.393	-0.393	-0.355	0.355	0.133	-0.133	-0.272	0.272
TXL--WFP	-0.470	0.470	-0.382	0.382	-0.408	0.408	0.732	-0.732
Variances of Returns								
WOL--RFP	2.572		2.744		5.887		1.284	
TXL--RFP	7.812		11.954		8. 303		2.252	
WOL--WFP	3.895		2.499		1.041		2.253	
TXL--WFP	17.994		11.689		1.365		3.485	
Hedging Effectiveness (Risk minimizing)								
WOL--RFP	0.360		-0.233		-5.134		0.261	
TXL--RFP	0.557		-0.017		-4.749		0.178	
WOL--WFP	0.030		-0.123		-0.084		-0.298	
TXL--WFP	-0.020		0.006		0.055		-0.272	

The magnitude and the sign of the returns from world and Texas rice markets depend on when the agent takes his position and what kind of position he takes. In August through January, expected returns from hedging cash rice using CBOT rice futures are larger than returns from using CBOT wheat futures, when a short position is taken at the beginning of a period and a long position is taken in the end of the period. When the positions are reversed, the wheat futures market offers better returns.

In nonharvest time, February through April, returns from hedging cash rice using rice futures are larger than returns from using wheat futures market only if a long position is taken initially. Otherwise, using wheat futures provides higher revenue from rice trade in both cash rice markets. A simple conclusion that can be drawn from the complicated calculations and figures is that when using rice futures markets fails to provide adequate returns, the wheat futures market can offer better revenue to trader.

In all four seasons, variances for the return from Texas rice market are higher than those from world market. Texas milled rice prices are weekly averaged prices reported by USDA "Rice Market News", and world market rice prices are USDA-announced weekly benchmark prices. The phenomenon that the variances for the returns from Texas rice market are up to five times those from world market returns can not be explained simply by noting that world market rice prices are weighted prices. Since rice is more heavily traded in world markets, the high ratio of variances suggests that more stable revenue can be obtained from world rice markets than from Texas as well as other domestic rice markets. Interestingly, when the wheat futures market is used with either world or Texas rice markets in the seasons November-January and February-April, the variances, the risk associated with rice trade revenue, were lowered. Especially in February through April, the risk of revenue from using wheat futures in the underlying two markets was five times lower than from using rice futures.

The proportion of total risk eliminated by the hedging strategy varies from season to season and from commodity to commodity. In the period from May to October the rice futures markets reduce risk associated with world and Texas rice trade revenue about 18% to 56%. In the other two seasons, the risk of return from rice trade is increased . Especially in the season February through April, risk of revenue rise dramatically. But, if wheat futures markets were utilized in the season November- January and February-April, world rice trade is less risky, and Texas rice trade has a positive sign of hedging effectiveness, rather than a negative sign as in the case of using rice futures markets. Although the amount of risk eliminated by hedging using wheat futures markets is not large, it still suggests the potential of using wheat futures as a tool in stabilizing revenue in such risky rice markets.

Optimal Simple Hedging

The acceptability of any particular strategy in any season depends on an individual trader's preference among various expected returns and associated variance levels. The functional relationship is embodied in the expected utility function 3.22 in Chapter III, and table 4.18 presents the optimal rice hedge ratios at different expected utility level from simple hedging world rice and Texas rice in the four periods being studied. Optimal hedge positions using wheat futures markets are also reported for comparison.

TABLE 4.18

OPTIMAL HEDGE POSITIONS AT DIFFERENT RISK AVERSION LEVELS FOR SIMPLE HEDGING, 1986 - 93

Period	Risk Parameter Range			
	$\delta=10^5$	$\delta=10^2$	$\delta=10^0$	$\delta=10^{-3}$
August-----October				
Hedge with rice futures				
World market	0.574	0.576	0.682	107.55
Texas	1.006	1.007	1.113	107.98
Hedge with wheat futures				
World market	0.791	0.805	2.215	1,425.09
Texas	-0.359[a]	-0.345	1.065	1,423.94
November—January				
Hedge with rice futures				
World market	0.391	0.394	0.675	283.69
Texas	0.460	0.462	0.743	283.76
Hedge with wheat futures				
World market	-0.110	-0.097	1.181	1,291.36
Texas	0.659	0.672	1.950	1,292.13
February---April				
Hedge with rice futures				
World. Market	0.151	0.149	-0.112	-262.80
Texas	0.014	0.012	-0.248	-262.94
Hedge with wheat futures				
World. Market	0.159	-0.143	-1.439	-1,598.03
Texas	0.834	0.818	-0.764	-1,597.35
May----------July				
Hedge with rice futures				
World. Market	1.001	0.997	0.576	-423.51
Texas	1.040	1.036	0.616	-423.47
Hedge with wheat futures				
World. Market	-0.518	-0.526	-1.378	-860.54
Texas	-0.969	-0.978	-1.829	-860.99

a. Positive sign indicates that trader takes short cash and long futures in rice or wheat initially, then reverses it at the end of a period. Negative signs indicate that the initial futures position is short.

In the high risk aversion scenario (risk minimization strategy, $\delta=10^5$), the hedge ratios range from buying futures rice contracts larger than the cash rice position (e.g., for Texas milled rice in August-October period with rice futures, the optimal hedge ratio is

1.006) to very small futures positions (e.g., for Texas rice in February-April period with rice futures, the optimal hedge ratio is 0.014). Interestingly, the hedge ratios larger than one are all hedged with rice futures, and the hedge ratios with negative signs are all hedged with wheat futures.

However, the risk minimizing hedge ratios computed in this study are often less than one, a fully hedged position. This is consistent with the results reported by many authors and is summarized in table 2.1. Johnson and Stein (1961) suggested it may be reasonable for hedgers to hedge only partially. It may be correct in general, but not in the case when seasonal difference is significant. In addition, when the risk aversion level changed from 10^5 to 10^2, even to 10^0, the optimal hedges do not vary significantly.

In August through January, which is the period closet to rice harvest, a Texas rice trader buys more futures contracts (1.006 and 0.46) than a world market trader (0.574 and 0.391) for an optimal hedge. However, in February through April, which is the period most distant from rice harvest, a Texas rice trader buys fewer futures contracts (0.014) than a world market trader (0.151). In the May-July period, a trader in the world rice market takes similar positions to those in the Texas rice market. But, hedge ratios are higher when hedged with rice futures (1.001 and 1.04) than hedged with wheat futures - 0.518 and -0.969). When the sign of the positions are negative as in the case of hedging with wheat futures in May-July, traders buy more future contracts than the size of the cash position when selling the futures contract initially is the normal position.

Specifically, given size of spot rice and wheat, traders in February through April should buy rice futures contracts equivalent to 15.1% of the world market spot rice and/or only 1.4% of the Texas market spot rice, or buy wheat futures contracts equivalent to 15.9% of the world market spot rice and/or 83.4% of the Texas market spot rice. All the other statistics in table 4.5 can be interpreted likewise.

Optimal Cross Hedging

Accurate hedge design can increase expected utility by a significant amount in the long-run. Seasonal difference in hedge design is identified in this study not only for simple hedging rice and wheat, but also for multiple product hedging.

TABLE 4.19

OPTIMAL HEDGE POSITIONS AT DIFFERENT RISK AVERSION LEVELS FOR MULTIPLE PRODUCT HEDGING, 1986 - 93

Period	Risk Parameter Range			
	$\delta=10^5$	$\delta=10^2$	$\delta=10^0$	$\delta=10^{-3}$
August-----October				
Cross Hedge in World Market				
Rice futures	0.577	0.578	0.646	69.2
Wheat futures	0.105	0.118	1.448	1,342.9
Cross Hedge in Texas Market				
Rice futures	0.968	0.968	1.036	69.6
Wheat futures	-1.508	-1.495	-0.166	1,341.3
November—January				
Cross Hedge in World Market				
Rice futures	0.329	0.333	0.714	385.4
Wheat futures	0.416	0.435	2.324	1,908.1
Cross Hedge in Texas Market				
Rice futures	0.291	0.294	0.676	385.3
Wheat futures	1.124	1.143	3.032	1,908.8

TABLE 4.19

OPTIMAL HEDGE POSITIONS AT DIFFERENT RISK AVERSION LEVELS FOR MULTIPLE PRODUCT HEDGING, 1986 - 93

Period	Risk Parameter Range			
	$\delta=10^5$	$\delta=10^2$	$\delta=10^0$	$\delta=10^{-3}$
February---April				
Cross Hedge in World Market				
Rice futures	0.135	0.134	-0.013	-148.0
Wheat futures	-0.285	-0.296	-1.397	-1,112.0
Cross Hedge in Texas Market				
Rice futures	0.051	0.050	-0.097	-148.1
Wheat futures	0.666	0.655	-0.446	-1,111.0
May----------July				
Cross Hedge in World Market				
Rice futures	0.944	0.941	0.598	-345.5
Wheat futures	-0.661	-0.669	-1.469	-808.0
Cross Hedge in Texas Market				
Rice futures	0.945	0.942	0.599	-345.5
Wheat futures	-1.113	-1.121	-1.920	-808.5

With a risk minimization strategy ($\delta=10^5$), a hedge position larger than one (1.124) is taken in Texas rice market when cross hedged with rice futures and wheat futures. This means the short position in wheat futures contracts should be larger than the cash rice position in the Texas milled rice market in November through January, the after harvest season, even though the trader is highly risk averse. In May through October, wheat positions have negative signs (-1.508, -1.113), which suggests buying more wheat futures contracts than the size of the cash position when selling rice futures contracts initially. Hedge ratios for rice futures are a little less than one (0.968, 0.945) in those months for the cross hedging in Texas rice market. In the period February through April, however, the trader in Texas rice market sells a much smaller portion of rice contracts

(0.051) than of wheat contracts (0.666).

With a cash position in the world rice market, the trader takes short positions in rice futures ranging from 0.135 to 0.944, while positions in wheat futures range from positive (short) 0.416 to negative (long) 0.661. In February through July, the trader buys futures wheat contracts when selling futures contracts is the normal position.

The first column in the August-October period indicates that the trader should sell rice futures contracts equivalent to 57.7% of the given rice units size, and sell wheat futures contracts equivalent to 10.5% of that size in world rice market. In Texas rice market, the trader should sell rice futures contracts equivalent to 96.8% of the given rice units size, and buy wheat futures contracts equivalent to 150.8% of the given rice unit size.

Interestingly, when the risk aversion level decreases, the optimal hedge positions increase only in August through January, the period close to harvest. Some negative (long) positions become positive (short) as the risk aversion level decreases. However, in February through July, the optimal hedge positions decrease as the trader's risk aversion level decreases. Some positive (short) positions become negative (long), which is opposite to the normal circumstances. This reveals once again that the seasonal difference is very significant in hedging decisions.

Comparison of the Strategies

The best hedge strategy is identified in this section using the criteria of expected returns and variances of returns, maximized expected utilities, and certainty equivalents.

Comparison of Expected Returns and Variances of Returns

For a given level of mean income, traders will prefer the trade that has the lowest variance of income. Conversely, for a similar level of income variance, traders will prefer a higher return. Table 4.20 provides a summary of expected returns and variances of returns from optimal simple hedging at four risk aversion levels.

TABLE 4.20

EXPECTED RETURNS AND VARIANCES OF RETURNS FROM OPTIMAL SIMPLE HEDGING AT DIFFERENT RISK AVERSION LEVELS, 1986 - 93

Period		Risk Parameter Range 10^5		10^2		10^0		10^{-3}	
		Return	Var.	Return	Var.	Return	Var.	Return	Var.
Aug.-Oct.	World	0.692	0.813	0.694	0.813	0.803	0.924	111.7	110,982
	Texas	0.277	7.822	0.279	7.822	0.388	7.933	111.3	110,989
Nov.-Jan.	World	-0.381	1.861	-0.379	1.861	-0.190	2.052	190.8	191,204
	Texas	-0.361	11.255	-0.359	11.255	-0.170	11.446	190.8	191,213
Feb.-Apr.	World	0.042	0.798	0.047	0.798	0.530	1.287	488.3	488,277
	Texas	-0.246	1.443	-0.241	1.443	0.243	1.931	488.0	488,278
May-Jul.	World	-0.245	1.284	-0.244	1.284	-0.164	1.366	81.0	81,236
	Texas	0.751	2.252	0.752	2.252	0.832	2.333	82.0	81,237

Table 4.21 reports expected returns and variances of returns from optimal multiple hedging at different risk aversion levels. Similar to the results in Table 4.20, the lower the risk aversion level, the higher the expected return that may be obtained. In addition, the expected returns obtained from the world rice market and Texas rice market converge as the risk aversion parameter gets smaller.

Since the best strategy is identified using the criteria of expected return and variance of return simultaneously, using graphical analysis may be helpful to the comparison. The information in tables 4.20 and 4.21 will be used together with the report on expected returns and variances of returns from cash and futures activities in table 4.14 to built risk-return possibility curves for the trader in world rice market and Texas rice market in the four seasons.

TABLE 4.21

EXPECTED RETURNS AND VARIANCES OF RETURNS FROM OPTIMAL MULTIPLE HEDGING AT DIFFERENT RISK AVERSION LEVELS, 1986 - 93

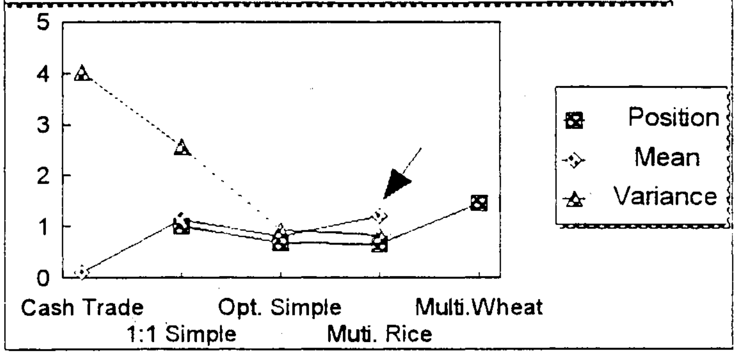
Period		Risk Parameter Range 10^5		10^2		10^0		10^{-3}	
		Return	Var.	Return	Var.	Return.	Var.	Return	Var.
Aug.-Oct.	World	0.726	0.781	0.731	0.778	1.195	0.822	469.8	420,436
	Texas	-0.209	8.084	-0.205	8.077	0.260	7.811	468.9	420,130
Nov.-Jan.	World	-0.303	1.929	-0.295	1.933	0.510	3.434	812.0	1169,502
	Texas	-0.150	11.274	-0.142	11.275	0.663	12.53	812.1	1169,263
Feb.-Apr.	World	0.125	0.821	0.130	0.822	0.611	1.272	486.1	301,939
	Texas	-0.440	1.373	-0.435	1.373	0.046	1.642	485.6	301,757
May-Jul.	World	-0.090	1.223	-0.088	1.224	0.152	1.519	242.4	219,592
	Texas	1.012	2.022	1.014	2.023	1.254	2.331	243.5	219,605

Assuming a risk parameter of 10^0, figure 4.1 provides a graphical comparison of mean return, variance of return, and hedge position for the four strategies (cash trade, direct hedge, optimal simple hedge, and optimal multiple hedge rice). Seasonal comparisons for both the world rice market and the Texas rice market are provided in Figures 4.2 through 4.8.

World Market in August-October

	Position	Mean	Variance
Cash Trade		0.096	4.016
1:1 Simple	1	1.134	2.572
Opt. Simple	0.682	0.803	0.924
Muti. Rice	0.646	1.195	0.822
Multi.Wheat	1.448		

Figure 4.1. Risk-Return Possibility Curve for World Rice Market in Aug.-Oct., 1986-93

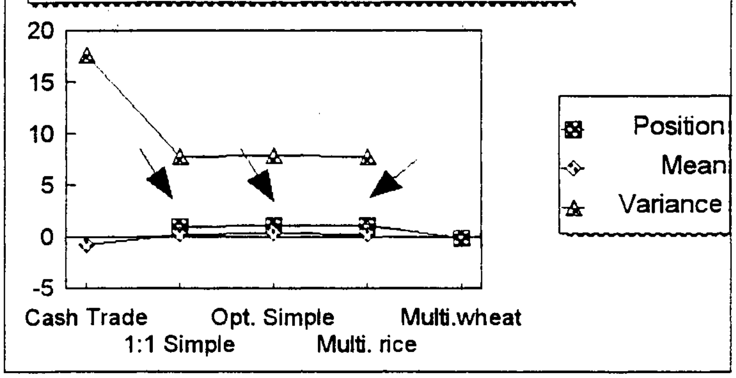


In this period, the strategy of multiple hedging obtained highest mean income, and lowest variance of income in world rice market.

Texas Market in August-October

	Position	Mean	Variance
Cash Trade		-0.766	17.637
1:1 Simple	1	0.271	7.812
Opt. Simple	1.113	0.388	7.933
Multi. rice	1.036	0.26	7.811
Multi.wheat	-0.166		

Figure 4.2. Risk-Return Possibility Curve for Texas Rice Market in Aug.-Oct, 1986-93

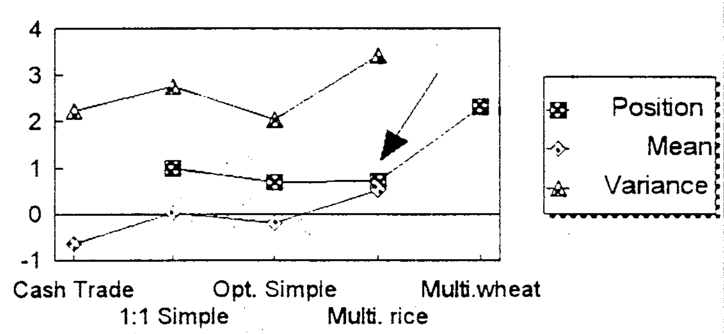


In this period, the strategies of full hedge, optimal simple hedge, and multiple hedge are superior to cash trade with higher income, and lower variance of income.

World Market in November-January

	Position	Mean	Variance
Cash Trade		-0.645	2.226
1:1 Simple	1	0.03	2.744
Opt. Simple	0.675	-0.19	2.052
Multi. rice	0.714	0.51	3.434
Multi.wheat	2.324		

Figure 4.3. Risk-Return Possibility Curve for World Rice Market in Nov.-Jan., 1986-93

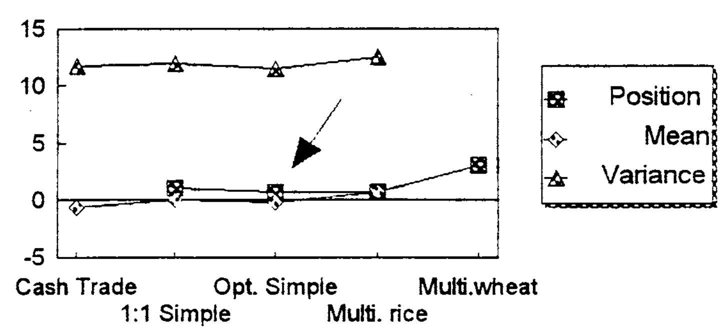


In this period, multiple hedge strategy achieved highest mean income, however, with highest variance of income.

Texas Market in November-January

	Position	Mean	Variance
Cash Trade		-0.671	11.759
1:1 Simple	1	0.004	11.954
Opt. Simple	0.743	-0.17	11.446
Multi. rice	0.676	0.663	12.53
Multi.wheat	3.032		

Figure 4.4. Risk-Return Possibility Curve for Texas Rice Market in Nov.-Jan., 1986-93

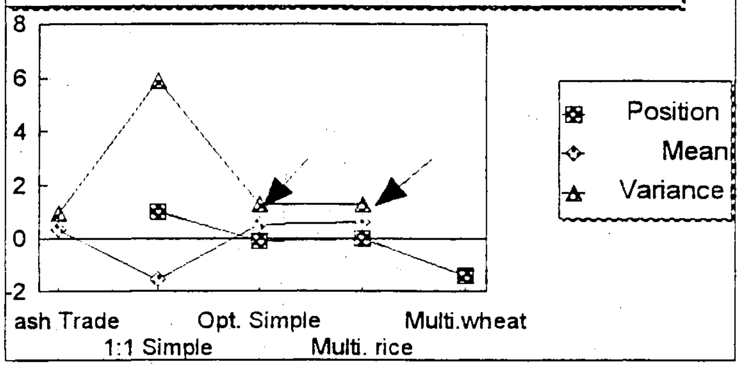


In this period, simple hedge strategy is superior to multiple hedge strategy with lower variance of income.

World Market in February-April

	Position	Mean	Variance
Cash Trade		0.323	0.96
1:1 Simple	1	-1.534	5.887
Opt. Simple	-0.112	0.53	1.287
Multi. rice	-0.013	0.611	1.272
Multi.wheat	-1.397		

Figure 4.5. Risk-Return Possibility Curve
for World Rice Market in Feb.-Apr., 1986-93

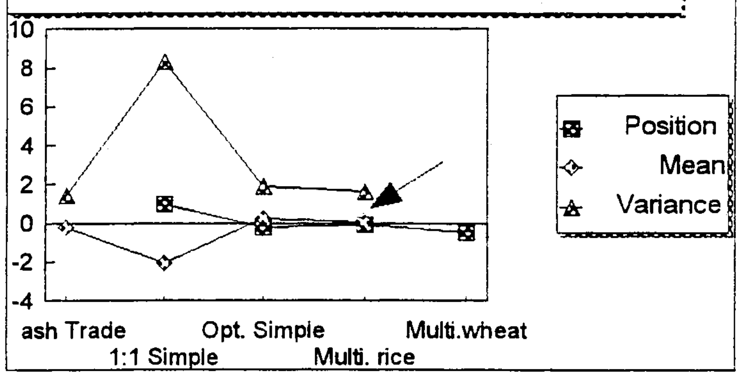


In this period, Multiple hedge and optimal simple hedge are superior to cash trade and 1:1 naive hedge.

Texas Market in February-April

	Position	Mean	Variance
Cash Trade		-0.219	1.444
1:1 Simple	1	-2.076	8.303
Opt. Simple	-0.248	0.243	1.931
Multi. rice	-0.097	0.046	1.642
Multi.wheat	-0.446		

Figure 4.6. Risk-Return Possibility Curve
for Texas Rice Market in Feb.-Apr., 1986-93

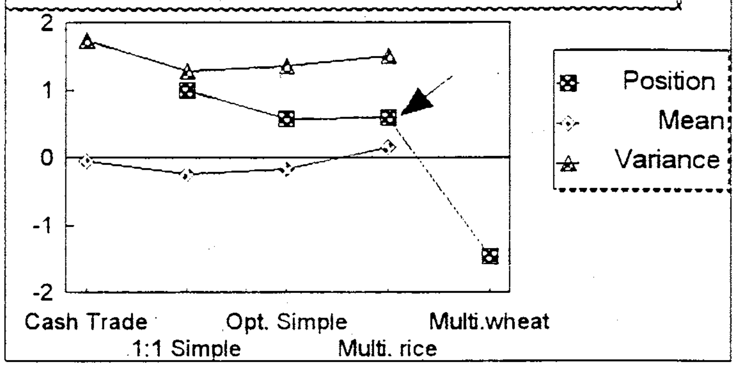


In this period, although multiple hedging achived lower variance of income than optimal simple hedging, its mean income is also lower. However, both strategies are superior to cash trade and 1:1 naive hedge strategy in higher income.

World Market in May-July

	Position	Mean	Variance
Cash Trade		-0.054	1.736
1:1 Simple	1	-0.245	1.284
Opt. Simple	0.576	-0.164	1.366
Multi. rice	0.598	0.152	1.519
Multi.wheat	-1.469		

Figure 4.7. Risk-Return Possibility Curve
for World Rice Market in May-Jul., 1986-93

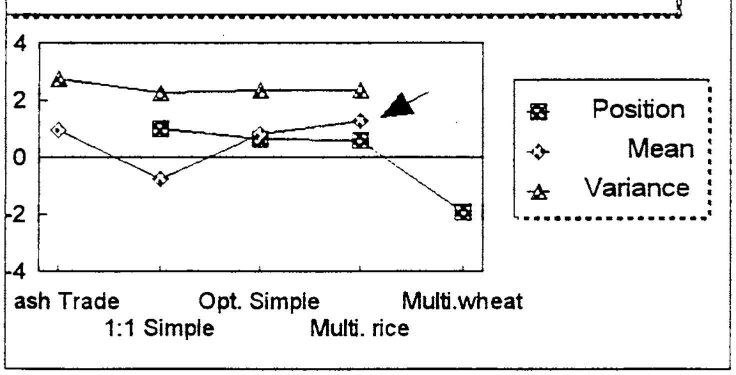


In this period, multiple hedging rice and wheat is superior to simple hedging rice by much higher mean income, although with a little higher variance of income.

Texas Market in May-July

	Position	Mean	Variance
Cash Trade		0.95	2.739
1:1 Simple	1	-0.759	2.252
Opt. Simple	0.616	0.832	2.333
Multi. rice	0.599	1.254	2.331
Multi.wheat	-1.92		

Figure 4.8. Risk-Return Possibility Curve
for Texas Rice Market in May-Jul., 1986-93



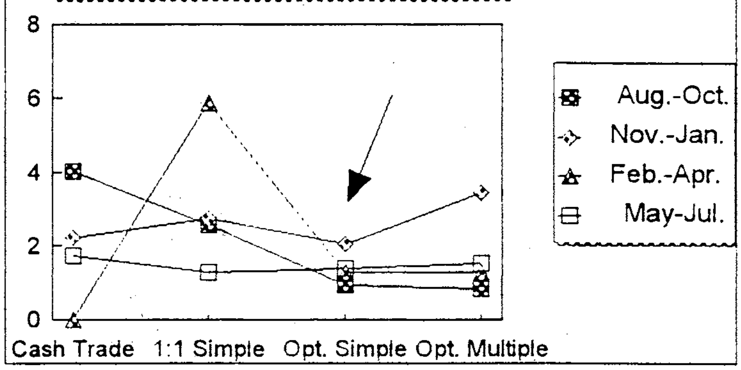
In this period, multiple hedging rice and wheat achieved highest mean income among all the strategies, while the variance levels are similar to each other.

Which marketing strategy is best varies depending on the season. The hedging strategy superior to others in November-January may be inferior to others in August-October. To check if there is any strategy which is superior all the year round, figure 4.9 through 4.12 provide visual comparisons in the criteria of seasonal variances and seasonal expected returns.

Comparison of Seasonal Variances in World Market

	Aug.-Oct.	Nov.-Jan.	Feb.-Apr.	May-Jul.
Cash Trade	4.016	2.226	0.960	1.736
1:1 Simple	2.572	2.744	5.887	1.284
Opt. Simple	0.924	2.052	1.287	1.366
Opt. Multiple	0.822	3.434	1.272	1.519

Figure 4.9 Comparison of Seasonal Variances in World Rice Market

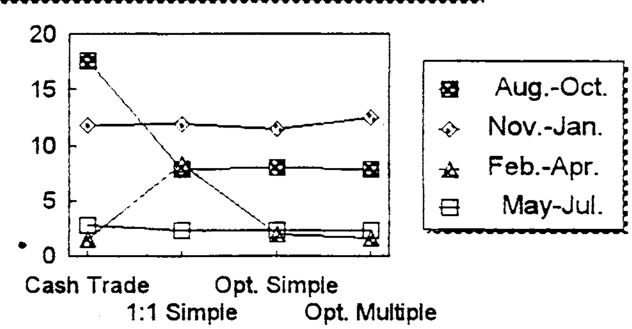


In world rice market, variances for optimal simple hedging has lowest seasonal difference, followed by multiple hedging.

Comparison of Seasonal Variances in Texas Market

	Aug.-Oct.	Nov.-Jan.	Feb.-Apr.	May-Jul.
Cash Trade	17.637	11.759	1.444	2.739
1:1 Simple	7.812	11.954	8.303	2.252
Opt. Simple	7.933	11.446	1.931	2.333
Opt. Multiple	7.811	12.53	1.642	2.331

Figure 4.10. Comparison of Seasonal Variances in Texas Rice Market

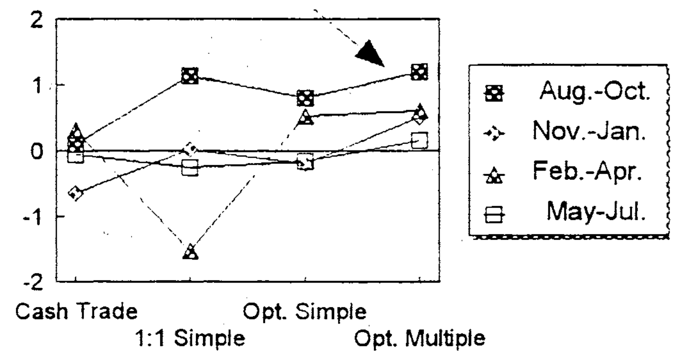


Variance in any hedging scenario is high in November-January, followed by variance in August-October. It suggests that risk is higher in harvest seasons (including Asian second harvest season).

Comparison of Seasonal Expected Returns in World Market

	Aug.-Oct.	Nov.-Jan.	Feb.-Apr.	May-Jul.
Cash Trade	0.096	-0.645	0.323	-0.054
1:1 Simple	1.134	0.03	-1.534	-0.245
Opt. Simple	0.803	-0.19	0.53	-0.164
Opt. Multiple	1.195	0.51	0.611	0.152

Figure 4.11. Comparison of Seasonal Expected Returns in World Rice Market

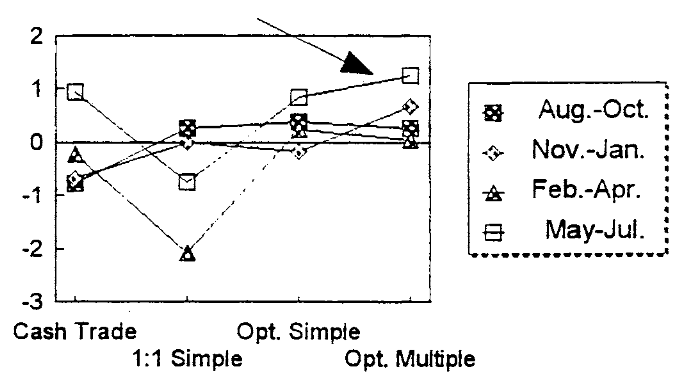


In world rice market, August-October season offers largest hope to achieve higher returns.

Comparison of Seasonal Expected Returns in Texas Market

	Aug.-Oct.	Nov.-Jan.	Feb.-Apr.	May-Jul.
Cash Trade	-0.766	-0.671	-0.219	0.95
1:1 Simple	0.271	0.004	-2.076	-0.759
Opt. Simple	0.388	-0.17	0.243	0.832
Opt. Multiple	0.26	0.663	0.046	1.254

Figure 4.12. Comparison of Seasonal Expected Returns in Texas Rice Market



In Texas rice market, May-July season offers largest hope to achieve higher returns.

Figures 4.13 through 4.20 focus the visual comparison on just two strategies: optimal simple hedging and optimal multiple hedging. Risk-return possibility curves are drawn only for the hedging scenarios where Arrow-Pratt coefficient of absolute risk aversion equals 10^5, 10^2, and 10^0, since Arrow-Pratt risk coefficient equals to 10^{-3} will produce too large difference in the scale, and is inappropriate for graphical comparison here. The curves are drawn in exponential or linear regression lines, for all four seasons, and for both the world rice market and the Texas rice market.

The observation from the graphs is clear: no hedging strategy can claim itself as best in all the year round. The superiority of strategy varies depending on season. In the world rice market, optimal multiple hedging is superior to optimal simple hedging in three of the four periods, except for November-January period, which is the season right after the second Asian harvest season. In the Texas rice market, however, the superiority of optimal multiple hedging can be seen only in the May-July season, which is the season right before rice harvest.

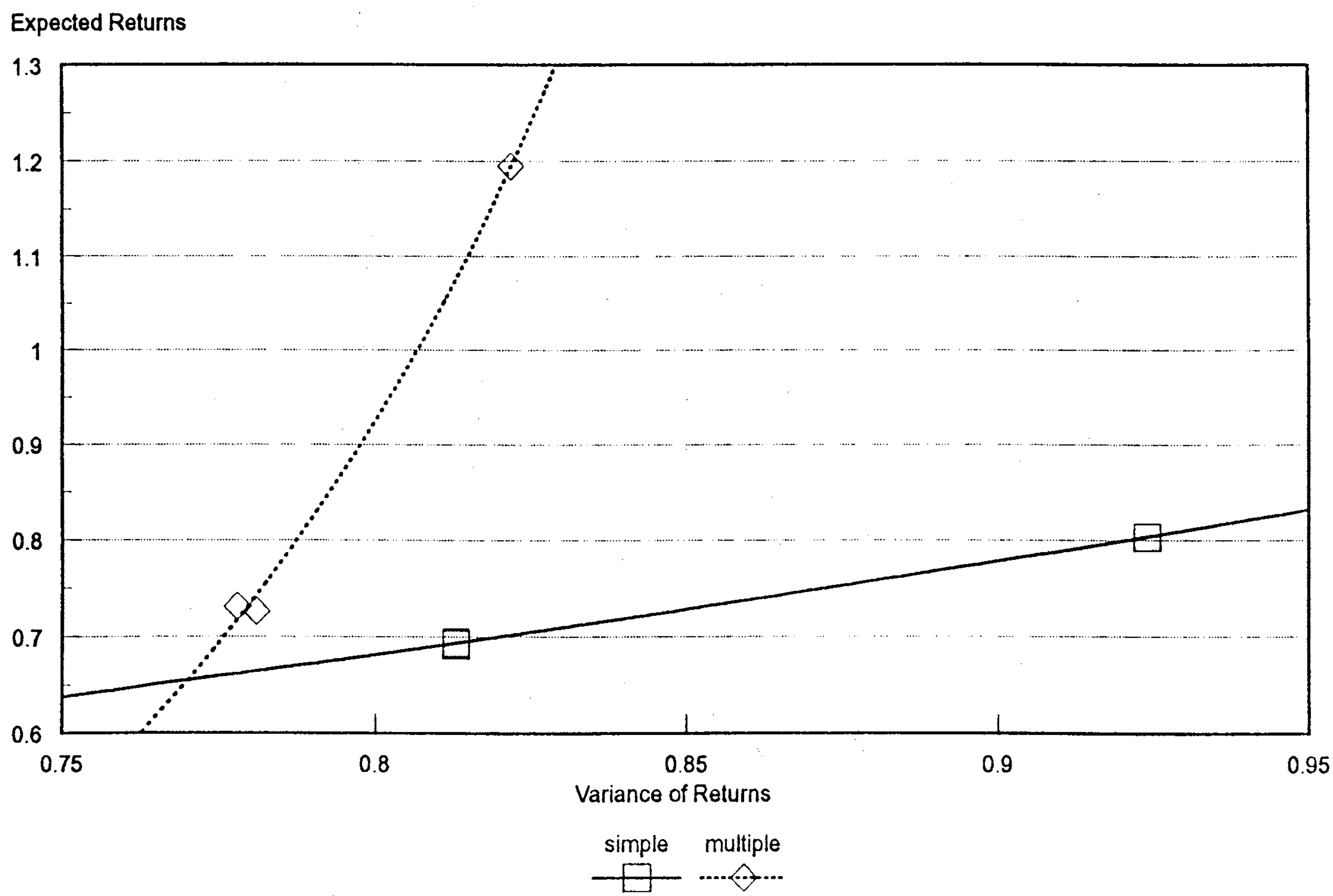


Figure 4.13. Risk-Return Possibility Curve for Simple and Multiple Hedging in World Market in Aug.-Oct., 1986-93, for Different Arrow-Pratt Coefficients

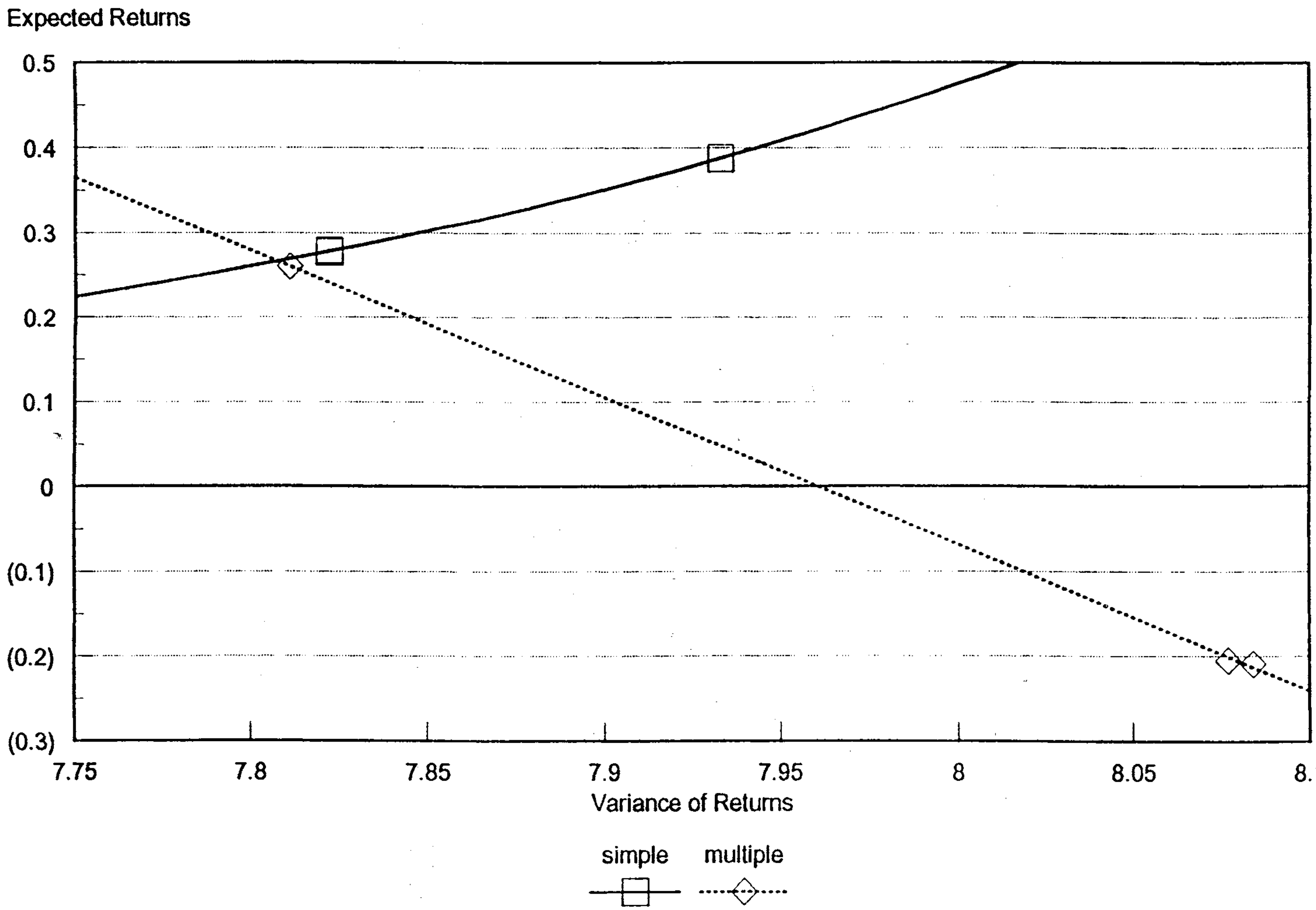


Figure 4.14. Risk-Return Possibility Curve for Simple and Multiple Hedging in Texas Market in Aug.-Oct., 1986-93, for Different Arrow-Pratt Coefficients

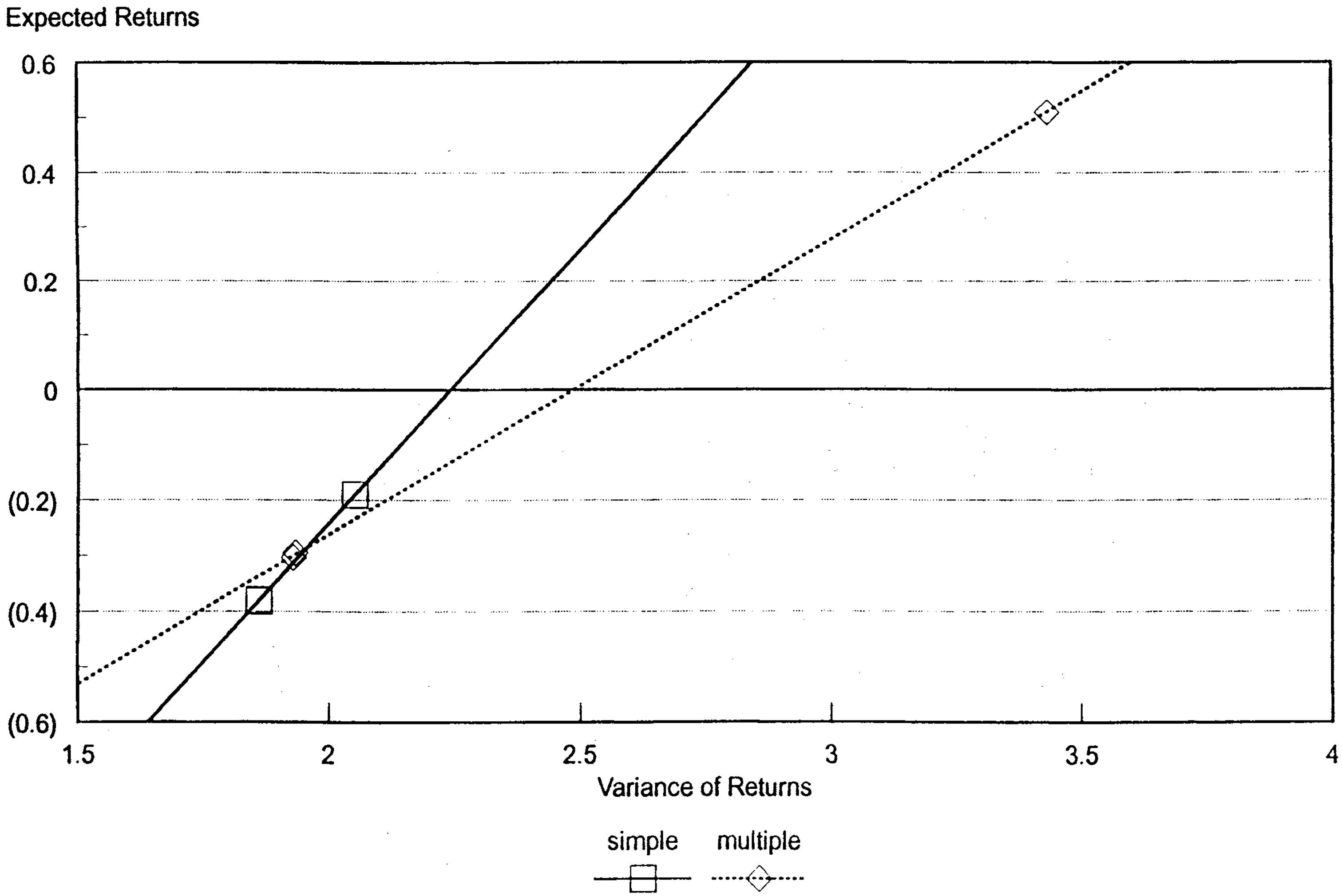


Figure 4.15. Risk-Return Possibility Curve for Simple andMultiple Hedging in World Market in Nov.-Jan., 1986-93, for Different Arrow-Pratt Coefficients

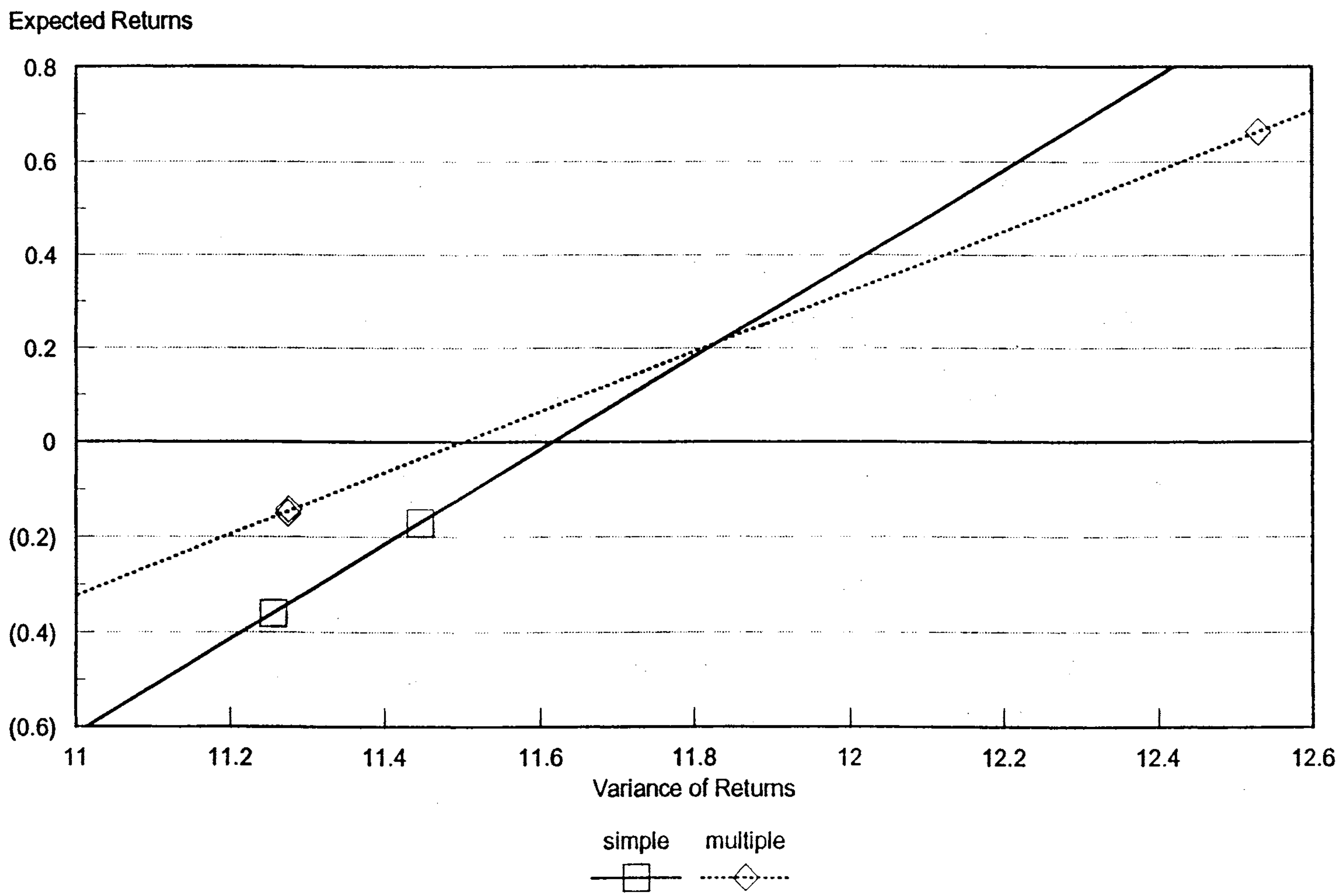


Figure 4.16. Risk-Return Possibility Curve for Simple and Multiple Hedging in Texas Market in Nov.-Jan.,1986-93, for Different Arrow-Pratt Coefficients

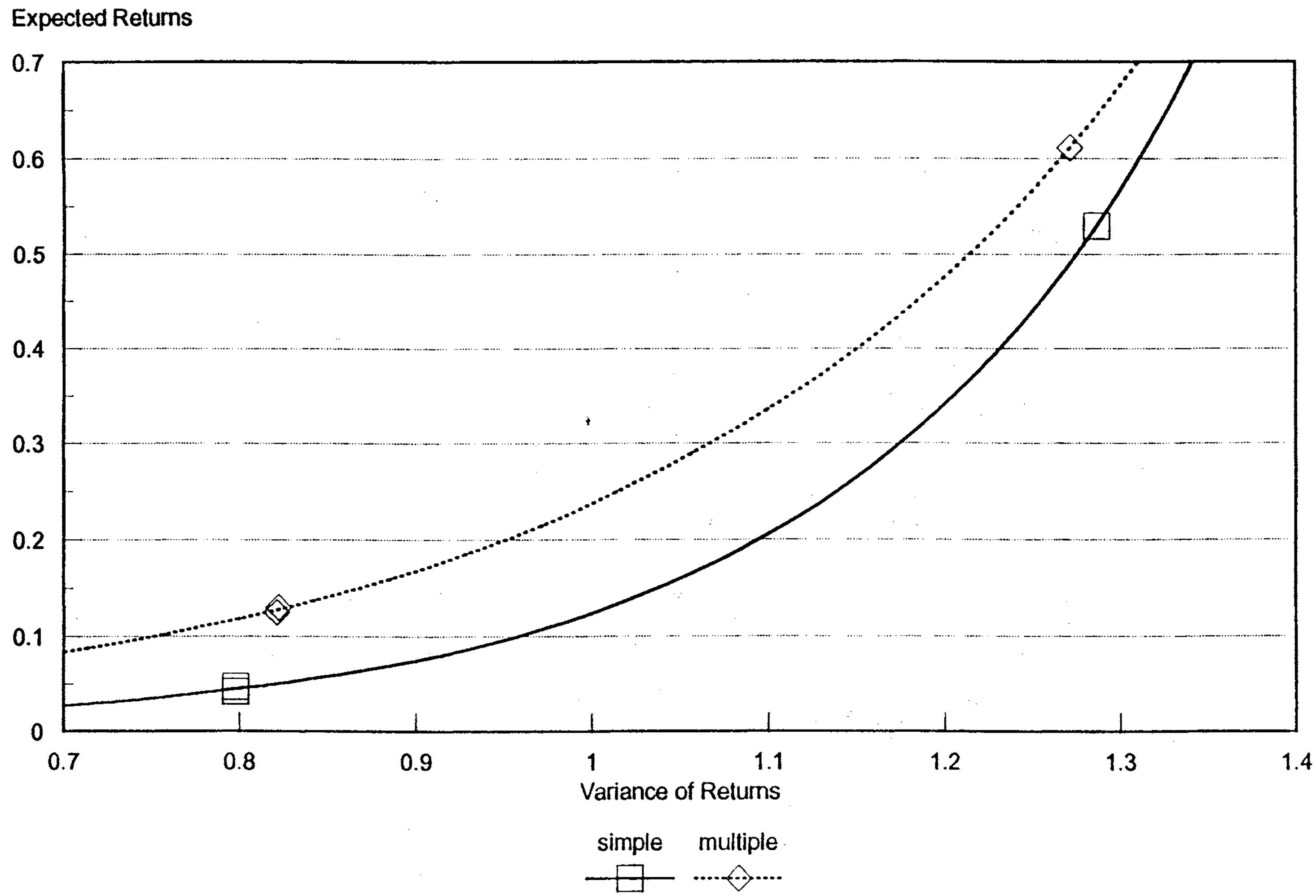


Figure 4.17. Risk-Return Possibility Curve for Simple and Multiple Hedging in World Market in Feb.-Apr., 1986-93, for Different Arrow-Pratt Coefficients

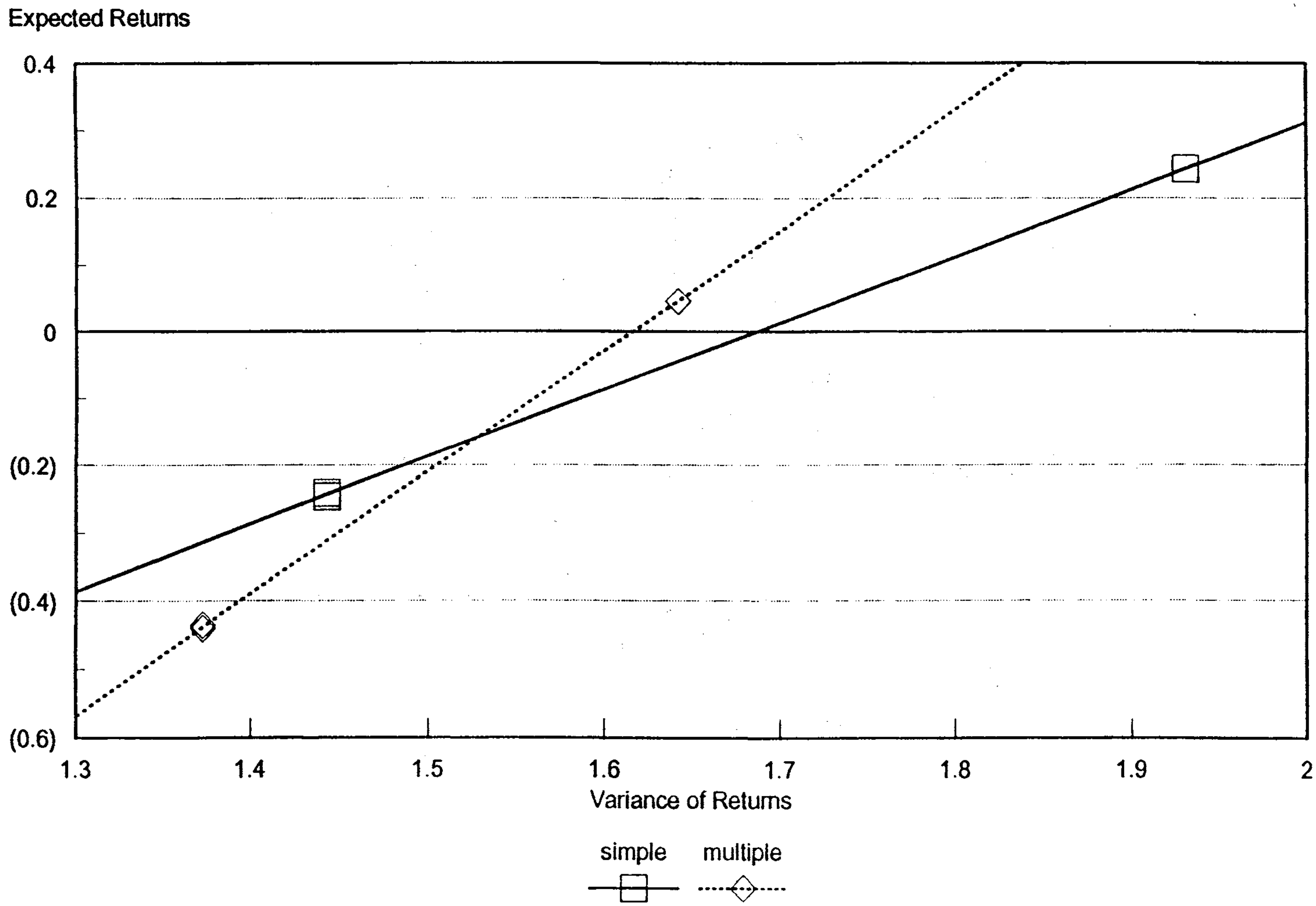


Figure 4.18. Risk-Return Possibility Curve for Simple and Multiple Hedgin in Texas Market in Feb.-Apr., 1986-93, for Different Arrow-Pratt Coefficients

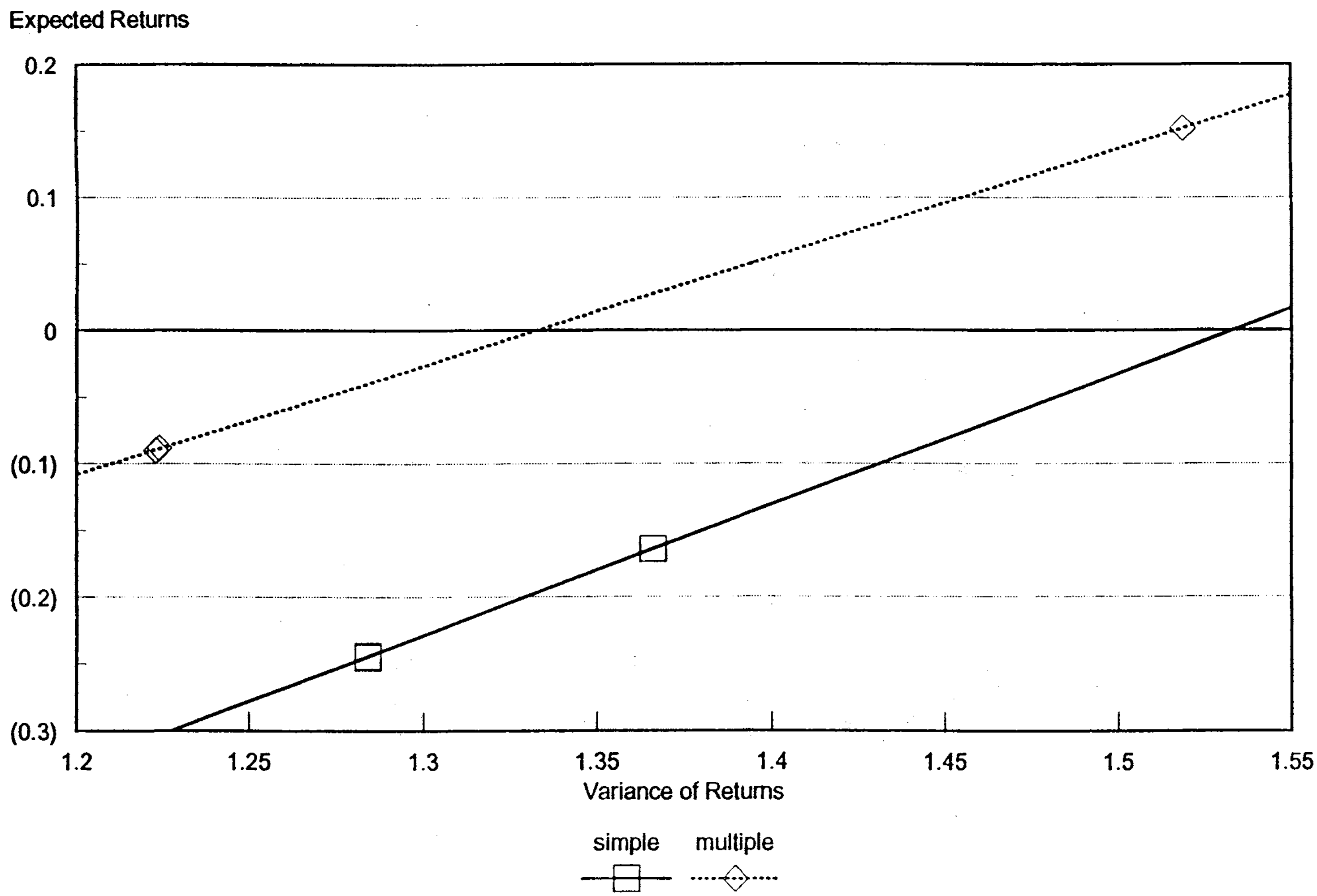


Figure 4. 19. Risk-Return Possibility Curve for Simple and Multiple Hedging in World Market in May-Jul., 1986-93, for Different Arrow-Pratt Coefficients

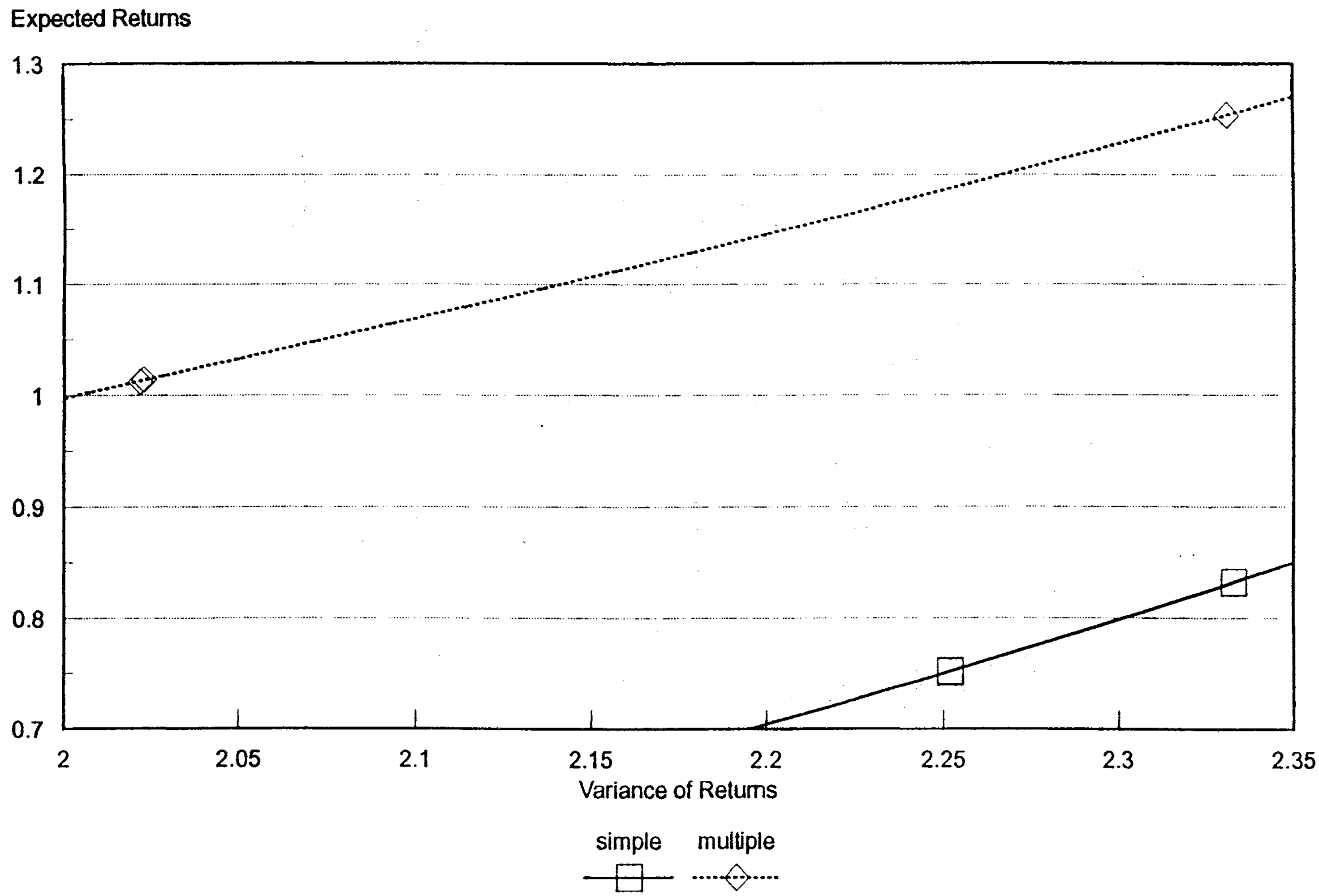


Figure 4.20. Risk-Return Possibility Curve for Simple and Multiple Hedging in Texas Market in May-Jul., 1986-93, for Different Arrow-Pratt Coefficients

Comparison of Expected Utilities

For a given level of risk aversion and hedge ratios, traders will prefer the trade that has the highest expected utilities. Table 4.22 provides a comparison for maximized expected utilities for simple hedge and multiple hedge at certain hedge ratios, assuming risk parameter equals to 10^0.

TABLE 4.22

MAXIMIZED EXPECTED UTILITIES AT SELECTED HEDGE RATIOS, ASSUMING RISK PARAMETER $\delta = 10^0$, 1986 - 93

			WOL-RFP	TXL-RFP	WOL-WFP	TXL-WFP
Simple Hedge	H=0.5	Aug.-Oct.	0.181	-5.400	-1.707	-9.500
		Nov.-Jan.	-1.252	-5.963	-1.653	-6.360
		Feb.-Apr.	-1.435	-2.701	-0.258	-1.001
		May-Jul.	-0.848	-0.337	-1.128	-0.684
	H=1	Aug.-Oct.	-0.150	-3.640	-1.555	-9.467
		Nov.-Jan.	-1.341	-5.971	-1.605	-6.225
		Feb.-Apr.	-4.478	-6.227	-0.387	-1.091
		May-Jul.	-0.887	-0.368	-1.398	-1.011

			WOL-RF,WF	TXL-RF,WF
Multiple Hedge	H_r=0.5,H_w=0.5	Aug.-Oct.	0.386	-5.315
		Nov.-Jan.	-1.147	-5.772
		Feb.-Apr.	-1.535	-2.761
		May-Jul.	-1.055	-0.601
	H_r=1, H_w=1	Aug.-Oct.	0.207	-3.522
		Nov.-Jan.	-1.189	-5.646
		Feb.-Apr.	-4.708	-6.377
		May-Jul.	-1.364	-0.959

If the trader simply uses the rice futures market and takes a fully hedged position, H =1, his maximized expected utility in world cash rice market is -0.15, -1.341, -4.478, and -0.887, respectively, for the four seasons from August through July. If the trader simply uses wheat futures market and takes a full hedged position, his maximized expected utility in world cash rice market is -1.555, -1.605, -0.387, and -1.398 respectively for the four seasons from August through July. Among them, the expected utility from using wheat futures (-0.387) in the period February through April is higher than that from using rice futures (-4.478). In the Texas rice market, the expected utility from using wheat futures (-1.091) in the period February through April is also higher than that from using rice futures (-6.227). In this season, the expected utility from using wheat futures is higher than that from using rice futures (-0.258 vs. -1.435, 1.001 vs. -2.701) when the trader changed his hedge position to 0.5, regardless of whether the world market rice price or Texas rice price was used.

If the trader utilizes both CBOT rice and wheat futures markets and cross hedges his cash rice by equally dividing his position to rice and wheat contracts, that is $H_r = 0.5$ and $H_w = 0.5$, his maximized expected utility in world cash rice market is 0.386, -1.147, -1.535, and -1.055 respectively for the four seasons from August through July, and is -5.315, -5.772, -2.761 and -0.601 respectively in Texas rice market. The trader's expected utility increases in most of the season except for May-July when he multiple hedges, compared with the expected utility from simple hedge with rice futures. The trader's expected utility also increases in most of the season except for February-April when he multiple hedges, compared with the expected utility from simple hedge with wheat futures.

Observations drawn from the table 4.22 are: 1) Hedger can increase his maximized expected utility by utilizing CBOT wheat futures instead of using rice futures in some specific season; 2) hedger can further increase his maximized expected utility by multiple hedging in most of the season of a crop year.

Comparison of Certainty Equivalents

To compare the differences among strategy outcomes, certainty equivalent (CE) is a method to exhibit the differences in risk-adjusted money terms (Adam, Garcia, and Hauser, 1993). Table 4.23 through 4.25 summarized the certainty equivalents from spot trade, simple hedging and multiple hedging at different Arrow-Pratt coefficient of absolute risk aversion level by using specified utility function (1) through (7), assuming the model is maximized.

TABLE 4.23

CERTAINTY EQUIVALENTS FROM NO HEDGING AT DIFFERENT RISK AVERSION LEVEL, 1986 - 93

	$\delta=10^5$	$\delta=10^2$	$\delta=10^0$	$\delta=10^{-3}$
Aug.-Oct.				
World	-200,799	-200.702	-1.912	0.094
Texas	-881,843	-882.609	-9.585	-0.775
Nov.-Jan				
World	-111,282	-111.926	-1.758	-0.646
Texas	-587,921	-588.592	-6.550	-0.677
Feb.-Apr.				
World	-47,984	-47.662	-0.157	0.322
Texas	-72,217	-72.435	-0.941	-0.219
May-Jul.				
World	-86,790	-86.844	-0.922	-0.055
Texas	-136,968	-136.019	-0.420	0.949

Period		Risk Parameter Range											
		10^{5}			10^{0}			10^{-3}					
		CE	E(Y)	V(Y)	CE	E(Y)	V(Y)	CE	E(Y)	V(Y)	CE	E(Y)	V(Y)
Aug.-Oct.	Rice futures												
	World	-40,671	0.692	0.813	-40.0	0.694	0.813	0.3	0.803	0.924	56.2	111.7	110.982
	Texas	-391,083	0.277	7.822	-390.8	0.279	7.822	-3.6	0.388	7.933	55.8	111.3	110.989
	Wheat futures												
	World	-194,292			-194.0			-1.4			211.4		
	Texas	-880,502			-881.4			-9.5			210.2		
Nov.-Jan.	Rice futures												
	World	-93,028	-0.381	1.861	-93.4	-0.379	1.861	-1.2	-0.190	2.052	95.2	190.8	191.204
	Texas	-562,729	-0.361	11.255	-563.1	-0.359	11.255	-5.9	-0.170	11.446	95.2	190.8	191,213
	Wheat futures												
	World	-111,146			-111.8			-1.6			186.3		
	Texas	-583,052			-583.5			-6.1			186.5		
Feb.-Apr.	Rice futures												
	World	-39,918	0.042	0.798	-39.9	0.047	0.798	-0.1	0.530	1.287	244.2	488.3	488,277
	Texas	-72,143	-0.246	1.443	-72.4	-0.241	1.443	-0.7	0.243	1.931	243.9	488.0	488,278
	Wheat futures												
	World	-47,833			-47.5			-0.04			151.8		
	Texas	-68,092			-68.5			-0.9			151.1		
May--July	Rice futures												
	World	-64,216	-0.245	1.284	-64.5	-0.244	1.284	-0.8	-0.164	1.366	40.4	81.0	81,236
	Texas	-112,576	0.751	2.252	-111.8	0.752	2.252	-0.3	0.832	2.333	41.4	82.0	81,237
	Wheat futures												
	World	-83,387			-83.3			-0.7			93.9		
	Texas	-125,048			-123.9			0.005			95.0		

Note: 1) Cash Short initial, futures long initial.
2) Expected returns and variances of returns for simple hedging using rice futures only.

TABLE 4.24 CERTAINTY EQUIVALENTS FROM OPTIMAL SIMPLE HEDGING AT DIFFERENT RISK AVERSION LEVEL, 1986 - 93

Period	Risk Parameter Range											
	10^5			10^2			10^0			10^{-3}		
	CE	E(Y)	V(Y)	CE	E(Y)	V(Y)	CE	E(Y)	V(Y)	CE	E(Y)	V(Y)
Aug.-Oct.												
World Market	-39061	0.726	0.781	-38.1	0.731	0.778	0.8	1.195	0.822	259.6	469.8	420,436
Texas Market	-404203	-0.209	8.084	-404.1	-0.205	8.077	-3.6	0.260	7.811	258.8	468.9	420,130
Nov.-Jan												
World Market	-96464	-0.303	1.929	-96.9	-0.295	1.933	-1.2	0.510	3.434	227.2	812.0	1169,502
Texas Market	-563700	-0.15	11.27	-563.9	-0.142	11.28	-5.6	0.663	12.53	227.5	812.1	1169.263
Feb.-Apr.												
World Market	-41025	0.125	0.821	-40.9	0.130	0.822	-0.03	0.611	1.272	335.2	486.1	301,939
Texas Market	-68660	-0.44	1.373	-69.1	-0.435	1.373	-0.8	0.046	1.642	334.7	485.6	301,757
May-Jul.												
World Market	-61147	-0.09	1.223	-61.3	-0.088	1.224	-0.6	0.152	1.519	132.6	242.4	219,592
Texas Market	-101122	1.012	2.022	-100.2	1.014	2.023	0.09	1.254	2.331	133.7	243.5	219,605

TABLE 4.25 CERTAINTY EQUIVALENTS FROM OPTIMAL MULTIPLE HEDGING AT DIFFERENT RISK AVERSION LEVEL, 1986 - 93

Table 4.26 put the calculated certainty equivalents from no hedging and optimal hedging scenarios together and table 4.27 put the calculated certainty equivalents from optimal simple hedging and optimal multiple hedging scenarios together for the convenience of comparison.

The conclusion from table 4.26 and table 4.27 is straightforward: 1) Optimal simple hedging is superior to no hedging in all seasons for all Arrow-Pratt coefficient of absolute risk aversion levels; 2) Optimal multiple hedging is also superior to no hedging in all seasons for all Arrow-Pratt coefficient of absolute risk aversion levels; 3), Which is better strategy between optimal multiple hedging and optimal simple hedging for rice trade depends on the season and the market the hedge is taken. For example, the trader can expect to gain $0.1/cwt in Texas market in May-July at Arrow-Pratt coefficient 10^0 if he use optimal multiple hedging, and that is higher than if he use optimal simple hedging (-0.3). However, the outcome will be reversed if he hedge in February-April, even though he hedges in the same market and at same risk aversion level.

TABLE 4.26

CERTAINTY EQUIVALENTS FROM NO HEDGING AND OPTIMAL SIMPLE HEDGING AT DIFFERENT RISK AVERSION LEVEL, 1986 - 93

	10^5		10^2		10^0		10^{-3}	
	no	simple	no	simple	no	simple	no	simple
Aug.-Oct.								
World	-200,799	-40,671	-200.7	-40.0	-1.9	0.3	0.1	56.2
Texas	-881,843	-391,083	-882.6	-390.8	-9.6	-3.5	-0.8	55.8
Nov.-Jan								
World	-111,282	-93,028	-111.9	-93.4	-1.8	-1.215	-0.6	95.2
Texas	-58,7921	-562,729	-588.6	-563.1	-6.6	-5.893	-0.7	95.2
Feb.-Apr.								
World	-47,984	-39,918	-47.7	-39.9	-0.2	-0.1	0.3	244.2
Texas	-72,217	-72,143	-72.4	-72.4	-0.9	-0.7	-0.2	243.9
May-Jul.								
World	-86,790	-64,216	-86.8	-64.5	-0.9	-0.8	-0.1	40.4
Texas	-136,968	-112,576	-136.0	-111.8	-0.4	-0.3	0.9	41.4

TABLE 4.27

CERTAINTY EQUIVALENTS FROM NO HEDGING AND OPTIMAL MULTIPLE HEDGING AT DIFFERENT RISK AVERSION LEVEL, 1986 - 93

	10^5		10^2		10^0		10^{-3}	
	no	multi	no	multi	no	multi	no	multi
Aug.-Oct.								
World	-200,799	-39,061	-200.7	-38.1	-1.9	0.8	0.1	259.6
Texas	-881,843	-404,203	-882.6	-404.1	-9.6	-3.6	-0.8	258.8
Nov.-Jan								
World	-111,282	-96,464	-111.9	-96.9	-1.8	-1.2	-0.6	227.2
Texas	-58,7921	-563,700	-588.6	-563.9	-6.6	-5.6	-0.7	227.5
Feb.-Apr.								
World	-47,984	-41,025	-47.7	-40.9	-0.2	-0.03	0.3	335.2
Texas	-72,217	-68,660	-72.4	-69.1	-0.9	-0.8	-0.2	334.7
May-Jul.								
World	-86,790	-61,147	-86.8	-61.3	-0.9	-0.6	-0.1	132.6
Texas	-136,968	-101,122	-136.0	-100.2	-0.4	0.1	0.9	133.7

Summary

This chapter provided the results of rice and wheat cash and futures markets investigation. In harvest season, CBOT rough rice futures price changes are more closely related to milled rice cash price changes in Thailand and in world market than they are with milled rice cash price changes in California and Texas. After harvest, The Texas and California milled rice price changes exhibit much higher correlation with March rice futures prices than with November rice futures prices.

Although the months of lowest and highest prices are almost the same for rice and wheat, the direction of wheat price movement is different from that of rice after August. Noticeably, all the U.S. and world rice cash prices changes are more closely related with wheat futures price changes than with CBOT rough rice futures price changes in the August-September period using the November rice futures contract and the December wheat contract.

Thus, same types of rice cash price changes are more closely related with CBOT wheat futures price changes than with CBOT rice futures price changes in certain time periods. Since CBOT wheat futures prices are correlated with milled rice cash prices, some wheat futures contracts can serve as hedging instruments for rice cash prices.

However, there are regional differences among the cash rice price changes in relative with CBOT rice or wheat futures price changes. The influence of the second Asian rice harvest was stronger on world rice price than on the Texas and New Orleans rice prices.

This chapter has also presented the results of various marketing strategies based upon the rice and wheat hedging simulation used in this study. Expected returns and variance of returns, maximized expected utility, and certainty equivalent criteria are used in comparing each strategies at different risk aversion level. Cash trade is a strategy of complete exposure to price risk, and results in either large losses or large profits due to high variances of returns. The variance of returns is smaller in the world rice market and in the wheat futures market than in the Texas rice market. The amount of risk eliminated by direct hedging varies from season to season and from commodity to commodity.

Since returns from certain rice markets are closely related with those of wheat futures returns in some months, the wheat futures market can offer higher risk-adjusted revenue to hedgers in seasons when the rice futures market fails to provide hedgers with satisfactory returns. That is, a hedger can increase his expected utility by utilizing CBOT wheat futures instead of using rice futures in certain seasons.

Optimal simple hedging and optimal multiple hedging are superior to a no-hedging strategy and a direct-hedging strategy. Using an optimal multiple hedging strategy is likely to have more opportunity to achieve higher expected utility. However, comparisons in this chapter reveal that the seasonal difference is very significant in hedging decisions. Which strategy is the better strategy between the two hedging strategies depends on the season and the market in which the hedge is taken. No strategy is best in all seasons. Accurate hedge design in hedge position, season, market and strategy can increase expected utility by a significant amount.

CHAPTER V

SUMMARY AND IMPLICATIONS

The first two sections of this chapter restate the rationale, objectives, and methods used to implement the analysis. A brief summary of the findings about rice and wheat hedging and a discussion of the implications of the strategies are presented in the next two sections. The final section presents concluding comments.

The Rationale of This Study

Rice and wheat are the most important food grains in almost all Asian countries. More than 90% of the world's rice production and consumption occurs in Asia. But, rice and wheat also make up the highest volume of agricultural products imported from outside the region. Since the early 1980s, Asia has been the largest regional market for U.S. agricultural products, including rice and wheat. Because of the increasing food demand of Asia and the need to stabilize food supply in Asia, analyzing alternative rice and wheat marketing approaches has economic and political significance.

However, the world rice market is thin in relation to world production and compared with the world wheat market. High price volatility results in high search cost in world rice markets. How food grain traders can utilize alternative hedging strategies to enhance returns and reduce risks in trade with Asian countries, where exports and imports are exposed to substantial price and exchange rate instability, is a concern of many international agencies as well as private companies.

The purpose of this study was to identify risk management strategies for firms that conduct trade in rice and wheat with Asian countries. The specific objectives were: 1). To measure the price uncertainty perceived by exporters and importers of rice and wheat; 2). To develop a hedging model to generate expected utility maximizing hedging strategies for multiple commodities; and 3). To use the model to identify practical strategies that will enhance risk-adjusted returns to traders.

Methods Used in This Study

This study models a rice trader in Asia who would like to buy a given quality and quantity of rice as cheaply as possible, or to sell a given quality and quantity of rice at a price as high as possible. Since risk is also a consideration, the trader is assumed to maximize expected utility. Rice futures markets would be the logical market to hedge purchases or sales of rice. However, the rice futures markets are not heavily traded, and thus may have relatively high transaction costs. As a result, traders, especially large ones, may wish to consider cross-hedging a portion of their anticipated purchases or sales on the CBOT soft red winter wheat market or the KCBT hard red winter wheat market.

Three types of analytical tools were used to conduct the analysis: descriptive, theoretical, and empirical. This study investigated price movements in several cash and futures markets for rice and wheat, identified the characteristics of rice and wheat marketing activities, and evaluated the potential for using the wheat futures market as a cross hedge for rice trade. First, cash price movements were analyzed graphically and statistically. A dummy variable technique was used to test seasonality of cash prices. Second, trade volume and annualized price volatility were examined for futures prices. The correlation level of futures prices with cash prices was measured. Third, basis patterns were compared each other and the degree of market integration was provided.

The theoretical framework for this study drew from Bernoulli's principle, or expected utility theory and efficient portfolio theory (Johnson, 1960; Stein, 1961). Based on the information from the market investigation, an expected utility model was specified for alternative strategies for rice and wheat trade. Four strategies were evaluated: cash rice trade, hedging rice utilizing the rice futures market, hedging rice utilizing the wheat futures market, and hedging rice using both the rice and wheat futures markets. Crop years were divided into four trading periods: August-October, November-January, February-April, and May-July. Given a set of efficient strategies, the acceptability of any particular strategy to a trader or trading agency depends on the firm's preferences among various expected income and associated variance levels. Practical strategies that would have enhanced risk-adjusted returns to traders were identified.

Summary of Results

Seasonality is one of the most important characteristics of rice and wheat marketing activities. Seasonal differences have effects not only on rice and wheat cash price movements, but also on the effectiveness of available futures contracts. The time from harvest (August) through January is the period of greatest liquidity in the rice market. In harvest season, CBOT rough rice futures price changes are more closely related to milled rice cash price changes in Thailand and in the world market than with milled rice cash price changes in California and Texas. After harvest, the Texas and California milled rice price changes exhibit much higher correlation with March rice futures prices than with November rice futures prices. In addition, the second Asian rice harvest had a greater impact on world rice price than on the Texas and New Orleans prices.

Interestingly, all the U.S.- based cash rice price changes and world market rice price changes are more closely related with December wheat futures price changes than with November rough rice futures price changes in the August-September period. Some types of rice cash price changes are more closely related with CBOT wheat futures price changes than CBOT rice futures price changes in certain time period. Since CBOT wheat futures prices are correlated with certain milled rice cash prices, some wheat futures contracts can serve as hedging instruments for rice cash prices.

The simulation results of various marketing strategies based upon the expected returns and variance of returns, maximized expected utility, and certainty equivalent criteria suggest: 1) Cash trade is a strategy of complete exposure to price risk, and it results in either large losses or large profits due to variances of returns. The variances of returns are smaller in the world rice market and the wheat futures market than in the Texas rice market. The amount of risk eliminated by direct hedging varies by season and by commodity; 2) Optimal simple hedging and optimal multiple hedging are superior to a no-hedging strategy and a direct-hedging strategy. Since the returns from certain rice markets are closely related with wheat futures activities in some months, the wheat futures market can offer higher risk-adjusted revenue to hedgers when the rice futures market fails to provide hedgers with satisfactory returns. That is, a hedger can increase expected utility by using wheat futures instead of rice futures in some specific seasons. Using an optimal multiple hedging strategy is likely to achieve even higher expected utility; 3) The seasonal difference is very significant in hedging decisions. The optimal hedging strategy depends on the season and the market in which the hedge is placed. No one strategy is best in all situations. Accurate hedge design in hedge position, season, market and strategy can increase expected utility by a significant amount in the long-run.

Implications

Several authors have noted that the rice futures market is a thin market and that its performance is inefficient, although the analyses on this issue are still limited. A study by Gordon (1984) assessed market performance of the New Orleans rice futures market. Several tests showed this market to possess some of the hedging properties of an efficient futures market. Six years later, Hoffman (1990) examined the performance of the rough rice futures market relative to the Arkansas cash market. Some possible inefficiencies were found in some early or low volume contracts (e.g. the March 1988 contract). More recently, Herrmann (1994) evaluated the performance of the rice futures market and its contribution to reducing inefficiencies in the rice cash market. Statistics show that the U.S. rice markets are not well integrated with the international market. The Louisiana rice market was less closely related to the world market (as interpreted by the USDA) than was the Arkansas market in 1986 and 1987. In 1988, both price series diverged from world prices. While the Arkansas price and announced world price movements are closely related to changes in the futures price, rice price movements in other U.S. markets (Louisiana and Brinkley in Herrmann's study) do not show a strong relationship to futures price movements. Most recently, Lee, Hayenga, and Lence (1995) analyzed the cross hedging relations between rough rice futures and cash markets in four rice producing states (Texas, Louisiana, Arkansas, and California). These results suggest that rough rice futures can provide rice traders with effective measures to hedge price risks, but only in small volume transactions, and not in California.

The wheat futures market is a much more heavily traded market and a more efficient market than rice futures. In world markets, wheat is the closest substitute for rice. In addition, an increase in the price ratio between rice and wheat, and a decrease of rice transaction costs, will encourage an Asian country like China to export more rice and import more wheat to meet food demand for its people and to "make money" (Chen, p151). In these cases, a cross hedge, as Anderson and Danthine (1981) suggested, may be attempted "by taking a position in a futures for a related commodity" (p.1187). However, wheat (wheat flour) is a substitute for rice other than as a "complement" (p.1188) as suggested by Anderson and Danthine. An empirical attempt can be found in Elam, Miller, and Holder (1984). They evaluated cross-hedging rice bran and millfeed using corn, oats, wheat and soybean meal futures. A 42 percent reduction of risk for rice bran and up to 24 percent risk deduction for rice millfeed were achieved by cross-hedging. However, no empirical applications directly addressing rice and wheat cross-hedging were found in the literature.

The present study provides empirical evidence that cross-hedging rice trade with wheat futures is an alternative risk management tool. However, the multiple product hedging proportion is not constant. It depends on the type of hedge, the season of the hedging, and the trader's risk aversion coefficient. In general, a producer hedges less than his total expected production. However, an optimal hedge, especially for trader, could have been speculative, either a short position or a long futures position grater than one. Peterson and Leuthold (1987) and Tzang and Leuthold (1990) suggested that to fully hedge, to hold equal cash and futures positions but of opposite signs, is not optimal. On the other hand, Grant and Eaker (1989) asserted that estimated multiproduct and cross-hedge positions do not perform any better than do fully-hedged positions in the markets for corn, coats, and wheat. However, Fackler and McNew's study (1993) for a representative central Illinois soybean processor reaches the opposite conclusion, demonstrating that a fully-hedged position and a single commodity optimal hedge are suboptimal to a multiproduct hedge. Actually, hedging soybean products could be termed complex hedging rather than multiproduct hedging, since the soy oil, soy meal and soybeans have a fixed input/output ratio. The present study provides a multiproduct cross-hedging approach for world grain traders and demonstrates its advantages.

Seasonal differences affect the implication of this approach. Sarassoro and Leuthold (1991) developed a risk management model for cocoa and coffee exports in the Ivory coast. The hedging effectiveness reported in their study (table 2) raged from 27% to 89%, depending on the season. Lee, Hayenga, and Lence (1995) noticed that most of the hedge estimates for rice are lowest in the period when July is the nearby contract. Although monthly U.S. rice exports during 1976-86 do not exhibit statistically significant seasonality (Schwartz, Bickerton, and Marks, 1987), the monthly U.S. rice imports during 1980-1990 do have a clear seasonal pattern. The bulk of U.S. rice imports were during the second half of each marketing year, "which corresponds with the new rice harvest in the South Asian countries (Wailes and Livezey, 1991, p15). This seasonality helps to explain why a hedging strategy that is not adjusted by seasonality might fail.

Conclusions

Food grain traders in Asia have available to them two major futures markets, wheat and rice futures markets. This study suggests that appropriate futures contracts should be selected for utility-maximizing grain traders in a specific region, such as in Asia. This study also demonstrates how grain traders in Asia can utilize the available futures markets to manage multiple risks simultaneously.

Unfortunately, data limitations preclude strong hedge recommendations. There is a complete lack of daily cash prices. The present study was constrained to weekly data, but certainly traders make decisions more frequently. There are no daily milled rice cash market prices for any specific variety and grade. Also, the rice futures market is relatively thin, which means that its relationship with wheat futures is less stable and predictable. Increasing volume and open interest in rice futures market will provide a longer and more reliable data set and make the results more convincing.

However, although different data will generate different coefficients, the general level of price correlations is not expected to change dramatically. Most important is the development of a set of methods to analyze multiple product hedging, and the empirical demonstration that multiple product hedging can reduce risks and increase expected utility compared to either no hedging or simple hedging. Further investigation is warranted in world rice and wheat markets, to identify ways to take advantage in seasonal differences in hedging, using U.S. futures markets to achieve effective risk management.

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