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A game theoretic analysis of U.S. rice exports under alternative Japanese and South Korean policy scenarios

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A GAME THEORETIC ANALYSIS OF U.S. RICE EXPORTS UNDER ALTERNATIVE JAPANESE AND SOUTH KOREAN POLICY SCENARIOS

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ABSTRACT

As a result of the Uruguay Round (UR), the impact on the international rice market is profound. In addition, another round of the WTO trade negotiations has started and the impacts of potential policy changes on rice trade are unknown. The major U.S. benefit of the UR has been the access to the Japanese market. However, the U.S. share of this import market has been unstable and the share of Korean rice market is zero percent. Therefore, this study attempts to analyze the potential implication of U.S. rice exports to Japan and Korea.

The Japanese and Korean rice economies as well as U.S. export demand are analyzed using empirical supply and demand models. This study captures the dynamics inherent in supply and demand of the Japanese and Korean rice sectors. For the study, the supply parameters are estimated using two stage least squares (2SLS), and the demand equations are estimated using ordinary least squares (OLS).

Since rice is a political commodity, this study incorporates the political influence of various interest groups in the policy-making process. The analysis measures the pattern of the implicit political weights given to the interest groups, considering a Political Preference Function (PPF).

In the final stage, the estimated elasticities and political weights are incorporated in a noncooperative dynamic game framework to analyze the possible impacts of policy changes in the three countries. This study analyses various policies, including several reasonable scenarios regarding changes in Japanese and Korean tariff equivalents from 2% to 8% with respect to U.S. export programs, such as credit guarantee and market development programs.

The results show that the best export policy option from the U.S. perspective is obtained at a 4% tariff reduction for Japan and Korea under a combination of U.S. market access

program and foreign market development program. The results suggest that the U.S. policy makers might focus more on the U.S. export policy options than the tariff reduction of Japan and Korea. However, it depends on how the policies are implemented, given the state trading enterprises and implicit trade barriers in both countries.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Under the Uruguay Round (UR) agreement the rules governing international trade in agricultural products were fundamentally changed (Gilbert and Wahl, 2000). Members of the World Trade Organization (WTO) agreed to a process of tariffication of non-tariff agricultural trade barriers (NTBs), to bind those tariffs, and to subject them to reductions. They also agreed to institute disciplines and reduction commitments on export subsidies and other domestic support mechanisms. Significant progress has been made towards subjecting agriculture to the same disciplines as trade in manufactures.

The multilateral trade agreement reached through the UR negotiations is important and extensive. Besides forming the WTO, it includes general tariff reductions and new rules relating to services, intellectual property, trade related investment and general subsidies. It also includes important new procedures for dispute settlement (Tangermann, *et. al*., 1997).

As a result of the multilateral trade negotiations, the world rice economy is becoming more market oriented. The impact of trade liberalization on the international rice market is profound because rice trade has been highly restricted in both developed and developing nations. In addition, another round of the WTO trade negotiations has started and the impacts of potential policy changes on rice production and trade flows in the world rice industry are unknown.

Japan and South Korea are industrial market economies with agriculture contributing less than 5% of their gross national products. These two countries are also major markets for U.S. agricultural exports (Wailes, et al., 2000).

The agricultural systems of Japan and South Korea have been largely focused on rice production with major political and economic support given to rice producers. Because of the special importance of rice, these countries have followed similar policies of high levels of protection in their rice economies to achieve self-sufficiency in production. These policies include banning foreign rice imports and maintaining their domestic rice price level above their border price. A result of this strong protection is that Japan has incurred rice surpluses for two decades, requiring expensive acreage diversion programs to help curb the over-supply. South Korea has also developed a surplus rice problem with burdensome stock levels since 1987 (Lee, 1997).

The situation surrounding the Japanese and Korean rice industries has changed drastically. The biggest change was the partial opening of the rice market. As a result of the UR agreement, Japan and Korea were required to guarantee some minimum access (MA) level of rice imports on regular basis.

This partial opening of these rice markets had a significant impact on the domestic rice industries in both countries, especially on prices and production. In fact, the reality is that farmers and the governments of Japan and Korea are suffering from the larger minimum access (MA) imports through suppressed domestic rice prices. In addition, imported rice is supposed to be used partially as foreign aid, but this cannot be a long-run solution for either country.

The Uruguay Round negotiations resulted in agreement by Japan and South Korea to relax their rice import bans with minimum access requirements. Japan agreed to imports equal to 4% of consumption in 1995, increasing to 8% by the year 2001. Korea agreed to a minimum access of 1% of consumption in 1995, increasing to 2% by 2000 and 4% by 2004 based on the consumption of the year of 1986-88. These minimum access requirements are essentially treated as mandatory import quotas, although either country is free to import more than the MA if they wish.

The minimum access quotas in Japan have been implemented using two mechanisms: 1) state trade purchases under the Food Agency of Ministry of agriculture, Fishery, and Forestry (MAFF) and 2) the simultaneous buy and sell (SBS) auctions for private trade (USDA/Attaché report, 1996). Food Agency purchases have been largely isolated from direct food markets, with purchases going to food aid, industrial use, animal feed and stocks. The share of the quota allocated to the two mechanisms has largely been an internal policy matter. However, burdensome stocks and external pressures have motivated MAFF to increase the share of the MA quota through the SBS from an initial 3% to 22% more recently.

Rice imports are a very emotional and political issue in Korea, leading the government to spend a great deal of resources in trying to ensure self-sufficiency. Korea has not imported any significant amounts of rice since it was forced to import over 2.0 million metric tons (MMT) in 1981/82 over a two-year period after the 1980 crop was severely damaged due to unusual cold weather.

In the UR agreement, Korea insisted that there should be some exemption from the tariffication in the case of basic foodstuffs such as rice and beef. However, Korea committed a full range of market liberalization at the UR negotiations with only the exception of rice, of which tariffication was postponed 10 years.

Despite protests from the U.S. government, Korean MAFF has announced that all rice imported during the initial years was for processing purposes only. The U.S. government's position is that this is against the spirit if not the rules of the UR agreement.

Among competitors, many local experts expect China to be a major supplier over the long term. China has reportedly developed new varieties of rice to meet Korean taste. This rice is being grown by ethnic Koreans in the northeastern provinces of Jilin, Liaoning and Heilongjinag (USDA, 1998).

The price of Chinese rice is about one-eighth that of similar rice produced in Korea, and has been a major rice exporter to Korea. China also has the obvious advantage of lower transportation cost due to its close proximity to Korea. Vietnam and Thailand are also reportedly making plans to export their long-grain rice. Australia is also aggressively seeking to gain a share of any medium-grain rice imported by Korea.

Korea imported 51,000 MT of Indian rice to meet its Market Access requirements in 1996. This rice was intended to meet its 1995 obligations. Since then, Korea imported an additional 64,000 MT of medium grain rice from China to meet it 1996 MA requirements in 1996. In addition, Korea imported 81,000 MT from China and 13,000 MT from Thailand in 1999 (USDA, 2000).

Korea's MA commitment is in effect until 2004. Korea's strategy for meeting its commitment includes the purchase of only lower quality rice, equivalent to U.S. No. 3 or lower. This is done in order to avoid table competition for its heavily subsidized domestic rice.

1.1.1 Recent Changes

In December 1998, the Japanese government notified the WTO of its decision to introduce rice tariffication beginning April 1, 1999. Under tariffication, a specific duty of 351.17 yen per kilogram (kg) was applied to imports outside of the MA volume. In and after Japanese fiscal year (JFY) 2000, April to March, a specific duty of 341 yen per kg was applied to imports outside of MA (MAFF, 1999).

Japan's tariffication agreement has three components. First, a secondary tariff applied to rice imports above the MA import levels where the mark-up associated with the tariff equivalent of the MA is considered the primary tariff. The initial secondary tariff rate is set at 351.17 yen per kg for 1999 (approximately $3,000MT) followed by a 2.5% reduction to 341 yen in 2000. Second, in agreeing to the possibility for over quota imports, Japan was allowed to reduce the annual increase in MA imports from 0.8% to only 0.4%. Third, the new policy adds a safeguard tariff of an additional 33%, triggered at 125% of the previous 3-year moving rice import volume (USDA, 2000).

The result of tariffication is lower import volumes than what would have occurred with the original MA quota, 38 thousand MT less in 1999 and 76 thousand MT less in 2000. The prohibitive tariff essentially results in capping of Japanese rice imports until reductions in the tariff rate are negotiated in the next round. Japan's MA quota will remain at the 7.2% of base period use until another agreement is reached (Table 1.1). Despite the negative effect on trade volume of Japan's recent tariffication, the MA quotas have resulted in an expansion of total world rice trade of approximately 5% and over 30% more trade of high quality medium grain rice (Wailes, 2000). Opening of the import market, along with domestic market reforms in Japan, has resulted in lower domestic market prices by 10 to 15% (USDA/Attachè report, 2000).

Table 1.1 Japanese MA Obligation for Rice (MT).

	Without Tariffication		With Tariffication	
	Volume	% of consumption	Volume	% of consumption
JFY* 1998	606,000	6.4 %	606,000	6.4 %
JFY 1999	682,000	7.2 %	644,000	6.8 %
JFY 2000	758,000	8.0 %	682,000	7.2 %

*:Japanese fiscal year (April to March)
Source: USDA

1.1.2 U.S. Exports to Japan and Korea

The United States accounts for less than 2% of global rice production, but exports more than 12% of world trade. Most countries produce only one type of rice. However, the United States produces both types (japonica in California, and indica in Arkansas, Louisiana, Texas, Mississippi, and Missouri) and is in a unique position in that it can export significant amounts of both types (Song and Carter, 1996). Despite this, the U.S. rice programs, marketing loan payments and marketing loan programs, essentially treat rice as a homogenous product (Wailes, 2000) and do not provide clear market signals corresponding to changing market conditions by subspecies (Childs and Lin, 1989). Rice is treated as a homogenous crop in the sense that (a) a single target price and acreage reduction program (ARP) rate is applied to all rice types, and (b) the rice grading system does not distinguish California medium grain (japonica) from southern long grain (indica) (i.e., it applies the same loan rate and marketing loan repayment rate). This distinction becomes more critical under freer trade, because the largest potential importers, Japan and Korea, have strong preferences for japonica rice.

From 1967 to 1982, Korea imported 8 million metric tons (MMT) of rice and U.S. rice exports supplied 65% of that market, mostly from California (Schnepf and Just, 1995). However, by the mid 1980s, Korea attained self-sufficiency in rice due to generous government programs, while imports were essentially banned. After losing its largest importer, Korea, in 1983, California accumulated rice stocks, relative to the southern states. Since 1983, the U.S. has exported no rice to Korea. In the meantime, the U.S. market share in the Japanese import market has been about 50% since 1995. However, the U.S. market share in Japan decreased in recent years due to heavy competition among the major export countries, such as Australia, China, and Thailand.

1.2 Problem Statement

Traditional leading rice exporters, such as Thailand and the United States, have gradually lost market share to newly emerging exporters, primarily Vietnam and India. The U.S. lost second position to India in 1995 (USDA, 2000) and was the fourth leading exporter in 1996 (Wailes, 2000). With unexpected reductions in exports by India, the U.S. moved up to third place in 1997 and 1998.

The impact of the UR agreement on the U.S. rice industry has been favorable. The major benefit has been the access to the Japanese market. The U.S. share of this market has been about 50% as opposed to the Korean market, in which its market share is zero. However, the U.S. share of the Japanese market has gradually decreased and been unstable due to strong competition with major exporters as mentioned above.

The uncertain factors in Korea, in terms of potential U.S. rice exports, are Korea's stock and political situations. How these factors will affect future U.S. exports is still uncertain at this time. In the past, in terms of stock, the Korean government has kept a minimum four-month reserve for both price stabilization and food/military security reasons and the policy-making process in rice trade is a politically sensitive matter.

Nevertheless, the U.S. rice industry can potentially increase its market share in Japanese and Korean rice import markets, given that both countries will likely be required to expand their imports in the next round of the WTO negotiations. Expanded market access remains one of the most important issues for rice trade. The UR can claim credit for part of the expansion in rice trade in the 1990s, but the two rice markets remain highly protected. For instance, the tariff rate quota (TRQ) for Japan will remain at 682 thousand MT until a new agreement is negotiated. Tariffication established a prohibitive tariff and reduced the terms of MA quota that would have resulted without tariffication. Both the tariff level and quota will receive considerable attention in the next round. Similar pressure will be on the MA quota for South Korea along with a push for tariffication (Wailes, 2000; Cramer, et al., 1999; Koo, et al., 1996).

Looking at the historical and recent structural changes in both countries, it is useful for the U.S. rice industry, especially the export market, to examine how much market share the U.S. can potentially obtain in the Japanese and Korean markets. In addition, it is important to examine how changes in Japanese and Korean rice policies, as related to their WTO commitments, will impact the U.S. market.

Japanese and Korean imports have stimulated resource adjustments in the rest of the world, including Australia, China and the United States, countries that have been the primary beneficiaries of Japanese and South Korean market access. This has occurred because Japan and Korea are the primary consumers and importers of japonica rice. Therefore, changes in both countries rice policies have a large impact on the U.S. rice industry as well as the world rice market.

1.3 Justification

The existing research on Japan, Korea, and the U.S. export market is quite limited and is not linked, in the sense that the existing studies focus specifically on either the Japanese or Korean rice market (Im, 2000; Koo and Taylor, 1999; Park, 1996; Kako, et al, 1995). In addition, some studies examined implications of the rice trade liberalization for U.S. rice policies and the world rice market, considering Japanese and Korean markets as a part of their studies (Wailes, 2000; Cramer, et al., 1999; Lee, 1997; Song and Carter, 1996). However, these studies did not examine nor forecast potential U.S. market share in Japanese and Korean markets. Furthermore, there is no analysis that examines the linkage between U.S. exports and the other two countries' imports. Therefore, this study focuses specifically on Japanese and Korean rice markets from the U.S. perspective, considering the linkage between U.S. rice export policies and the other two countries' potential import policies. This study can help policy makers in these three countries and the people engaged in international rice trade to better understand and improve decision-making with regard to the rice economies of Korea and Japan.

Since the U.S. share of the Japanese rice import market has been relatively unstable in recent years, an analysis of the Japanese import market from the U.S. perspective is needed. In addition, Korea imported rice from the U.S. until the early 1980s. However, prior to the GATT negotiations, the Korean government suspended rice imports, with the exception of years when they had unusual bad weather. As a result of the GATT negotiation, Korea must meet its MA commitment each year until 2004. Korea has had tremendous pressure from rice exporting countries such as the Cairns group and the U.S. concerning its MA requirement. Nevertheless, Korea has not imported its MA commitment from the U.S.; India and China have been the major rice suppliers for Korea. However, China and India are volatile exporters, moving from net importers in one year to net exporters in the next (Wailes, 2000). Therefore, an analysis of the Korean rice economy and import policy will benefit the U.S. rice industry.

1.4 Objectives

The issue of uncertainty regarding potential U.S. rice exports to Japan and Korea will be analyzed by combining an econometric analysis with game theoretic-model to determine the impact of various policies. To conduct the game theoretic analysis, econometric models of supply and demand for Japan and Korea and an export demand model for the U.S. will be estimated. The estimated elasticities will be used to initialize the simulation model, which uses the game theoretic approach. In addition, political weights of various interest groups will be determined, and the weights will be incorporated into the model. For the policy analysis, several potential import policies of Japan and Korea will be considered for U.S. rice export policies.

The general objective of this study is to determine the potential U.S. rice exports to Japan and Korea. The goal of the analysis is to determine the implications for U.S. export policies. The specific objectives to accomplish this are:

1) To estimate econometric models of supply and consumption behavior for Japan and Korea, and export demand for the U.S. as an input to initialize the empirical model;

2) To determine the political weights of relevant interest groups of the three countries as an input to initialize the empirical model;

3) To conduct a game theoretic analysis to determine the optimal policy options of Japan and Korea for U.S. rice exports, incorporating econometric estimates and the political weights of different interest groups determined in specific objective 2) and;

4) To analyze the potential policies of Japan and Korea and determine the best export policy options for the U.S.

1.5 Literature Review

An extensive literature has evolved in the past decades using economic theory to determine the impact of policy reform and trade liberalization of agricultural commodities. This section outlines recent studies concerning Japan, South Korea, and the U.S. rice industries, including econometric analyses, political economic analysis of rice in the three countries, and game theoretic analyses.

Wailes, Ito and Cramer (1991/a) have provided a comprehensive study of the Japanese rice market prior to the GATT reforms. The Japanese rice economy is described in the context of the 1991 trade liberalization discussions. This study examined the high-cost Japanese rice production structure that is supported by managing the rice surpluses. They also analyzed the implications of trade liberalization for the world rice market in another study (1991/b). The authors used a multi-product quadratic programming model to investigate the impacts on the world market. The study focused on the changes in Japan's rice market. Dyck, Huang and Wailes (1993) reviewed South Korea, Japan and Taiwan's farm structures and rice economies. Kako, Gemma and Ito (1995) have estimated a Japanese rice model adopting two scenarios, which were analyzed with respect to future per capita expenditure, rice prices and meat prices.

Myung (1989) analyzed the effects of the government's price intervention in Korea's rice economy. The study used a partial equilibrium approach to examine the effects on the rice markets with and without government intervention. In this study, the author used a Nerlovian supply model in the logarithmic form. The Nerlovian lagged supply function was fitted to the observed data in order to obtain supply elasticity estimates. For the demand model, the study used the Almost Ideal Demand System (AIDS) model. Park (1995) estimated supply and demand models for the Korean rice economy over the period from 1965 to 1993. the analysis was conducted for three scenarios; 1) no imports of rice, 2) imports assumed to follow the UR agreement (2-4%), and 3) both rice imports and processing use assumed to increase to 10% of domestic consumption. However, a limitation of his study is that he did not evaluate the international impacts. A study by Koh (1996) analyzed recent changes in Korea's rice acreage, yield, consumption and government policy. Koh also provided a brief historical background of Korean rice policy and the import situation.

Grant, Beach, and Lin (1984) estimated U.S. acreage response by each state instead of by grain types. They have estimated state-by-state rice-planted acreage for the five major producing states using the effective farm price and a lagged dependent variable. They also have estimated rice demand for seed, food, brewing, commercial exports, government exports, and rough rice exports. However, they did not consider the effects of government policy details such as acreage set-aside programs or deficiency payments. Chen and Ito (1992) estimated U.S. rice demand and supply models using the implicit revenue function approach. The study also demonstrated the utility of a switching procedure that allows evaluation of supply response behaviors for time periods governed by multiple farm programs in a system of equations. However, they treated rice as a homogeneous crop. Song and Carter (1996) estimated U.S. supply and demand disaggregating types. They analyzed several scenarios according to the GATT agreement and the impacts of the global rice trade liberalization on the U.S. Wailes, Cramer, Chavez, and Hansen (2000) constructed a model called Arkansas Global Rice Model that consists of 22 sub-models and the rest of the world (ROW). The model is a representation of the world rice economy, and is used to simulate world rice trade. They disaggregated rice types such as indica and japonica solving for Thai 5% f.o.b. rice price and California price. They used econometric and partial equilibrium approach to closed the model such that world imports and exports are equal in each year.

The new political economy or endogenous theory of economic policy recognizes that policy-makers are rational agents who select policy-maximizing objectives, subject to political and economic constraints. There has been interest from both a theoretical and empirical perspective in examining the effects of government price stabilization (or support) programs on commodity market performance. The main issue in this area has been the desirability of price stabilization in terms of its welfare effect on interest groups. Different approaches have been adapted to analyze income support and price stabilization policies.

For agricultural policies, much of the literature focuses on the integration of political and economic markets and the endogenization of government policies (Zusman and Amiad, 1977; Anderson and Hayami, 1986). The approach, called new political economy, shows that the government as a rational agent may be manipulated by powerful interest groups. A fast growing literature on the political economy of agricultural policy has introduced new analytical methods for dealing with the political influences of special interest groups in the policy making process (Rausser and Foster, 1990). The political economy approach to agricultural policy has developed along two paths, which depend on how the political process is viewed. These two approaches to modeling the political economy of farm programs are the political preference function (PPF) approach and the clearing-house government (CHG) model.

The PPF approach assumes that policymakers maximize a political preference function in which different interest groups in society have different weights in the function. The fundamental assumption of the PPF approach is that current policies reflect a political economic equilibrium summarizing all the relevant political power among interest groups. Empirical work began in this area with Rausser and Freebairn (1974) who estimated political preference weights under the U.S. beef import quota. Similar studies are Lianos and Rizopoulos (1988) for the Greek cotton sector, and Oehmke and Yao (1990) for the U.S. wheat sector. Multi-country and single-commodity political preference function studies are Sarris and Freebairn (1983) and Paarlberg and Abbott (1986) for the world wheat market. Tyers (1990) applies estimated political weights to the welfare incidence of EC agricultural policy reforms and evaluates their political feasibility. Recently, some theoretical assessments of the political preference function approach have been discussed in the literature (von Cramon, 1992; Bullock, 1994, 1996). Bullock provides a theoretical explanation of the PPF methodology and assumptions. He argues that one can estimate political power with a PPF only if observed policies are Pareto-efficient, which may depend on the assumed number of interest groups and policy instruments. To ensure that observed policies are efficient, he shows that PPF studies must choose the number of policy instruments to be exactly one less than the number of interest groups.

Game theory has appeared in agricultural economics research primarily in studies of international trade and political economy problems that inherently deal with collective action. In trade models, countries formulate policies considering other countries' alternative behaviors that affect access to markets or prices received in those markets (Karp and McCalla, 1983). In political economic models, producer groups formulate and argue for price/production policies and argue against the policies supported by rival producer and consumer groups; in so doing, they must anticipate demands made by rival groups and actions undertaken by other law makers.

Agricultural trade research has for a long time recognized the importance of imperfect competition. McCalla (1966) first argued that wheat trade should be explained as a duopoly involving the United States and Canada. Carter and Schmitz (1979) claimed that in the wheat market, power resided with the buyers, who were able to extract rent by imposing a tariff or some other kind of trade barrier. Carter, McCalla, and Sharples (1990) examined the linkage between imperfect competition and political economy of trade policy. Most approaches have utilized the conjectural variations method (Paarlberg and Abbott, 1986; Kolstad and Burris, 1987), an approach not included by strict game theorists among their tools (McMillan, 1986; Tirole, 1988). Some recent approaches have followed explicit game theoretic methods (Karp and McCalla, 1983; Hillberg, 1988; Johnson, Mahe, and Roe, 1993; Kennedy, von Witzke, and Roe, 1994).

In addition, Kydland (1975) compared open loop and feedback solutions for suitable equilibrium solutions for cooperative and dominant player dynamic games. He argued that the feedback solution is generally more appropriate as an equilibrium concept. For the interdependency of trade, Karp and McCalla (1983) provide an application of dynamic difference game to the world corn market. The difference game provides a plausible model for evaluating the effects of trade restrictions. These effects include the direct impact on prices and quantities and the retaliation of trading partners. The total effect can be disaggregated to determine the impact on various interest groups within nations.

In trade policy debates, it is often argued that domestic industries should receive temporary protection from import competition (MAFF, 1997). Immediate trade liberalization and ensuing inflows of foreign products and capital would jeopardize domestic firms, while protection would allow the domestic industries to introduce new technologies and products, thereby effectively competing with their foreign rivals. Any such protectionist measure should be temporary, because, under permanent protection, the lack of competitive pressure reduces incentives for domestic firms to rationalize their operations and to hold down costs (Matsuyama and Itoh, 1986; Matusyama, 1990). A similar argument arises in the context of infant industry protection. Temporary support by governments sometimes helps new industries grow strong enough to meet international competition. But indefinitely imposed protection often results in perpetual industrial stagnation (WTO, 1997). In that sense, game theory is a fruitful ground for conceptualizing micro-level transactions, particularly those that take place in more isolated markets or among cooperating groups (Horowitz, Just, and Netanyahu, 1996).

These various studies described in the above literature review give an overall picture of the concerns associated with the rice markets, and provide a sense of the magnitude of the issues involved with the government rice policies and international rice trade.

1.6 Outline of the Dissertation

This dissertation will be organized into five chapters. Chapter One consists of the research problem statement, justification of the research, objectives of the study and a description of research procedures. Chapter Two reviews the rice economies of Japan, Korea and the U.S. export market. The theoretical framework for the econometric estimation, the PPF determination, and the game theoretic approach will be discussed in Chapter Three. The empirical approach will be conducted to determine the Nash Equilibrium import and export policies for these three countries, and the results will be discussed in Chapter Four. The summary, conclusions, and suggestions for further study will be contained in Chapter Five.

CHAPTER 2

JAPANESE AND KOREAN RICE ECONOMIES

2.1 Japanese and Korean Rice Economies

The rice economies of Japan and Korea are distinguished by small-scale rice farms. The two countries radically reformed their land tenure systems in the late 1940s and early 1950s (Dyck, *et al*., 1993). The land reforms were important economic and social changes during the postwar period since they resolved long-simmering class conflicts in rural society and enabled millions of households to become freeholders, with economic status, at least by the 1950's, comparing favorably to that of the urban working class (Tweeten, 1993). The two economies taxed agriculture to some extent in the earlier decades of the post-WWII era. All shared a common experience of suffering poverty and hunger before they became industrially developed.

In Japan, there were 4,661 thousand farm households in 1980, among which 3,721 thousand rice farm households. The number of rice farm household accounted for 79.8 % of total farm households in 1980. However, the number of farm household decreased dramatically to 3,239 thousand households and 2,134 thousand rice farm households, accounting for 71 % of the total farm households in 1999 (Table 2.1).

For Korea, there were about 1.38 million farm households cultivating 1.9 million hectares of agricultural land in 1999, implying that the average farm size is about 1.37 hectare (Table 2.1).

The agricultural statistics of MAFF (ministry of agricultural, fishery and forestry) and the USDA indicate that the average area of farms in the two countries has grown only slightly since those countries' land reforms in the late 1940s. The average arable land per farm household in these two countries increased from 1.02 ha in 1980 to 1.5 ha in 1999 (Table 2.1). On rice farms, the average area has been less than 1 hectare even though it has been increasing.

Table 2.1. Farm Structure in Japan and Korea, Selected years.

	1980	1985	1990	1995	1999
Total farm households (A) (1000 households)					
Korea	2,155	1,926	1,767	1,501	1,382
Japan	4,661	4,376	3,835	3,444	3,239
Total arable land (B) (1,000 ha)					
Korea	2,196	2,144	2,109	1,985	1,899
Japan	5,461	5,379	5,243	5,038	4,866
Average arable land (per household (ha), B/A)					
Korea	1.02	1.11	1.19	1.32	1.37
Japan	1.17	1.23	1.37	1.46	1.50
Rice farm households (1,000 households)					
Korea	1,837	1,649	1,525	1,205	1,064
Japan	3,721	3,437	3,063	2,301	2,134
Land for rice (1,000 ha)					
Korea	1,233	1,237	1,244	1,056	1,066
Japan	2,377	2,342	2,074	2,118	1,788
Average rice land (per household, ha)					
Korea	0.52	0.75	0.82	0.88	1.00
Japan	0.64	0.68	0.68	0.77	0.84

Source: MAFF, Republic of Korea, various years.
MAFF, Japan various years.

These two countries' governments have adopted diversion programs to reduce government stocks and program costs, to increase the average rice area per farm, and to reduce the higher production costs compared with those of U.S.

Most of the farm households are headed by an aging population, 55 to 65 years of age or older, who have poor prospects for earning comparable incomes in other occupations and whose assets consist largely of high-valued farm land (Wailes, 1994).

A general feature of both countries is an aging farm population (generally over 55) with rice farming being mostly a part-time farming operation with high dependence on off-farm income. Currently these two countries have high rice production costs compared to border prices due to the small scale of farming, relatively high labor costs, and high land costs.

Table 2.2. Rice Production Cost for Selected Years in Japan, Korea, and the U.S.

Year	Japan (US$/ha)	South Korea (US$/ha)	U.S. (US$/ha)
1981	7,527	2,616	877.8
1983	7,350	2,932	867.8
1984	7,326	2,971	875.7
1986	10,545	2,996	875.2
1991	12,520	5,456	968.0
1992	13,200	5,089	932.9
1993	15,576	4,953	982.2
1994	16,106	4,984	1,046.3
1995	17,989*	5,341	1,058.4
1996	15,529	5,497	1,130.6
1997	13,877*	4,818	1,130.4
1998	12,988*	3,651*	1,105.2

Source: MAFF, various years, and USDA 2001.
*: due to exchange rate.

The economic conditions of rice farm households and the rice markets in Japan and Korea are much more complex since the structure of rice agriculture in both countries has changed markedly over the last two decades and continues to change.

Given their similar backgrounds and the importance of rice production, the rice economies of Japan and Korea have many characteristics in common. These two countries experienced hunger during war years and land reform conflicts, creating strong pressure to continue the status quo of small farm ownership and self-sufficiency in rice production. These two countries taxed agriculture as a national policy to successfully help develop the industrial sector. Therefore, there is strong public support to preserve agriculture now. The farm structure is dominated by small scale rice farms and mostly operator-owned rather than rented rice farms. They produce high quality japonica medium-grain rice as a staple food. During the past several decades, they have been experiencing a decrease in per capita rice consumption, and normally produce rice surpluses as a result of highly protectionist government programs.

2.1.1 Korean Rice Farm Structure

More than 65 percent of rice farm households operate less than 1 hectare of farmland in 1999, as shown in Table 2.3. The number of rice farm households in each class of farm size has been decreasing. However, the number of rice farm households with more than 2.0 hectares has been fluctuated. This implies that the structural changes in rice farm sector has been affected by Korean financial crisis occurred in 1997. Rice farmers need to get any type of loan from the government, agricultural cooperation, and banks to expand their rice farmland. However, it was extremely difficult to get a loan from any financial organizations since the financial crisis. In spite of all efforts for structural changes, the majority of the farmers are still operating small-scale farms.

Table 2.3. Number of Korean Rice Farm Households by Farm Size, Selected Years
(Units: 1,000 households (%)).

Year	Below 0.5ha	0.5-1.0 ha	1.0-2.0 ha	Above 2.0 ha	Total*
1980	529(28.8)	646(35.2)	543(29.6)	119(6.5)	1,837(100.0)
1985	467(28.4)	601(36.5)	483(29.3)	96(5.8)	1,647(100.0)
1990	422(27.6)	475(31.1)	475(31.2)	150(9.9)	1,525(100.0)
1995	354(29.4)	353(29.3)	341(28.4)	157(13.1)	1,205(100.0)
1996	355(30.3)	339(29.0)	327(27.9)	151(12.9)	1,172(100.0)
1997	353(30.9)	332(29.0)	308(27.0)	150(13.1)	1,143(100.0)
1998	381(34.7)	312(28.4)	274(25.0)	131(11.9)	1,098(100.0)
1999	380(35.8)	304(28.5)	260(24.5)	120(11.3)	1,064(100.0)

Source: Korean MAFF, various years.
*: Non-crop farm households are excluded.

In Korea, the family farm is broadly defined as a farm, which is operated by a farm household, meaning that both the farm operator, and all farm laborers, are family members.

This concept of a family farm was first adopted by the Korean government in the process of enacting the Farmland Reform Law in 1948-50 (Park, 1996). The fundamental structure of Korean agriculture, the owner-operated family farm system, was established during this period. In the Farmland Reform Law, the maximum farmland holding by a farm household was limited to 3.0 ha of cropland (MAFF, 1995). In fact, it was not possible for a farm family to manage more than three hectares of farmland in the 1950s, due to the low level of farm mechanization.

The proportion of part-time rice farm households has been increasing, while the proportion of full-time farmers has been decreasing until 1996 as shown in Tble 2.4. For example, the proportions of full-time and part-time households in total farm households were 76.2 percent and 23.8 percent respectively in 1980. In 1996, they were 56.5 percent and 43.5 percent, respectively (Table 2.4). This suggests that the part-time household was an inevitable solution to the problem of income parity with non-agricultural households given the small farm size.

Table 2.4. The Number of Rice Farms by Type in Korea (Unit: 1,000 households).

Year	Total*	Full-time	Part-time
1980	1,837(100.0)	1,399(76.2)	438(23.8)
1985	1,649(100.0)	1,299(78.8)	350(21.2)
1990	1,525(100.0)	909(59.6)	616(40.4)
1995	1,205(100.0)	682(56.6)	523(43.4)
1996	1,172(100.0)	662(56.5)	510(43.5)
1997	1,143(100.0)	671(58.7)	472(41.3)
1998	1,098(100.0)	694(63.2)	404(36.8)
1999	1,064(100.0)	677(63.6)	387(36.4)

Source: MAFF, 2000.
*: Non-Marketing farm households are included.

In the end of 1997, however, the Korean economy confronted with the worst financial crisis in its history. The underlying causes of the Korean financial crisis are intermingled by internal and external factors (Han, 1999). Financial shocks resulted in a lot of self-employment bankruptcies and a sharp increase in unemployment rate, almost to 10%. As a result, people who previously engaged in general economic sector as part-time farmers started becoming full-time farmers. As a result, the proportion of the full-time rice farms has increased since 1997 when the financial crisis occurred.

In addition, most young capable farmers have been migrating to urban areas to find more highly paid jobs, leaving only the older and less occupationally mobile farmers in rural areas. In 1990, approximately 56 percent of the Korean farmers were more than 50 years old as shown in Table 2.5. The proportion increased to 68 percent in 1999. The substantial proportion of older farmers may be a primal cause of the lack of vitality and international competitiveness of Korean agriculture because it is unrealistic to expect that the older farm operators will adopt new farm technology, and invest more to improve their farm operations. Therefore, a dramatic increase in productivity and farm income cannot be expected in the near future.

Table 2.5. Rice Farm Labor Trends in Korea (Unit: %).

	1990	1995	1996	1997	1998	1999
Total	100.0	100.0	100.0	100.0	100.0	100.0
– 19	0.00	0.00	0.00	0.00	0.00	0.00
20 – 29	0.06	0.03	0.03	0.03	0.03	0.03
30 – 39	15.3	12.8	11.7	10.5	10.5	9.7
40 – 49	21.6	19.7	19.6	18.6	18.4	18.2
50 – 59	32.6	28.0	26.8	26.8	27.2	25.3
60 –	23.7	36.1	39.0	41.5	40.6	43.3

Source: Korean MAFF, various years.

In general, production costs are much higher than those of the U.S. because of the high farmland prices (Table 2.2). Therefore, small size farms find it difficult to purchase farmland for enlarging their farm size. As shown in Table 2.2, the production cost in Korea is approximately five times higher than that of the U.S. in 1996, but decreased to three times higher in 1999. This did not mean that the Korean production costs decreased dramatically due to the structural reform. This was mainly due to the Korean currency depreciation since the financial crisis in 1997. The exchange rate was 805 Won/$1 in 1996, but it was 1400 Won/$1 in 1997 (MAFF, 1998).

2.1.2 Japanese Rice Farm Structure

Japan's agricultural land reform, rigorously implemented throughout the country, abolished absentee ownership by 1950 and transferred two million hectares of farmland into the hands of small-scale cultivators, mostly former tenants (Goto and Imamura, 1993). Ceiling provisions for individual holdings were set at 12 hectares in Hokkaido and 3 hectares in the rest of the country. However, the agricultural land reform in 1950s did not change the average size of individual farms (Tweeten, 1993).

Table 2.6. Number of Japanese Rice Farm Households by Farm Size*

(Unit: 1,000 households (%)).

Year	Below 1.0 ha	1.0 ha – 2.0 ha	Above 2.0	Total
1990	1,753(60.8)	782(27.2)	348(12.1)	2,883(100.0)
1995	1,740(75.6)	380(16.5)	180(7.8)	2,301(100.0)
1996	1,689(74.9)	382(16.9)	183(8.1)	2,254(100.0)
1997	1,687(75.8)	366(16.4)	174(7.8)	2,227(100.0)
1998	1,658(75.9)	357(16.4)	169(7.7)	2,184(100.0)
1999	1,643(77.0)	334(15.7)	156(7.3)	2,133(100.0)

Source: MAFF, Japan, 2000.
*: Non-marketing farm households are excluded.

The area of arable land in Japan decreased from 5,461 thousand ha in 1980 to 4,866 thousand ha in 1999 (Table 2.1). Table 2.1 shows that the number of farm households was 4,661 thousand households in 1980 and decreased to 3,239 thousand households in 1999, resulting in an average farm size of about 1.5 hectare.

Most Japanese rice farms are very small in size (Table 2.6). The share of farms of less than 1.0 hectare was 60.8 percent and that of over 2 hectares was only 12.1 percent in 1990. In 1999, the farms below 1 hectare increased to 77 percent and the number rice farming over 2 hectares were decreased to 7.3 percent due to the diversion program and trade liberalization. As shown in Table 2.1, the Japanese farm size has been increasing gradually but it is still small. For rice farms, the number of farms has been decreasing due to the diversion program and trade liberalization as well. The average rice farm size is still less than 1 hectare although it has been increasing.

Table 2.7. The Number of Farms by Type* in Japan, 1990-1999

(Units: 1,000 households, %).

Year	Total	Marketing Farms Full-time	Part-time	Non-marketing Farms*
1990	3,835(100.0)	473(12.3)	2,497(65.1)	865(22.6)
1995	3,444(100.0)	428(12.4)	2,224(64.6)	792(23.0)
1996	3,388(100.0)	432(12.8)	2,171(64.1)	785(23.2)
1997	3,344(100.0)	436(13.0)	2,133(63.8)	775(23.2)
1998	3,291(100.0)	434(13.2)	2,088(63.5)	769(23.4)
1999	3,239(100.0)	433(13.4)	2,041(63.0)	764(23.6)

Source: MAFF, various years.

*: Non-marketing farmers, as part-time, produce agricultural products to consume, not to sell.

Small farm size has contributed to the fact that rice in Japan is produced predominantly by part-time farmers (Table 2.7). More than 80 percent of Japanese farmers are part-time including non-marketing farms. Therefore, the importance of part-time farming has to be considered in the Japanese farm structure.

The rapid decrease of new entrants to rice farming beginning in the 1960s is consistent with the aging of the current population of farmers. More than 50 percent of farmers in Japan are 50 years of age or older (Immamura, 1993). Younger generations fail to enter farming not because of low income from farming. Even if they can become high-income earners in farming, or they are the inheritors of high-income family farms, many of them still will not enter farming because they prefer to work in non-farm corporations, which provide more satisfying work for them.

Table 2.8. Japanese Rice Farm Labor by Age, 1999 (Unit: thousand people).

Total	19 – 29	30 – 59	60 – 64	64 <
6810	484	3295	805	2227
(100.0)	(7.1)	(48.4)	(11.8)	(32.7)

Source: MAFF, 2000.

As shown in Table 2.8, approximately 45 percent of rice farmers were older than 60 years of age in 1999. Therefore, we cannot expect either fast productivity increase adopting cutting-edge technology or dramatic changes in their rice farm structure.

Table 2.9 shows production costs by farm size in 1998. Total costs per hectare decrease as size increases from less than 0.5 hectares to more than 5 hectares. Labor cost per hectare decreases from US$ 6,425 for farms less than 0.5 hectares to US$2,640 for farms greater than 5 hectares. In addition to labor, more efficient utilization of equipment contributes to economies of size.

Table 2.9. Rice Production Costs by Farm Size in Japan, 1998 (U.S.$/ha).

	Average	< 0.5	0.5-1.0	1.0-1.5	1.5-2.0	2 .0-3.0	3.0-5.0	> 5.0
Equipment*	6,192	8,134	6,911	6,225	5,762	5,495	4,989	4,836
Labor	4,353	6,425	5,121	4,385	3,947	3,734	3,234	2,640
By-product	-258	-267	-264	-236	-245	-248	-252	-288
Interest	394	164	190	233	452	533	677	805
Rent	2,307	2,573	2,459	2,434	2,368	2,314	2,112	1,702
Total	12,988	17,028	14,416	13,041	12,284	11,828	10,760	9,695

Source: MAFF, 2000, Japan.
*: Including fertilizer, chemicals, and machine.

Large-scale farms may be able to cut costs substantially. Table 2.9 shows that farm size/structure is a major constraint to lowering the national average cost of rice production and the substantial cost reductions could be achieved in Japan by enlargement of farms. However, current average rice production costs in Japan are several times higher than those in major rice exporting countries such as Thailand and the U.S.

2.2 Rice Supply and Demand in Japan and Korea

Rice supply and demand in Japan and Korea share many similarities. The production structure and policies for the rice sector have many common characteristics. As these countries have become more wealthy industrial countries, they have experienced a similar long-term decline in per capita rice consumption.

In terms of production, rice is the major crop grown in Japan and Korea, accounting for 37 percent and 56 percent of the total planted acreage in 1999, respectively. Although rice production has been relatively stable during the past 20 years, it has come from improved yield. The supply of paddy land for rice production has been stable over time due to the limited availability of land, as well as the low substitutability in land use between paddy and upland. Improvements in rice yields are mainly due to the adoption of new varieties, mechanization, and improved production practices in both countries (Im, 1999; Park, 1996). Table 2.10 and 2.11 indicate that the yield in Japan and Korea has increased by 31 percent and 52 percent in 2000, compared to 1980, respectively.

On the consumption side, an increase in per capita income created a change in food consumption patterns in both countries. In addition, as per capita income has grown, per capita consumption of rice has declined gradually. This is mainly due to the change in the dietary pattern of consumers in favor of protein food such as meat and vegetables (MAFF, 1995). However, the total consumption in rice has been stable in both countries due to an increase in population and higher demand in processing industries.

2.2.1 Japan

Rice production in Japan has decrease gradually with changes in food consumption patterns and with the recent changes in the rice marketing system.

As rice consumption began to decrease, the build-up of rice stocks began to place pressure on the government budget. Due to this pressure, the rice diversion program was initiated in 1970 on a trial basis with an incentive subsidy for areas diverted from rice production. Rice area declined to 2,377 ha by 1980. Since 1970, several types of diversion programs have been implemented depending upon the level of rice stocks and the government budget situation (Ito, et al., 1997). As a result, the area planted to rice in Japan decreased from 2,377 thousand ha in 1980 to 1,788 thousand ha in 1999 (Table 2.1). Total production declined to 8,636 thousand metric tons (MT) (milled) in 2000 from 10,612 MT (milled) in 1985.

Rice yields increased by more than 20% from the level of 3.73 MT/ha (milled) in 1980 to a level of 4.88 MT/ha (milled) in 2000 (Table 2.10). Since 1985, yields have been relatively stable ranged between levels of 4.53 to 4.93 except for the crop failure in 1993, when yields declined to 3.33 MT/ha due to cold weather. Yield growth has been primarily due to varietal improvements and chemical inputs but also due to the diversion programs as less productive rice land has generally been diverted to alternative crops (Kako, et al., 1997; MAFF, 1998).

Table 2.10. Supply and Utilization of Rice in Japan, 1980-2000.

Year	Area 1,000ha	Yield MT/ha	Production --- 1,000MT ---	Consumption	Per Capita Kg	Stocks --- 1,000MT ---	Imports	Exports
1980	2,377	3.73	8,873	10,100	78.9	4,000	75	909
1985	2,342	4.53	10,612	10,150	74.6	1,110	20	0
1990	2,074	4.61	9,554	9,620	70.0	1,005	17	0
1993	2,139	3.33	7,129	9,400	69.2	731	2,623	0
1994	2,212	4.93	10,903	9,350	66.3	1,883	9	410
1995	2,118	4.62	9,781	9,300	67.8	2,615	451	200
1996	1,977	4.77	9,413	9,250	67.3	3,078	600	300
1997	1,953	4.67	9,123	9,200	66.7	3,094	499	574
1998	1,801	4.53	8,154	9,100	62.5	2,492	554	210
1999	1,788	4.67	8,350	9,450	N/A	1,831	639	200
2000	1,770	4.88	8,636	9,300	N/A	1,297	730	600

Sources: MAFF, 2000; USDA/PS&D, 2000.
N/A: not available.

Annual per capita rice consumption decreased from 78.9kg in 1980 to 62.5kg in 1998. The Japanese diet has shifted to larger shares of dairy products, meats, and wheat products, although the government has tried to increase rice consumption with a school lunch program and other promotional activities (Wailes, et al., 1999). The total consumption has decreased from 10,100 thousand MT (milled) in 1980 to 9,300 thousand MT (milled) in 2000 (Table 2.10). While rice has not lost it's significance as a food staple, it has become a less important component of the Japanese diet. The decline in rice consumption is continuing in spite of high government expenditures to promote rice consumption, such as the school lunch program.

The Japanese rice market was closed to imports except for processed rice products and for occasional severe domestic production shortfalls as occurred in 1980 and 1993 before the GATT agreement was reached on Japanese minimum access imports (USDA, 1995). However, the Japanese refused to eat imported rice in 1980 because the imported rice was not the japonica type. Therefore, the Japanese government reexported the rice imported in 1980. In 1993, rice imports reached a peak of 2,623 thousand MT (milled) (Table 2.10). Stocks have been normally about 10 to 15 percent of production, and production has been controlled by an elaborate supply management program in Japan involving fixed delivery quotas for producers and massive rice diversion programs with heavy subsidy payments (MAFF, 1994).

Japan had a turbulent year for rice production and trade in 1993/1994. Because of cool and rainy weather, the 1993/1994 rice harvest plunged to 7.129 million metric tons (MMT), the lowest in almost 50 years (Lee, 1997). Faced with a disastrous crop and low domestic stocks, Japan temporarily abrogated its almost total ban on rice imports and signed contracts to import 2.45 million tons. When Japanese traders began to import rice, the impact on world rice prices was immediate and strong but fleeting: in the fall of 1993, prices initially soared, but dropped considerably by $80/MT in 1994 (Figure 2.1). A recovery in Japan's 1994/1995 rice crop, to 10.9 MMT, along with large rice crops for most of the major exporters in 1994, led to significantly lower world rice prices in 1994.

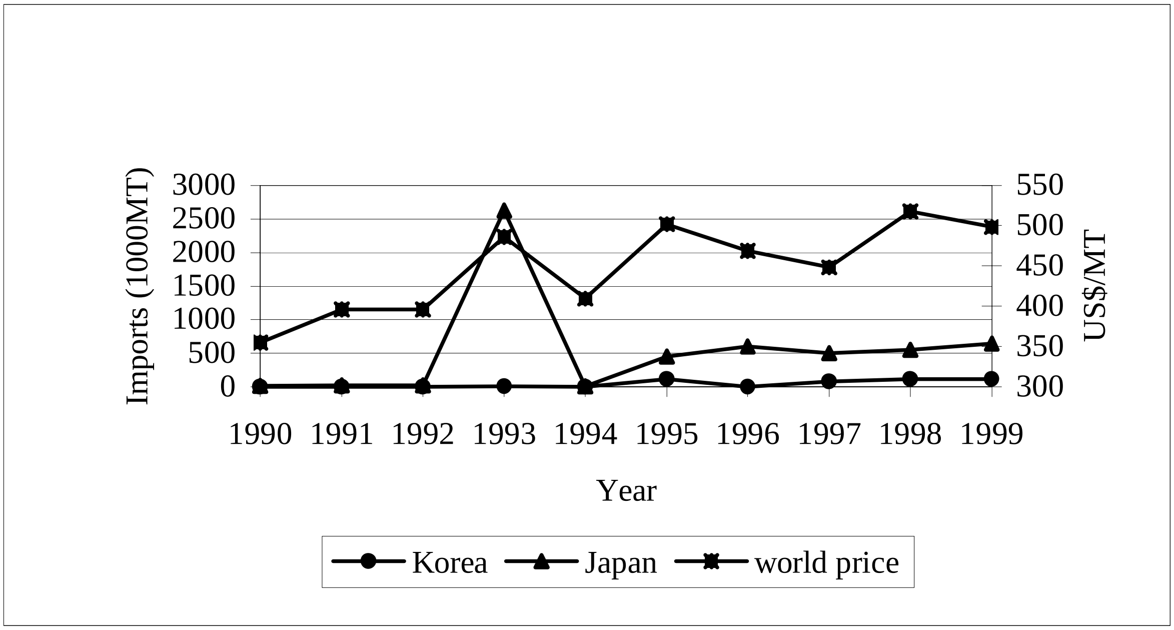

Figure 2.1 Japanese and Korean Imports and the World Rice Price.

Japan has imported all its rice from the United States, China, Australia, and Thailand. The first three countries provided mainly short-to-medium grain (japonica) rice, while Thailand supplied mainly long-grain (indica) and some glutinous rice (USDA/Attaché report, 1997). Thai and Chinese rice has sold at a significant discount to the U.S. and Australia rice as Chinese japonica is of very poor quality, while Thai indica rice has not been well received by Japanese consumers, who prefer high-quality japonica rice. Domestically grown rice has sold at a large premium to all imported rice, but U.S. rice has fared well compared with rice from other countries. Consumers have reluctantly purchased blended domestic and foreign rice as many customers preferred to buy domestic and imported rice packaged separately (MAFF, 1999).

2.2.2 Korea

The South Korean government has intervened in the rice market through both output and input pricing. The government has intervened in the rice market because rice is a very important part of both Korean culture and economy. The total planted acreage of rice decreased from 1,233 thousand ha in 1980 to 1,072 thousand ha by 2000. Rice yields increased from 3.24 kg/ha in 1980 to 4.94 kg/ha by 2000 (Table 2.11).

Rice yields fluctuated until the 1960s, with either floods or droughts seriously affecting the yields. In the 1970s, the government invested in large-scale irrigation projects for paddy fields, developed new high-yielding varieties (Tongil), and also improved traditional japonica varieties. Consequently, rice yields increased in the mid 1970s and became stable thereafter, except for 1980 when unusually cold weather was detrimental to yields (Song, et al., 1995).

Table 2.11. Supply and Utilization of Rice in Korea, 1980-2000.

Year	Area 1,000ha	Yield MT/ha	Production --- 1000MT ---	Consumption --- 1000MT ---	Per Capita Kg	Stocks --- 1000MT ---	Import --- 1000MT ---	Export --- 1000MT ---
1980	1,233	3.24	4,000	5,432	132.4	1,495	2,245	0
1985	1,237	4.55	5,626	5,807	128.1	1,251	0	0
1990	1,244	4.51	5,606	5,490	119.6	2,151	2	17
1993	1,136	4.18	4,750	5,300	110.2	1,393	4	0
1994	1,102	4.59	5,060	5,300	108.3	1,006	3	150
1995	1,056	4.45	4,694	5,200	106.5	615	115	0
1996	1,050	5.07	5,320	5,100	104.9	912	0	0
1997	1,052	5.18	5,450	5,112	102.4	805	77	0
1998	1,059	4.82	5,100	5,038	99.2	980	113	0
1999	1,066	4.94	5,263	5,003	96.6	1,355	115	0
2000	1,072	4.94	5,291	5,000	N/A	1,776	130	0

Source: PS&D, MAFF.
N/A: not available.

Due to this production shortfall in 1980, the government imported more than 2.2 MMT of rice from the United States, mostly from Louisiana and California (Song and Carter, 1996). The actual shortfall was only 1.4 MMT. The excess rice imports resulted in excess stock problems. The ending stocks jumped to 1.5 MMT in 1980 (Table 2.11).

Good harvests followed after 1980, so the self-sufficiency rate exceeded 100 percent throughout the 1980s. A poor harvest in 1993 reduced self-sufficiency to 86 percent but it recovered to 100 percent by 1996. On the other hand, Korean rice production has increased from 3.0 MMT in the early 1960s to more than 5.0 MMT since late 1970's, and this was possible due to the introduction of the Tongil high-yielding variety. Acreage planted to Tongil accounted for 15.8% of the total rice acreage in 1972 and 76.2% in 1987. Beginning in 1992, the government refused to buy Togil and farmers immediately stopped production, resulting in some rice yield decline (Rainey, 1993; MAFF, 1994).

Total paddy rice production has ranged from 4 MMT in 1980 to 5.6 MMT in 1990, and it was 5.3 MMT in 2000. Significant reductions in production in 1993 and 1995 prompted the government to import 115 thousand MT in 1995. This import level was in excess of MA required by the World Trade Organization (WTO).

During the period of 1980-2000, Korean rice consumption has decreased from 5.43 MMT in 1980 to 5.0 MMT in 2000. Ending stocks fell to 0.98 MMT in 1998, but increased to 1.78 MMT in 2000 (Table 2.11). Overall per capita consumption of rice in the 1980 was 132.4kg, but it has decreased gradually to only 119.6 kg by 1990. In the 1990s, the overall per capita consumption has continued to decline to 96.6 kg by 1999.

2.3 Japanese and Korean Rice Policy Changes

2.3.1 Japan

Japan's current rice policy has its roots in the country's economic development policy following World War II. At that time the government sought to encourage rice production through investment in rural infrastructure, research, and extension, while keeping producer rice prices low (Coyle, 1981). The government's policy was carried out under the Staple Food

Control Law ("The 42 Act"). The purpose of the law was to control food and to carry out the adjustment of supply, demand and prices and also to control distribution in order to secure food for customers and to ensure stability in the national economy. The 42 Act gave the government exclusive control over the purchase, sale, and pricing of major foods such as rice, wheat, barley, and potatoes (MAFF, 1995; Kako, et al., 1997).

In addition, Japan's agricultural development initially was further stimulated by land reform. The reform measures transferred ownership of approximately one-third of all farmland to former tenants, imposed maximum sizes on farms, prohibited non-farm residents from renting out more than one hectare, and effectively outlawed the sale of land between farmers. The average family farm size, approximately 1 hectare, was considered a reasonable size for family labor in view of the labor productivity of that time (Susumu and Ito, 1993). Since then, however, Japan's rice policy has had the effect of (1) curtailing the establishment of more efficient and larger farms and (2) encouraging cultivation of rice on a part-time basis.

During the early 1960s, the producer price was roughly at parity with the world price. Producer rice prices subsequently began to increase rapidly, however, ultimately doubling between 1960 and 1969. This rapid increase far exceeded the modest increase in prices paid in the international market. In 1969, the Japanese producer price was more than double the world price (Tweeten, 1993).

Resale prices for rice set by the Japanese Food Agency (JFA) were also high. Just as higher producer rice prices were encouraging production, rising retail price levels also dampened demand, thereby contributing to a decline in total as well as per capita rice consumption in Japan. Under this artificial stimulus, Japan became "self-sufficient" in rice by the late 1960's. The increase in the resale rice price above world market levels was made possible by restrictions on imports. Japan's imports from the United States, which had averaged around 162 thousand MT of milled rice annually from 1964-1967, were sharply curtailed to an average of about 2 thousand MT in 1968 and 1969 (Wailes, *et al*., 1993).

High support prices not only resulted in the accumulation of increasing levels of surplus rice in government stocks, but also contributed to increasing government budget deficits.

To cope with excess production, the government sought to divert farmers to other crops and to dispose of surplus government rice stocks. The JFA responded to overproduction primarily in two ways: diversion programs and surplus disposal schemes. These efforts failed as rice stocks again doubled by the end of the decade (MAFF, 1992).

Beginning in 1969, the government implemented a series of diversion programs designed to induce rice farmers to divert land planted as paddy to the production of other crops. However, this program did not work as expected.

With per capita rice consumption decreasing and excess production remaining at high levels, in 1971, the JFA established a new, long-term program, the Rice Production Control and Diversion Program. The JFA's goal was to cut annual rice production by 2 million tons by inducing farmers to shift about 15 percent of the total paddy field area to other crops.

The diversion program operated through a combination of "administrative guidance" and economic incentives. This consisted of recommendations, advice, or directives issued by the JFA. The JFA supplemented its administrative guidance with a package of economic incentives. The principal measure consisted of direct incentive payments for diversion to other crops. The JFA also took measures to subsidize additional investment costs associated with switching from rice to other crops, such as the acquisition of new machinery and livestock and land improvement to transform paddy to upland fields. Despite the JFA's efforts, however, rice production, stimulated by the high producer prices, continued to exceed target levels in four of the five years the program was in effect. During this period, the JFA also sought to use a rice purchase program to reduce production.

The JFA launched a second diversion program in 1976, the Comprehensive Paddy Field Utilization Program. Target levels of the second diversion program were reduced somewhat. Under the new plan, incentive payments also varied depending on the crop selected. Nonetheless, production in 1977 again exceeded the JFA's target level.

The JFA initiated a third program in 1978, the Paddy Field Utilization Reorientation Program, a diversion plan scheduled to operate through 1987. The program set an annual reduction target of 1.7 MMT of rice for the first two years of the program, and increased upwards to 2.45 MMT in 1980. Japanese imports of U.S. rice during that period averaged only about one thousand MT per year for a total domestic market of about 10 MMT.

In 1986, the government announced that it would divert a total of 70 thousand hectares each year between 1987-1989. This was necessary because of higher than normal rice stocks held as a result of three consecutive bumper harvests from 1984 to 1986. With a fourth bumper crop in 1987, and increasing stock levels, the government decided to expand the rice land diversion by an additional 52 thousand hectares for the 1988 crop (Ito, *et al.*, 1997). The oversupply problem had been further exacerbated by declining consumption as the Japanese diet diversifies further away from rice to other grains and to red meat.

Recently, the situation in the Japanese rice industry has been changing drastically because of the implementation of the GATT Uruguay Round agreement. The GATT agreement allows Japan to exempt rice from tariffication for the period 1995-2001. Even this partial opening of Japanese rice market has been shown to a large impact on the domestic and international rice industry (Cramer, *et al.*, 1996).

Besides the MA rice imports, the Japanese rice sector faces the following emerging issues. First, domestic rice production costs are far above the international prices due to the small scale of farming, relatively high labor costs, high land costs, and over investment in farm machinery. Since Japan has partially opened the rice market, it became critically important to reduce the gap between domestic production costs and those of the major rice exporting countries. The government has implemented various measures to reduce the production costs by promoting structural improvement policies and accelerating technological change. However, Japan's rice farm size has been static. Although the number of large scale farms has increased slightly, the average rice harvested area per rice farm household was 0.64 ha in 1980 and it has not increased significantly since then. Rice production costs in Japan still far exceeds that of rice exporting countries (Table 2.2).

Second, rice is an inferior good in Japan, and a decrease in rice consumption will likely continue in the future (Ito, 1996). On the other hand, rice supply would increase as a result of the MA rice import and rice yield increase. Therefore, the rice diversion program may have to be strengthened in the future in order to maintain a balance between supply and demand. The rice diversion program requires all rice producers to divert the same proportion of paddy field from rice production regardless of their farm size. Thus, the rice acreage diversion program discouraged full time and core farmers from trying to expand their scale of operations. Many researchers pointed out the importance of improving the rice diversion programs not to provide disincentives for more efficient large scale rice farms (Kako, *et al.*, 1996).

Third, the average age of rice farmers has been increasing because of the decline in the number of young farmers staying on the farm. This is due to the inferior income from rice farming and less favorable working conditions compared with non-agricultural economic activities. Most of the rice is produced by small scale part-time farm households with a high dependence on off-farm income.

Under the Uruguay Round minimum access agreement for rice, the government of Japan (GOJ) committed to purchase 379 thousand MT of rice on a milled basis. Of the total minimum access rice, 9,811 MT were allocated for the Simultaneous Buy and Sell (SBS) tenders. The U.S. captured 53 percent market share under the SBS tenders and approximately 46 percent of the minimum access tenders. These tenders were completed in December 1995, and actual imports were completed by the end of the Japanese fiscal year 1995. The GOJ also used 560 thousand MT of foreign rice, which was imported in 1994 on an emergency basis, as food aid to North Korea and other developing countries. The GOJ also implemented the New Food Law in November 1995 replacing the Staple Food Control Law, which had existed over the previous 50 years. Under the new law, some market-oriented principles were introduced into the Japanese rice market but the Japanese Food Agency (JFA) of the MAFF continues to control rice importation, and continues to exert strong influence over domestic distribution.

In the meantime, as mentioned in Chapter one, the Japanese government notified the WTO of its decision to introduce rice tariffication beginning April 1, 1999. Under tariffication, a specific duty of 351.17 yen per kilogram (kg) was applied to imports outside of the MA volume. In and after Japanese fiscal year (JFY) 2000, April to March, a specific duty of 341 yen per kg was applied to imports outside of MA (MAFF, 1999). Japan's tariffication agreement of April 1 has three components: (1) a secondary tariff applied to rice imports above the MA import levels (where the mark-up associated with the tariff equivalent of the MA is considered the primary tariff). The initial secondary tariff rate is set at 351.17 yen per kg for 1999 (approximately $3,000/MT) followed by a 2.5% reduction to 341 yen in 2000; (2) in agreeing to the possibility for over quota imports, Japan was allowed to reduce the annual increase in MA imports from 0.8% to only 0.4%; (3) the new policy adds a safeguard tariff of an additional 33%, triggered at 125% of the previous 3-year moving rice import volume (USDA, 2000).

2.3.2 Korea

Agricultural prices have been unstable and low during the past half century. Low wage rates kept food prices from increasing. In addition, low inflation rates and high savings were needed to achieve high economic growth and to increase the export of industrial products. In particular, low domestic food prices were forced by imported agricultural products, not by the highly increased productivity of domestic agriculture (Song, *et al*., 1995).

As a result, the domestic agriculture system experienced severe damage. Naturally, farmers had a low income growth rate compared with the non-farm sector. An international comparison of the ratio of revenue from agriculture shows that the GNP decreased from 40% to 7% in the Netherlands over took 165 years, 110 years in Denmark, 113 years in Great Britain, 96 years in the U.S., 94 years in France, 92 years in Germany, and 73 years in Japan; however, only 26 years in Korea (Lee, 1996). Korea's rapid decrease in the ratio of agricultural revenue to the GNP resulted in a harsh sacrifice for the agricultural sector through reduced agricultural prices.

Low rice prices continued in the 1960's, and the export of industrial products was accelerated. The manufacturing sector became highly developed as well, therefore changing the whole economy of Korea. But agricultural development lagged behind the industrial sector. In the late 1960's, the government procurement price was lower than the market price. Subsequently, Two Price Systems for Barley (1969) and Rice (1970) were begun in the early 1970's. These policies were aimed at upgrading the self-sufficiency rate of domestic food-grains.

The purpose of rice policy in Korea is to contribute to food security and the stability of the national economy, achieving self-sufficiency of table rice (MAFF, 2000). This policy has the following objectives: efficient production of rice, alignment of demand and supply of rice and maintenance of reasonable prices. In order to achieve its goal of self-sufficiency of table rice, MAFF has strengthened its rice production policy, focusing on improving quality.

Since the 1970s, the rice policy has been changed to a mixed market system aimed at solving food shortages by adoption of a two price system, and the procurement and distribution of the higher yielding (but lower quality) Tongil rice variety. In the 1970s, the rice policy was designed to achieve self-sufficiency for rice and to protect the producers and consumers by the two price system.

In the 1980s, a surplus of rice developed. Although, in 1981, the government imported substantial volumes of rice to deal with the crop shortage in 1980. In this period, agricultural markets were based on the theory of liberalization of comparative advantage and the stabilization of agricultural price. As a result, agricultural imports into Korea increased drastically during this period (Lee, 1997).

From 1990, the rice policy was more concerned with the burdensome rice stocks and a deficit in the government grain account. The government intervened in the rice market and began to sell the government stocks for price stabilization. As a result, the market price of rice declined and the private market system became extremely unstable. At that time, direct management by the government was changed into an indirect management system, including agricultural cooperative associations. The main components of the indirect management system were: 1) allowance of seasonal variation in price, 2) introduction of the deficiency payment system that the government supplements the difference between the purchase and the market prices, and 3) abolition of the rice control fund (MAFF, 1997).

During this period, the full scale import of agricultural products was initiated under pressure by developed countries. For instance, 'The Super 301' trade legislation in the U.S. forced Korea to open its agricultural markets. Another international legal code that led to the liberalization of Korean agricultural markets was the Uruguay Round agreement of the GATT. Accordingly, liberalization was made for 234 commodity areas.

Thereafter, the main stream of agricultural policy was transformed from the policy of self-sufficiency to the policy of import liberalization, from price policy to structure policy, and from agricultural income policy to non-agricultural income policy, etc.

Since the early 1980s, as mentioned earlier, several steps have been taken to dismantle barriers to imports and to reduce export promotion measures. This policy was aimed at improving the efficiency and competitiveness of the Korean economy as it moved into a transitional phase of economic development.

Perhaps equally disturbing is the apparent change in direction in MAFF's basic policies. As mentioned earlier, MAFF has focused almost entirely on rice production policy, as evidenced by the fact that over 90 percent of support expenditures are to rice farmers. A change occurred in 1994 following the Uruguay Round agreement, with resources being gradually shifted from rice to other areas, including production of cash crops, marketing facilities and rural infrastructure.

Traditionally, the Ministry of Agriculture and Forestry has focused almost entirely on rice production policy. A more forward-looking policy was adopted in 1994 following the Uruguay Round agreement, with resources being gradually shifted from rice to other areas, including production of cash crops, marketing facilities and rural infrastructure as mentioned earlier. This past year, due in large part to political considerations, these forward-looking policies have been modified in favor of a renewed emphasis on rice production. This is seen as an attempt to minimize the highly politically-sensitive issue surrounding rice imports.

Starting in 1997 the Korean government introduced a new program, a direct payment system to encourage small and medium-sized rice farmers to retire and transfer productive lands to form larger operations. Productivity would then be enhanced through greater economies of scale (USDA/Attaché report, 1998).

As of 1999, rice income accounted for 39.1 percent of farm income. In 1999, the average rice income per farm household was $6,125, agricultural income was $15,662, and farm income was $18,759. The average rice acreage per farm was 1.0 ha and the rice income/ha was $7,919 (MAFF, 2000). Rice remains as the most important agricultural crop. Accordingly, Korean rice growers are experiencing a general consensus of alarm. The main reason for alarm is because the Korean rice price is very high compared to the foreign rice price, thus Korean rice does not have a competitive edge over the foreign rice. In 1999, the annual average producer price of Korean rice was $1,616/mt, whereas the international price was $499/MT (f.o.b., California Medium No.1), which means the Korean price is over 3 times higher than the international market price. Naturally, the domestic rice industry is challenged to become more cost efficient if it is to develop a competitive rice production system.

According to the UR agreement, Korea was bound to specified import levels under the minimum access rules. Korea has to increase rice imports under the minimum access rules from 1.0 % in 1995 to 4.0% of base year consumption (1986-1988) by 2005. In 1995, Korea was supposed to import 51 thousand MT of rice for the first year of UR/GATT agreement implementation. However, Korea imported 115 thousand MT in 1995, which is mainly due to production shortfall. In 2000, Korea imported 130 thousand MT of rice as the UR agreement commitment.

Despite protestations from the U.S. government, Korean MAFF has announced that all rice imported during the initial years was for processing purposes only. The U.S. government's position is that this is against the spirit if not the law of the UR agreement.

Among competitors, many local experts expect China to be a major supplier over the long term. China has reportedly developed new varieties of rice to meet Korean taste. This rice is being grown by ethnic Koreans in the northeastern provinces of Jilin, Liaoning and Heilongjinag (USDA, 1998).

The price of Chinese rice is about one-eighth that of similar rice produced in Korea. China also has the obvious advantage of lower transportation cost due to its close proximity to Korea. Vietnam and Thailand are also reportedly making plans to export their long-grain rice. Australia is also aggressively seeking to gain a share of any medium-grain rice imported by Korea. As a matter of fact, China has been a major rice exporter to Korea. For example, Korea imported 51 thousand MT of Indian rice to meet its MA requirements in 1995. This rice was intended to meet its 1995 obligations. Since then, Korea imported additional 64 thousand MT of medium grain rice from China to meet its 1996 MA requirements in 1997. In addition, Korea imported 81 thousand MT from China and 13 thousand MT from Thailand in 1999 (USDA, 2000).

Korea's MA commitment is in affect until 2004. Korea's strategy for meeting its commitment includes purchase of only lower quality rice, equivalent to U.S. No. 3 or lower, to avoid table competition for it's heavily subsidized domestic rice.

The WTO Agreement also requires a reduction of domestic production subsidies, which is also leading to a further reduction in rice production in Korea. While the Agreement allows for decoupled income compensation, which means a production-neutral subsidy, Korea is not implementing this direct payment system for all farmers yet (MAFF, 2000).

2.4 U. S. Rice Exports

The U.S. is a leading exporter of rice in the international market, accounting for about 12 percent of global rice trade although the U.S. accounts for less than 2 percent of global rice production. The U.S. currently ranks fourth among major exporters, behind Thailand, Vietnam, and China. More than 40 percent of the U.S. rice crop is exported each year, making the U.S. market sensitive to movements in international prices (USDA, 2000).

Most countries produce only one type of rice, but the United States produces both types (japonica in California, and indica in Arkansas, Louisiana, Texas, Mississippi, and Missouri) and is in a unique position in that it can export significant amounts of both types (Song and Carter, 1996). However, the U.S. rice programs, marketing loan payments and marketing loan gains, essentially treats rice as a homogenous crop (Wailes, 2000) and does not provide clear market signals corresponding to changing market conditions by subspecies (Childs and Lin, 1989). Rice is treated as a homogenous crop in the sense that (a) a single target price and acreage reduction program (ARP) rate is applied to all rice types, and (b) the rice grading system does not distinguish California medium grain (japonica) from southern long grain (indica); i.e., it applies the same loan rate and marketing loan repayment rate. This distinction becomes more critical under freer trade, because the largest potential importers, Japan and Korea, have strong preferences for japonica rice (Wailes, 2000; Haley, 1992).

The total volume of U.S. exports ranged from 2.5 MMT to 2.8 MMT (milled basis) from 1995/96 to 1999/2000. However, this is well below the 1994/95 record of 3.3 MMT. The U.S. was the largest exporter of rice most years from the late 1960's through 1980, with Thailand occasionally out-shipping the U.S. However, Thailand has been the leading exporter of rice every year since 1981, largely due to expanded area. By the mid-1990's, Vietnam had recovered enough from decades of war and political upheavals to become the second largest exporter. The country had returned as an exporter only in the late 1980's after a 30-year absence. In the late-1990's, China emerged as a major exporter due to declining per capita consumption and several years of bumper crops, making the country the third largest exporter.

From 1967 to 1982, Korea imported 8 million metric tons (MMT) of rice and U.S. rice exports supplied 65% of that market-mostly from California (Schnepf and Just, 1995). However, by the mid-1980's, Korea attained self-sufficiency in rice due to generous government programs, and imports were essentially banned. After losing its largest importer, Korea, in 1983, California accumulated rice stocks, relative to the southern states. Since 1983, the U.S. exported no rice to Korea.

In the meantime, Japan accounts for the bulk of U.S. medium grain brown rice exports. In 1999/2000, Japan imported nearly 150 thousand MT of medium grain brown rice from the U.S., down from a year earlier record 250 thousand MT. Japan divides its rice purchases between milled and brown rice, with each type's share varying each year. The U.S. typically supplies half of Japan's total rice purchases. The U.S. exports about 10 thousand to 14 thousand MT of short grain brown rice each year. Japan accounts for two-thirds, most of it sold under the Simultaneous-Buy-Sell (SBS) portion of their total WTO commitments.

The U.S. market share in Japanese import market has been about 50% since 1995. However, the U.S. market share in Japan decreased in recent years due to heavy competition among the major export countries, such as Australia, China, and Thailand. For example, the U.S. has recently lost substantial market share in the SBS to Australia and China.

2.4.1 Government Rice Programs

Rice farming in the U.S. has been affected by federal legislations since the enactment of Agricultural Adjustment Act of 1933. The main objectives of U.S. rice policy have been to support farm price and income, and thus to provide the safety-net for rice farming. To achieve the policy goals, various policy instruments have been adopted that can be classified by three basic categories: (1) price support programs, (2) supply control programs, and (3) income support programs.

Price support has been provided by non-recourse loan program since 1941. Under this program, producers may pledge their production as collateral for obtaining loans from the Commodity Credit Corporation (CCC). Once they have placed their rice under loan, producers have a 9-month period in which to redeem their loans. At the end of that period, they must decide whether to redeem the loan or forfeit their rice to the CCC. Producers have incentives to redeem the loan if the market price rises above the loan rate plus interest charges. Alternatively, they may default on the loan and forfeit the collateral rice to CCC without penalty, when the market prices are unfavorable. Thus, the loan rate may serve as a guaranteed minimum farm price to producers. Only farmers participating in the government farm programs are eligible for such loans.

During the early 1980's, loan rates well above market prices deteriorated U.S. competitiveness in world markets by serving as a "floor price" for U.S. rice. Loan rates in excess large quantities of rice to be forfeited to the government and a large U.S. price premium in international markets. As a result, the price support program was modified to introduce the marketing loan program for rice in the 1985 farm legislation.

The marketing loan program links loan repayment rates to the prevailing world price of rice rather than the higher announced loan rate (ALR). Rice producers can repay loans at the lower of a USDA-calculated world price (loan repayment rate or LRR) or a set percentage of the loan rate. Alternatively, producers can receive an equivalent loan deficiency payment with agreement to forgo placing their crop under loan. The difference between the ALR and the world price (LRR) is called the marketing loan gain, when the world price is below the ALR. If the world price is above the ALR, the LRR equals the ALR (Livezey, 1993).

Supply control programs for rice were changed by the 1981 farm legislation, which terminated acreage allotments and introduced the concept of crop acreage base for individual farms that is eligible for government program benefits. For rice, the acreage base is the average of the acreage planted to rice and the acreage considered planted to rice on the individual farm in the 3 preceding crop years (Schnef and Just, 1995). Supply controls have been implemented through acreage control programs such as the Acreage Reduction Program (ARP) and the Paid Land Diversion (PLD) program, and planting flexibility programs such as the 50/92 program, the normal flex acres (NFA) program, and the optional flex acres (OFA) program.

The ARP has been used as supply control method since 1982, requiring land to be diverted from a farm's rice base acreage and put into approved conservation uses. Compliance was required for eligibility for loans and deficiency payments. Acres reduced under ARP are not eligible for program payment but are considered planted to rice for acreage base purposed. The Secretary of Agriculture has discretion in setting an ARP level, which can range from zero to 35 percent of base acres. Other measures, such as the PLD program and the Payment-in-kind (PIK) program were used together with ARP in 1983 to reduce rice acreage and the large government stocks. The PIK was an acreage reduction program under which farmers received the commodity normally grown on acreage they withdrew from production.

Planting flexibility programs were introduced to allow producers to plant another crop without a reduction in the established crop acreage base so that producers can make production decisions in response to market conditions, rather than being locked into certain crops to maintain acreage base. Specific programs of planting flexibility were the 50/92 program in the 1985 farm legislation and the triple base provisions in the 1990 farm legislation.

Under the 50/92 program, rice growers who under plant their permitted acreage by planting between 50 and 92 percent of the permitted acreage and devoting the remaining permitted acres to a conservation use would receive deficiency payments on 92 percent of the permitted acreage. The 50/92 program was changed to the 50/85 program in 1994 under which farmers are eligible to receive payments on only 85 percent of maximum payment acres (Broussard, 1992).

The concept of "triple base" increased planting flexibility. Normal flex acres (NFA) made up the 15 percent of crop acreage base, which is not eligible for deficiency payments. Crops other than rice can be planted on NFA without decreasing established base. Optional flex acres (OFA) are an additional 10 percent of maximum payment acres that can be planted to rice while receiving deficiency payment or to other crops without losing established acreage base. Thus, maximum payment acreage is equal to the crop acreage base less NFA or any ARP. Under a combined NFA and OFA, up to 25 percent of crop acreage base can be flexed out of rice and planted to another crop while the crop acreage base is protected for future years (Salassi, 1991). As shown in Table 2.13, the ARP was used as a major tool for supply controls during 1982-1990, while the 50/85-92 program and the NFA/OFA provisions became more important starting 1991. However, as a result of the UR agreement, the U.S. agreed to lower its rice tariffs by 36 percent in six equal installments by 2000 starting in 1995. The United States also agreed to establish quantity and budgetary ceilings for export subsidies and reduce these 21 percent and 36 percent by 2000. The U.S. does not currently provide direct export subsidies for rice exports. The U.S. continues to include rice in international food aid shipments the Export Enhancement Program (EEP) provided targeted export assistance in former U.S. markets, but there have been no EEP sales for rice in 4 years.

The 1996 Farm Act, enacted more than a year after the UR was concluded, contained important policy reforms that reduced trade-distorting domestic support policies eliminating 50/85-92 and NFA/OFA programs in 1996. Under the 1996 Farm Act, producer support in the U.S. is provided in the form of direct payments that are not tied to current planting levels, thus fitting in the UR “Green Box” category where policies are exempt from the UR reduction commitments.

Since rice is a program crop, participating rice producers are eligible for production flexibility contract payments (PFCs). In 1997/98, the PFC payment rate was $2.71 per cwt, compared with a market price of $9.70. Participating producers received payments on 85 percent of their contract acreage based on their program yield.

In addition to annual PFC payments, a marketing loan program is provided to U.S. rice producers. Producer support under the marketing loan program includes both loan deficiency payments and marketing loan gains. Payment rates are based on the difference between the announced world price and the established loan rate, with payments resulting when the announced world rice price is less than the loan rate. The marketing loan program fits the UR "Amber Box" category.

Table 2.12. Farm Program Base Acres, Program Acres Idled, and Participation, 1982/83-1999/2000.

Crop Year	Contract acres		Partici-pation rate	ARP as a percent	Acres idled / Diverted / Flexed *				
	Total	Enrolled 1/			ARP	CRP	50/85-92	NFA/OFA	Total
	--- 1,000 acres ---		--- percent ---		--- 1,000 acres ---				
82/83	3,969	3,093	77.9	15	15	NA	NA	NA	0
83/84	3,946	3,857	97.7	15	547	NA	NA	NA	739
84/85	4,183	3,517	84.6	25	785	NA	NA	NA	785
85/86	4,234	3,814	90.1	20	682	NA	NA	NA	1,241
86/87	4,249	3,978	93.6	35	1,305	1	174	NA	1,480
87/88	4,160	3,998	96.1	35	1,325	3	241	NA	1,569
88/89	4,155	3,918	94.3	25	950	4	138	NA	1,092
89/90	4,168	3,906	93.7	25	939	9	245	NA	1,193
90/91	4,154	3,890	93.7	20	735	13	287	NA	1,035
91/92	4,155	3,947	95.0	5	196	13	654	454	1,143
92/93	4,139	3,989	96.4	0	0	13	446	448	907
93/94	4,143	4,000	96.5	5	199	13	481	469	1,162
94/95	4,158	3,969	95.4	0	0	13	258	433	703
95/96	4,182	3,962	94.7	5	197	13	279	427	916
96/97	4,176	4,158	99.6	2/NA	2/NA	6	2/NA	2/NA	2/NA
97/98	---	4,157	99.9	2/NA	2/NA	4	2/NA	2/NA	2/NA
98/99	---	4,161	99.9	2/NA	2/NA	4	2/NA	2/NA	2/NA
99/00	---	4,152	99.9	2/NA	2/NA	3	2/NA	2/NA	2/NA

*: Diverted acres are excluded.
1/ Enrolled for area reduction or contract payments.
2/ Eliminated under the 1996 farm act.
Source: USDA, Rice Situation and Outlook yearbook, 2000.

There were no marketing loan payments from 1996/97 through 1997/98, and payments were negligible in 1998/99. However, low world prices are responsible for sizable marketing loan payments in 1999/2000. Because of economic hardships stemming from falling farm incomes and weather-related disasters, the U.S. Congress provided supplemental emergency assistance payments to recipients of PFC payments in both 1998/99 and 1999/2000. These emergency payments increased payments to rice producers by 50 percent in 1998 and doubled the total level of direct payments in 1999 (Child and Hoffman, 1999).

2.4.2 Government Programs for U.S. Rice Exports

There are four types of government programs for U.S. rice exports. First, under PL 480, the U.S. sells rice on concessional credit terms and donates rice to needy countries either bilaterally or through the World Food Program. Second, USDA provides export credit guarantees (GSM-102) and intermediate Export Credit Guarantee (GSM-103) for commercial financing of U.S. agricultural exports. Third, the Export Enhancement Program (EEP) facilitates U.S. rice sales to markets where the U.S. competes with subsidized exports from other countries. Finally, USDA funds the creation, expansion, and maintenance of foreign markets for U.S. agricultural products. In addition, several other programs can assist U.S. rice exports such as the Emerging Market Program, the Qualities Samples Pilot Program, and the Cochran Fellowship Program.

PL 480

The PL 480 food aid program is comprised of three titles. Title I is administered by USDA. Titles II and III are administered by the Agency for International Development (AID). Each title has different objectives and provides agricultural assistance to countries at different levels of economic development.

Title I provides government-to-government sales of agricultural commodities to developing countries under long-term credit arrangements. Title II provides for donations of U.S. agricultural commodities by the U.S. government to meet humanitarian food needs in foreign countries. Commodities may be provided to meet emergency needs under government-to-government agreements, through public and private agencies, including intergovernmental organizations such as the World Food Program, and other multilateral organizations. Non-emergency assistance may be provided through private voluntary organizations, cooperatives, and intergovernmental organizations. Commodities requested may be supplied from the Commodity credit Corporation (CCC) inventory acquired under price support programs or purchased from private stocks. Title III provides for government-to-government grants to support long-term economic development in least-developed countries.

Credit Guarantees

The programs encourage exports to buyers in countries where credit is necessary to maintain or increase U.S. sales, but where financing may not be available without CCC guarantees.

GSM-102 and GSM-103 underwrite credit extended by the private banking sector in the U.S. to approved foreign banks using dollar-denominated, irrevocable letters of credit to pay for food and agricultural products sold to foreign buyers. New and experienced exporters can benefit from export guarantee programs. Theses programs promote exports by providing exporters greater access to credit and credit risk protection. The GSM-102 covers credit terms for up to 3 years, and the GSM-103 covers longer credit terms for up to 10 years (USDA, 2000).

Under Supplier Credit Guarantee Program, the CCC guarantees a portion of payments due from importers under short-term financing, up to 180 days, that exporters have extended directly to the importers from the purchase of U.S. agricultural commodities and products.

Market Access Programs

The Market Access Program (MAP) uses funds from the CCC to aid in the creation, expansion, and maintenance of foreign markets for U.S. agricultural products. The MAP forms a partnership between non-profit U.S. agricultural trade associations, U.S. agricultural cooperatives, non-profit State-regional trade groups, small U.S. businesses, and the CCC to share the costs of overseas marketing and promotional activities such as consumer promotions, market research, trade shows, and trade servicing.

Foreign Market Development Program

The Foreign Market Development (FMD) program uses funds from the CCC to aid in the creation, expansion, and maintenance of long-term export markets for U.S. agricultural products. The program fosters a trade promotion partnership between USDA and U.S. agricultural producers and processors who are represented by nonprofit commodity or trade associations called Cooperators (Childs and Burdett, 2000).

Export Enhancement Program

The EEP facilitates U.S. rice sales to markets where the U.S. competes with subsidized exports from other countries. The EEP was originally intended to counterbalance subsidized exports by the European Union (EU). Thus EEP has traditionally been used to assist medium grain exports to countries bordering the Mediterranean Sea. In recent years, the EEP's purpose is to counterbalance subsidized exports from specified exporters, i.e., not just the EU. However, with declining EU rice exports in recent years, the importance of EEP subsidies has diminished. In fact, EEP has been eliminated by 1996 FAIR Act. Therefore, there have been no rice EEP sales since August 1995 and no shipments since late 1995 (USDA, 1999).

CHAPTER 3

THEORETICAL FRAMEWORK

In this study, the linkage of the Japanese and Korean rice imports and U.S. rice exports are analyzed using a game theoretic approach along with econometric supply and demand models and the political preference function (PPF) determination.

The Japanese and Korean rice economies are analyzed using empirical supply and demand models and the elasticity estimates. For the U.S., the export demand will be estimated using an empirical econometric model. The elasticities are estimated as well. For U.S. rice exports, the domestic supply and demand will not be estimated because this study focuses on the linkage between the Japanese and Korean imports and U.S. exports, not on the U.S. domestic rice economy. For the reason, U.S. export demand will be estimated.

In addition, a political preference function (PPF) approach is applied to measure the implicit political weights of interest groups of these three countries that represent the policy-influencing powers.

This study analyzes the possible impacts of policy changes in these three countries incorporating the econometric and the PPF determination approaches into a game theoretic approach. Game theory is useful in understanding the nature of market outcomes when such policies matter.

3.1 Supply and Demand Specification

To conduct the analysis for U.S. rice exports, it is essential to coherently estimate the market models for the two countries and export demand for the U.S. In describing the structure of the domestic rice economy, the essential components of the Korean and Japanese rice market models are supply and demand functions. Producer supply and consumer demand are based on microeconomic foundations.

For producers, we assume that there is a profit maximizing producer with the production function f(x), where $x \in R^n$ is an input vector. Furthermore, assume the output price, p, and input costs $w \in R^n_+$ are exogenous. Then the producer's profit maximization problem can be written as: Max $\pi(x) = pf(x) - wx$. A set of input demand functions are derived by solving the first order conditions as: x* = x*(p,w) which are the producer's factor demands that express optimal choices as functions of output price (p) and factor prices (w). Output supply can be derived from the maximum profit functions by applying Hotelling's lemma: y* = y*(p, w). This set of equations shows output supply of the profit maximizing producer, which is a function of output price and input prices, and is homogeneous of degree zero in all prices.

Consumer demand is derived from a utility function that defines consumer preferences. Defining the utility function as U(q), where $q \in R^n$, then the consumer utility maximization problem is Max $\{ U(q): q \in R^n, pq \leq M\}$. Solving the first order necessary condition for q, the Marshallian market demand is derived as a function of price (p) and income (M): q*= q*(p, M) (Varian, 1992).

Agricultural producers operate in an environment with uncertain yields and prices. Farmers typically make production decisions at the beginning of the season, knowing neither the market price for their products at harvest time nor the weather conditions during the season that will determine their yields. Various models could be applied to the commodity markets depending on the objective of research and the market structure. For the purpose of this study, a distributed lag structure is specified to describe the dynamic responses of supply and demand caused by the price expectations and adjustment process. The assumption that the economic system has a distributed lag structure is often justified on the ground that changes in an endogenous variable caused by an exogenous shock may occur through time, and the impacts of exogenous changes on the dependent variable take time to work.

Various theories lead to specific distributed lag models. Initially, such a model was associated with Koyck's (1954) study of investment. However, the Koyck model is ad hoc since it is obtained by a purely algebraic process and has no theoretical underpinning. Two approaches are developed to specify the lag model: the theory-based approach and the data-based approach (Judge *et al*, 1985). The theory-based distributed lag model includes Nerlove's partial adjustment model. In this approach, the forms of the lag are the result of behavioral assumptions.

In this study, Nerlove's partial adjustment model is hypothesized as an appropriate model for capturing the dynamics inherent in supply and demand of the Korean and Japanese rice sectors. Since rice farmers tend to have a lagged response to market prices due to the fixity of costly inputs and imperfect information, the partial adjustment model can be hypothesized as an appropriate model for the study. The partial adjustment model has been widely used in the analysis of the supply and demand for particular commodities. Among the most typical studies, the work of Nerlove (1958, 1983), Rao (1989), Fan, Wailes and Cramer (1994), Song and Carter (1996), Love and Rausser (1997), Cramer, *et al*. (1999) are related to agricultural commodities. This short selective list suggests that the partial adjustment model is particularly appropriate for the analysis of agricultural commodities.

Dynamic specifications of supply and demand response models have been popular since Nerlove (1958) used the partial adjustment model of supply response. In the partial adjustment model, the actual value of the dependent variable adjusts by some constant fraction of the difference between the actual and desired values. This can be justified by citing technological, institutional or psychological inertia.

In Korea and Japan, adjustment inertia may be directly related to an unfavorable production structure and heavy regulation in the rice sector. In addition, Eckstein (1984) shows that a dynamic rational expectations supply equation derived from the farmer optimization problem is equivalent to the Nerlovian supply response model in that both models have the same reduced forms. Eckstein (1984) shows that the dynamic supply equation derived from the farmer optimization problem, which considers dynamic constraints on land allocations through the cost function, can justify the Nerlovian supply equation.

Furthermore, habit formation seems to be a predominant characteristic of agricultural demand behavior, particularly for a national staple food like rice in Japan and Korea. With rice being an important staple food, consumers may also buy stable quantities that are different from the equilibrium quantities indicated by their static demand equation. This implies that consumers tend to adjust only partially to changes in optimal purchase quantities. Thus, the partial adjustment model is also thought to be an appropriate model for explaining the dynamic nature of the Korean and Japanese rice consumption. In consumer demand it is assumed that consumers do not adjust their consumption behavior instantaneously to changes in price and income due to habit formation.

The dynamic econometric model specified in this study is characterized by a combination of a partial adjustment process both in supply and demand, and cobweb type price expectations in supply response. The long-run adjustment responses are embodied in this model due to factor fixity in supply and habit formation in demand.

Supply and demand responses for rice are specified in terms of domestic production and consumption. The dynamics and the relationship between short-run and long-run responses can be seen by the specified market model within the partial adjustment model framework.

3.1.1 Supply Model

We assume that the supply of rice is determined by profit-maximizing producers. They maximize their net revenue received from their outputs subject to technical and regulatory constraints. Based on the theory of the producer, the relationships can be expressed as functions of expected output price and input prices. Like other agricultural producers, however, rice farmers tend to have a lagged response to the market price because of fixed inputs such as land and machinery. Also, the rice price in the previous year may be a major factor in the current year's planting decision, since the price of rice has been controlled by both countries' governments after the harvesting season. Thus, the previous period's price is used as an expected price. When this naive expectation is combined with the partial adjustment behavior, the acreage response equation can be derived.

A Nerlovian expected price and partial adjustment model is used to specify each country model. Nerlove (1958) assumed that farmer's reactions are based on price expectations and/or area adjustments. In the partial adjustment model, the actual value of the dependent variable adjusts by some constant fraction of the difference between the actual and desired values. The basic concept of the Nerlovian model is as follows: Models of supply response can be formulated in terms of yield, area harvested, or output response of individual crops. For instance, the desired area to be allocated to a crop in period t is a function of expected relative prices and a number of shifters:

$$Q^*_t = \alpha + \beta P^*_t + \lambda Z_t + U_t \quad (3.1.1)$$

In equation (3.1.1), Q^*_t is the desired cultivated area in period t; P^*_t is the expected price; Z_t is a set of other exogenous shifters, principally private and public fixed factors and truly exogenous variables such as the price of major inputs; and U_t accounts for the unobserved random variable affecting the area under cultivation with expected value of zero. The α, β, and λ are parameters (or elasticities if the variables are expressed logarithmically) and β is the long-run coefficient (elasticity) of supply response.

Because full adjustment to the desired allocation of land may not be possible in the short run, the actual adjustment in area will be only a fraction δ of the desired adjustment:

$$Q_t - Q_{t-1} = \delta(Q^*_t - Q_{t-1}) \quad (3.1.2)$$

where Q_t is the actual area harvested of the crop, δ is the partial-adjustment coefficient.

Equation (3.1.3) and (3.1.4) indicate the producer's price expectation mechanism linking P* and W* to observable P and W values.

$$P_t^* = P_{t-1} \quad (3.1.3)$$

$$W_t^* = W_{t-1} \quad (3.1.4)$$

The reduced-form equation relating acreage and prices is found by solving equations (3.1.1)-(3.1.4) for acreage in terms of the observable variables of the system, yielding

$$Q_t = b_1 + b_2P_{t-1} + b_3Z_{t-1} + b_4Q_{t-1} + e_t \quad (3.1.5)$$

where $b_1 = \alpha\delta$, $b_2 = \beta\delta$, $b_3 = \lambda\delta$, $b_4 = 1-\delta$ and $e_t = \delta U_t$.

This hypothesizes that the current acreage response depends on the expected output and input prices as well as on the acreage in the previous year. The larger the coefficient of adjustment (δ), the faster the acreage adjustment is completed. If $\delta = 1$, then complete adjustment occurs in the current period so that the short-run acreage response is equal to the long-run equilibrium. The short-run supply elasticity with respect to the output price is easily derived from equation (3.1.5).

The lagged dependent variables are used in some specifications since it is assumed that producers adjust to changes in market condition over time rather than instantaneously following Nerlove.

In addition, the area harvested affects rice yield. When a government implements a diversion program, producers divert less productive land first if they are given a choice. The other factors affecting yield is technology (TT).

The domestic yield equation is specified as:

$$YHA_t = f(AHA_t, TT, D) \quad (3.1.6)$$

$$PD_t = YHA_t * AHA_t \quad (3.1.7)$$

where AHA_t = area harvested in time period t

YHA_t = yield in time period t

TT = time trend

PD_t = production

D = dummy variable to indicate a natural disaster and/or other unexplainable variations.

3.1.2 Demand Model

We assume that the demand for rice is determined by utility-maximizing consumers subject to the budget constraint. Based on the neoclassical theory of utility maximization, consumer demand for rice is described as a function of the own price, prices of substitutes, and income. The dynamics of demand, which is postulated as resulting from habit formation in this study, is analyzed similar to the producer case. For example, if we assume that rice consumption is gradually affected by the consumer’s price through a geometric lag, one-year lagged consumption could be selected to impose a lagged distribution effect on the current consumption behavior. Then, the consumption function is derived as follows:

$$CON_t^* = \delta_0 + \delta_1 P_t + \delta_2 PS_t + \delta_3 I_t + u_t \qquad (3.1.8)$$

$$CON_t - CON_{t-1} = \pi (CON_t^* - CON_{t-1}) \qquad (3.1.9)$$

where CON_t^* is desired consumption which depends on consumer price (P_t), substitute prices (PS_t), income (I_t), and a disturbance term (u_t).

Equation (3.1.9) is the partial adjustment process arising from habit formation. The coefficient of adjustment is denoted by π. Combining the above two equations yields a first-order difference equation,

$$CON_t = \delta_0 \pi + \delta_1 \pi P_t + \delta_2 \pi PS_t + \delta_3 \pi I_t + (1-\pi)CON_{t-1} + \pi u_t. \qquad (3.1.10)$$

The observable and estimable consumption equation is as follows:

$$CON_t = c_1 + c_2 P_t + c_3 PS_t + c_4 I_t + c_5 CON_{t-1} + e_t \qquad (3.1.11)$$

where $c_1 = \delta_0 \pi$, $c_2 = \delta_1 \pi$, $c_3 = \delta_2 \pi$, $c_4 = \delta_3 \pi$, $c_5 = 1 - \pi$, and $e_t = \pi u_t$.

The short-run and long run elasticities with respect to the retail price are defined as: $\eta^{LR} = \eta^{SR}/\pi$. One would expect that the own-price effect will be negative and that the income effect will be positive in the case of normal goods, with the sign reversed if rice is an inferior good.

In this study, consumption is specified in terms of per capita demand rather than the aggregate consumption level. An important issue in empirical work on market demand is the aggregation problem. Estimating the aggregated consumption parameters with any reliable confidence is not easy. The difficulties encountered when proceeding from individual demand equations to aggregate demand equations are generally referred to as ‘the aggregation problem’.

Per capita relationships have the additional advantage of being more meaningful and stable relationships (Varian, 1992; Houthakker and Taylor, 1970)

Actually it has often been argued that regression analysis of aggregated consumption could not give plausible estimation of parameters. Therefore, in this study, the domestic rice consumption is specified in terms of per capita rice demand. When we use aggregate consumption data divided by population to implement models derived from the theory of an individual consumer, we think of them as relating to a representative consumer whose behavior reflects the average consumer. Domestic consumption is defined as per capita consumption times population. Then, the aggregated consumption is calculated as

$$TCON_t = CON_t * POP_t \tag{3.1.12}$$

where $TCON_t$ represents the total rice domestic consumption and POP_t is total population determined exogenously in year t.

3.1.3 The Specification for U.S. Export Demand

Product differentiation is considered a critical factor in understanding rice trade flows (Siamwalla and Haykin, 1983; Cramer, *et al*., 1991). One difficulty in trying to differentiate among rice products is that there is no standard classification in use. Strong preferences for particular rice types are based primarily on cooking and taste characteristics (Wailes, 2000).

In this study, especially for the export demand model, U.S. rice is modeled as a heterogeneous commodity, and is categorized into two groups: California rice (japonica), and southern states' rice (indica) to avoid aggregation bias that may occur when rice is treated as a homogeneous product (Batemen, 1988; Cramer, *et al*., 1993; Song and Carter, 1996; Wailes, 2000).

California short/medium grain rice is acceptable in Japan and Korea. Therefore, California short/medium grain rice is considered as japonica and southern states' rice is considered as indica. In fact, It could be argued that since Korea imported Louisiana medium-grain rice in the early 1980s, southern medium–grain can be considered japonica, which Korea and Japan would consume. However, Korea imported Louisiana rice when threatened with an extreme food shortage. At that time Korea actually produced high-yielding varieties of a japonica-indica hybrid. In addition, Japan imported 2.6 million MT from the U.S., China, and other countries in the early 1980s when unusual cold weather caused a food shortage. But Japanese refused to eat the imported rice and the Japanese government reexported the imported rice to developing countries. Therefore, the way we differentiate the type of rice described above would be reasonable.

The export demand is specified as a function of the relative price of rice types (i.e., the ratio of the domestic price of type *i* to the world price of type *i*), quantity of rice exported via specific government export programs for both types of rice, world ending stock, and other exogenous variables. The specification is as follows:

$$EXP_{it} = f\ (P_{dit}/P_{wit}, GOV_{it}, ESTW_{it}, EX_{it}) \qquad (3.1.14)$$

where EXP_{it} = the Export quantity for type i

P_{dit}/P_{wit} = ratio of the domestic price of type i to the world price of type i

GOV_{it} = quantity of government-assisted rice exports for type i; Export Enhancement Program (EEP) and Commodity Credit Corporation (CCC)

$ESTW_{it}$ = world ending stock for type i

EX_t = other exogenous variables that affect export demand, Japanese japonica imports and beginning stocks for indica, and so forth (Song and Carter, 1996; Watanabe, *et al*., 1990; Goldstein and Khan, 1976).

3.1.4 Estimation and Evaluative Statistics

There are two equations in the supply system and the error terms are correlated with each other. As a result, ordinary least squares (OLS) estimates of the regression coefficients are inconsistent because quantities allocated to the separate supply components take place simultaneously (Green, 2000; Kennedy, 1998, Judge, *et al*, 1985). For the study, the supply parameters are estimated using two-stage least squares (2SLS).

The demand equations, per capita consumption and U.S. export demand, are estimated by ordinary least square (OLS). The OLS is chosen over other estimators to derive empirical results for the adaptive expectations model for the following reasons. Kennedy (1998) suggests that it is possible to use the OLS estimator and simply accept its asymptotic bias. This can be defended in several ways. First, although the OLS estimator is biased in small samples so also are all alternative estimators. Furthermore, the OLS estimator has minimum variance compared with alternative estimators such as two-stage least squares (2SLS), and instrumental variable (IV). Second, according to Monte Carlo studies, the properties of the OLS estimator are less sensitive than the alternative estimators to the presence of estimation problems such as multicollinearity, errors in variables or misspecifications. In addition, there is substantial justification for the continued use of OLS in relationships containing lagged dependent variables, provided the disturbance term is serially independent (Green, 2000; Judge, *et al*., 1988).

In addition to the estimated structural coefficients of the model, the estimation approaches used in this study generate several statistics. These include Durbin's *h* test (DW-*h*), t statistics, and others where appropriate.

Based on various statistical tests for autocorrelation, heteroscedasticity, and normality, the model specification tests are conducted in the single equation context to determine if the estimation method employed in this study is appropriate. DW-*h* test is conducted for autocorrelation, the White's test are carried out for heteroscedasticity. In addition, the Bera-Jarque normality test is conducted as well (Judge, *et al*., 1985).

For model validation, the *rms* (root-mean-square) *simulation error,* the *rms percent error,* and *the mean simulation error are* used. In addition, Theil's inequality coefficient, a useful simulation statistic related to the *rms* simulation error and applied to the evaluation of historical simulations, is used for the study (Green, 2000; Pindyck and Rubinfeld, 1991; Judge, *et al.*, 1985).

3.2 Determination of Political Weights

3.2.1 Political Preference Function (PPF)

In choosing agricultural policies, governments consider the effects of their policies on the welfare of various groups such as producers, consumers, and taxpayers. In addition, since agricultural policies can make some groups better off at the expense of others, governments must weigh the welfare gains of one group against the welfare losses of others. These trade-offs can be represented by a Political Preference Function (PPF), a weighted, additive function of commodity quasi-rents, indirect utility of consumers, and the costs of agricultural policies to tax-payers (Roe, 1993).

The political preference function approach views policy decisions as the outcome of a political bargaining process. It claims that an appropriate political preference function can reveal the role of interest groups in determining endogenous policies, which leads to the policymakers' political willingness to redistribute income through policy adjustments. In the political preference function, it is assumed that there exists a rice policymaker who acts to arbitrate the conflicting objectives of interest groups that seek to maximize their own benefits from the rice policy. As an arbitrator of competing interest groups, the policymaker selects the levels of a set of rice policy instruments so as to maximize his/her political preference function. With this assumption, the political preference function approach can measure the political willingness to redistribute income among interest groups in the course of setting the levels of rice policy instruments. This implies that the policy decision is determined endogenously according to the pattern of the implicit political weights given to the interest groups (Bullock, 1994; Gardner, 1987; Paarlberg and Abbort, 1986).

The political preference function approach typically assumes that the government chooses policy instruments so as to maximize a welfare criterion function consisting of interest groups' welfare measures. Formally, the government problem can be expressed as:

$$\text{Max PPF}(\omega(\text{x, b})) \qquad (3.2.1)$$

$$\text{subject to } \omega(\text{x, b}) \in \text{F} = \{\omega \mid \omega = \omega(\text{x}), \text{x} \in \text{X}\},$$

where PPF is the government's political preference function, which is assumed to be monotonically increasing in its arguments. ω represents a vector of welfare levels of interest groups. Also, let b denote a vector describing market structure, which is assumed to be exogenously given. X denotes the set of policy instrument levels from which the government can feasibly choose x, and F denotes the set of technically feasible policy outcomes.

Since ω indicates the vector of interest groups' welfare that can be brought about by government policy, the constraint in equation (3.2.1) implies that a rational government operates its policy level along a transformation contour, denoted as F. The first order necessary conditions for the above maximization problem imply that the contour of the PPF should be tangent to the boundary of F. Therefore, a political preference function approach can measure the political weights only by assuming that the observed policy is Pareto optimal.

Consider the general case of a policymaker who has $m \geq 1$ policy instruments and $n \geq 2$ interest groups. The vector $\omega(x)=(\omega_1, \omega_2, \ldots, \omega_n)$ represents a vector of welfare levels of interest groups such that each group's welfare depends on the level of policy instruments, and $x=(x_1, x_2, \ldots, x_m)$ is the policy instrument vector.

Under the assumption of PPF maximization, the relevant first order necessary conditions for x* to maximize the PPF as in (3.2.1) are derived by:

$$\begin{bmatrix} \frac{\partial\omega_2(x^*)}{\partial x_1}, \ldots\ldots\ldots, \frac{\partial\omega_n(x^*)}{\partial x_1} \\ \frac{\partial\omega_2(x^*)}{\partial x_2}, \ldots\ldots\ldots, \frac{\partial\omega_n(x^*)}{\partial x_2} \\ \vdots, \ldots\ldots\ldots\ldots\ldots, \vdots \\ \frac{\partial\omega_2(x^*)}{\partial x_m}, \ldots\ldots\ldots, \frac{\partial\omega_n(x^*)}{\partial x_m} \end{bmatrix} * \begin{bmatrix} -\frac{PPF_2}{PPF_1} \\ -\frac{PPF_3}{PPF_1} \\ \vdots \\ -\frac{PPF_n}{PPF_1} \end{bmatrix} = \begin{bmatrix} \frac{\partial\omega_1(x^*)}{\partial x_1} \\ \frac{\partial\omega_1(x^*)}{\partial x_2} \\ \vdots \\ \frac{\partial\omega_1(x^*)}{\partial x_m} \end{bmatrix} \qquad (3.2.2)$$

where $PPF_i = \frac{\partial PPF}{\partial \omega_i}$, which represents the marginal value that the policymakers place on the economic surplus accruing to interest group i(i=1,…,n) and $\frac{\partial \omega_i}{\partial x_j}$ denotes the marginal welfare change of interest group i according to the change in the level of policy instruments j.

The above optimal condition (3.2.2) can be expressed in matrix form as:

$(3.2.2)^{/}\ A_{-1} * \lambda_{i1} = A_1$

where A_{-1} is an m by n-1 matrix whose elements are $\frac{\partial \omega_i}{\partial x_j}$, λ_{i1} is an n-1 by 1 vector whose elements are $-\frac{PPF_i}{PPF_1}$, i=2…n which indicate the marginal rates of substitution along the indifference contour (Im, 1999).

PPF studies generally define λ_{i1} as the political weight for interest group i, relative to the weight for interest group 1. A_1 is an m by 1 vector whose elements are $\frac{\partial \omega_1}{\partial x_j}$, j=1, 2, …,m. Now, our interest is to find a political weight vector (λ_{i1}) from the equation (3.2.2) or $(3.2.2)^{/}$. The first order necessary conditions for the above maximization problem imply that the PPF approach can measure the marginal rates of substitution from observed data to infer the implicit political weights of interest groups that are not directly observable.

The nature and number of arguments that can be included in a political preference function is unrestricted. Basically, the political preference function originates from the social welfare function and can be expressed in various functional forms, such as exponential, additive, logarithmic, and multiplicative. In practice, however, the linear-additive form is almost always used for reasons of mathematical simplicity. In addition, we need to consider which policy instruments and interest groups are important. In reality, many policy instruments are available or used by governments, and many interest groups influence policy decisions. Therefore, we need to aggregate or omit some interest groups, or ignore the availability of some policy instruments, and use a simplified econometric model to estimate parameters. In other words, empirical PPF researchers have to decrease the dimension of the true political economy (Gardner, 1987).

The approach is graphically illustrated in Figure 3.1 with the help of the surplus transformation curve formulated by Gardner (1983, 1987). Figure 3.1 represents a surplus transformation curve for one policy instrument (m=1) and two interest groups (n=2). For simplicity, assume that taxpayers get the same welfare weight as consumers. The surplus transformation curve is the locus of all Pareto-optimal combinations of producer and consumer/taxpayer surplus that policymakers can generate given the constraint of only one instrument available. Such a curve (AA) is shown in figure 3.1 for the case of a policy, which improves the welfare of producers of a commodity at the expense of consumers and taxpayers. This curve represents the supply side of the market for intervention; its shape and location depend not only on the underlying supply and demand functions, but also on the type of policy. The demand side of the market for intervention is represented by W, which might be called political indifference curves. The political indifference curve can be derived by totally differentiating the government's political preference function and setting d(PPF) equal to zero. Point *b* is where policymakers maximize their political utility such that the political indifference curve is tangent to the surplus transformation curve.

In the absence of government intervention in the commodity market, economic surplus is distributed between producers and consumers as indicated by point *e*. The policy adopted has the effect of reducing the welfare of consumers and taxpayers by the amount *ce* and increasing the welfare of producers by *bc*. The dead-weight loss generated by the policy is *bd*.

However, with the political preference approach, the political equilibrium is found at point b where the government maximizes its utility and the marginal rate of transformation is the slope of *aba*. At the political equilibrium, *aba* is also the marginal rate of substitution between producers and other interest groups' welfare in the policy objective function. If we

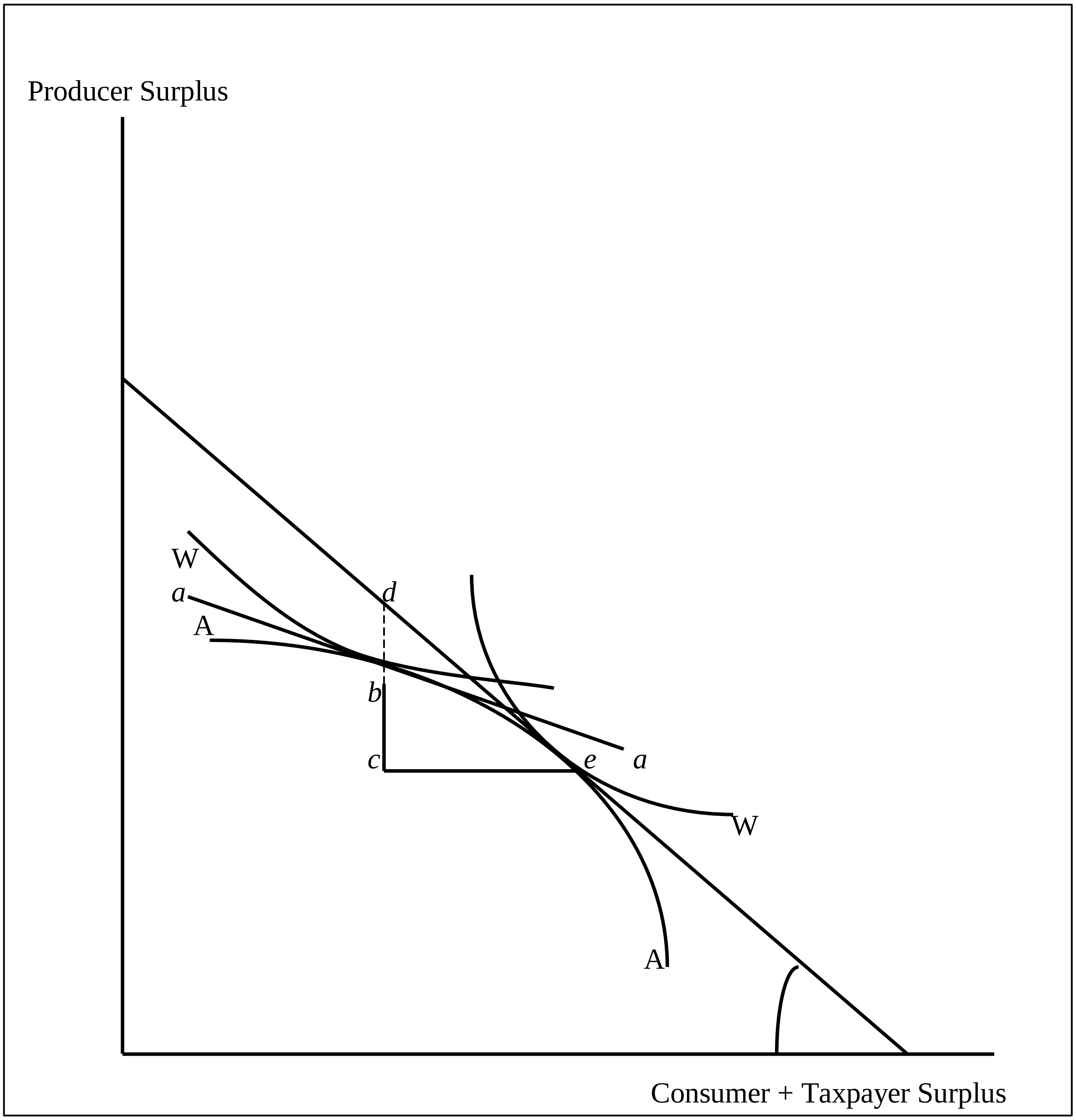

Figure 3.1 Determination of optimal policy with political weights.

Source: Gardner, 1987; Im, 1999.

assume that the set of policy choices available to the policymaker is continuous and unbounded, and if the Pareto frontier is strictly concave, we can determine the equilibrium weights from the first-order conditions of the policymaker's maximization problem. Observed policy levels reveal the weights on the policy preference function, given the structure of the economy. Although a major limitation of this model is that the underlying political process that determines the preference weights is not specified, this approach can be a useful tool for explaining policy selections, predicting future policy paths and normatively evaluating alternative policy reforms.

For the PPF model of the political economy of the rice markets, we must identify interest groups and policy instruments. This study uses a group distinction employed in conventional welfare economics (n=3): producers, consumers and taxpayers, which have their own independent objective functions. Rice producers are assumed to maximize producers' surplus (PS), consumers maximize consumers' surplus (CS), and taxpayers minimize net government expenditures (GS) on the rice policy.

For policy instruments, a two-price policy (m=2) is considered for Japan and South Korea, which has been an integral part of the both rice economies and has undoubtedly created large welfare effects on interest groups, and producer price and retail price for the U.S. Rice is often sold to consumers at prices below purchase prices, although the consumer price is much higher than the international price in Japan and South Korea. In fact, the two-price policy influences the private market through the operation of purchase and release price levels, and the amount associated with the government's stock and import management. In this study, the producer and consumer prices, which reflect the results of a combination of price and quantity operation, are regarded as the policy instruments.

The policymaker is assumed to set consumer and farm prices for rice in order to maximize a political preference function, which includes each interest group's welfare measure. It is consistent with the maximization of the following political preference function:

$$Maximize_{p}\ U = U(PS(P), CS(P), GS(P): \alpha), \tag{3.2.3}$$

where U represents the policymaker's policy preference based on producer surplus (PS), consumer surplus (CS), and government budget surplus (GS), where the latter represents taxpayers' welfare. P= (P_S, P_D) is a vector of rice price levels, where P_S and P_D are producer and consumer prices, respectively. α denotes a vector of parameters representing the underlying commodity model.

Each group's welfare depends on the level of policy instruments. Expressions for producer surplus, consumer surplus, and government surplus are derived from the commodity model. Based on this structure, the government chooses the optimal producer and consumer prices so as to maximize equation (3.2.3). The optimal price policy can be obtained by differentiating the political preference function with respect to the producer price, P_S and the consumer price, P_D. The first order conditions are:

$$\frac{\partial U}{\partial P_S} = \lambda_P \frac{\partial PS}{\partial P_S} + \lambda_C \frac{\partial CS}{\partial P_S} + \lambda_G \frac{\partial GS}{\partial P_S} = 0, \tag{3.2.4}$$

$$\frac{\partial U}{\partial P_D} = \lambda_P \frac{\partial PS}{\partial P_D} + \lambda_C \frac{\partial CS}{\partial P_D} + \lambda_G \frac{\partial GS}{\partial P_D} = 0, \tag{3.2.5}$$

where $\lambda_P = \frac{\partial U}{\partial PS}$, $\lambda_C = \frac{\partial U}{\partial CS}$ and $\lambda_G = \frac{\partial U}{\partial GS}$

Each λ_i (i= P, C, G) is a political weight that the government places on the interests of producers, consumers and government budget. The political weights represent the results of competing policy influencing efforts of interest groups and measure the degree of policymaker's political willingness to favor a group.

3.2.2 Derivation of the Political Weights

It has been widely recognized that the political (or welfare) weights reflecting the bargaining power and policy-influencing efforts play an important role in determining government behavior in agricultural policy. There are three general approaches to obtaining the political weights in a model of political economic behavior: 1) the direct approach, consisting of interviews with policymakers to determine the political weights, 2) the indirect approach, also known as the revealed preference method, in which policy decisions are assumed to optimize the political preference function subject to appropriate constraints so the policy preference weights can be inferred, 3) the arbitrary approach, in which the researcher simply chooses political weights according to his own beliefs (Sloof, 1998).

It has been accepted that the usefulness of the direct and arbitrary approach for policy setting and evaluation is limited (Love, Rausser and Burton, 1990). Along this line, the revealed preference approach has been developed to quantify the invisible policy influencing efforts of the interest groups. Within this structure, it is assumed that political weights of interest groups are inferred from past policy action. The basic assumption of the revealed preference method is that past levels of policy instruments are outcomes of optimizing the political preference function by the policymaker.

3.3 Game Theoretic Approach

This study analyzes the possible impacts of policy changes in these three countries using a game theoretic approach. Game theory is useful in understanding the nature of market outcomes when such policies matter. Agricultural policy games are now played on a transaction-by-transaction basis in an uncertain market environment and where payoff functions are also changing over time (Johnson, *et al*., 1993). The policy analysis in the game theoretic approach looks specifically at the behavior of the rice price, import policy, and export policy variables. This study addresses policy analysis including several reasonable scenarios with respect to tariff equivalents. Overall, a game theoretic approach is adopted to determine potentially possible policy options for U.S. exports on each policy change in Japan and Korea. The game theoretic approach focuses on the equilibrium for Japanese and Korean rice import policies and the U.S. export policies.

3.3.1 Axioms of Game Theory

Game theory is concerned with the study of situations involving two or more decision makers such as individuals, organizations, or governments. Decision makers are designated as players. The players often have partly conflicting interests and make individual or collective decisions (Dockner, *et. al*., 2000). In a game, the fortunes of the players are interdependent: the actions taken by one particular player influence not only his own fortune but also the fortunes of the other players. Such interdependence is well known from many areas of economics and international trade.

Game theorists make a distinction between two kinds of games: cooperative and noncooperative. Supposing that a game is played in a noncooperative way means that the institutional environment is one in which the players cannot or will not make binding agreements to follow some joint course of action. Players are rivals and all players act in their own best interest, paying no attention whatsoever to the fortunes of the other players. A fundamental problem for any player in a noncooperative game is that of strategic uncertainty: when a player must act, he does not know for sure how the other players will act.

Noncooperative game theory offers a formal methodology to try to resolve the strategic uncertainty and predict what could be the outcome when rational players have acted in accordance with their plans.

The categorization of games as cooperative and noncooperative should be seen as a recognition of the fact that often there is more than just one way in which a particular game can be played. It is less advisable to think that the set of all games in some exogenous way has been divided into cooperative and noncooperative ones. Depending on the underlying institutional characteristics, a game may be analyzed as cooperative or noncooperative.

The main part of game theory takes its starting point in a set of hypotheses concerning the kind of behavior that players are assumed to have. Fundamental axioms are that players are rational and think strategically. Being rational means that a player has clear preference, represented by a payoff function. Payoff can be expressed in terms of utility, profit, sales revenue, negative cost, or any other quantitative measure. Rationality includes that a player knows the number of opponents and the set of all possible strategies that are available to them, and that he can form probabilistic expectations about any uncertainty that may influence the play of the game.

The number of players, the sets of strategies available to them, and the payoffs are essential elements of what game theorists call the rules of the game. The rules are the theorist's formal description of a game and they should be derived from the institutional environment in which the game is supposed to be played, rather than being chosen on an ad hoc basis. The theory includes the assumption of common knowledge, which means that all players know the rules of the game and each player knows that his opponents know the rules, and that the opponents know that he knows the rules, and so forth. All players are aware that they face rational opponents and all players think strategically. The latter means that, when designing his strategy for playing the game, a player takes into account any knowledge or expectation he may have regarding his opponents' behavior.

At the same time, game-theoretic models are sometimes criticized for employing too many unrealistic behavioral assumptions and for including only a small number of the features of a real-world institutional environment. People who insist on realistic models say that this produces the right solution to the wrong problem. Here we should be aware that models sensations of real world phenomena, but even very simplified models do not necessarily produce useless predictions. The predictions that result from simple models are correct on their assumptions and one strength of formal modeling lies in the fact that everyone can verify the validity of the conclusions derived from the model. In contrast, a fair part of the strategic recommendations offered by policy makers on strategic decision-making cannot be verified and any faith placed in such advice is largely a matter of trust (Dockner, *et. al.*, 2000; Norman and Thisse, 2000; Sloof, 1998; Gardner, 1995).

Usually there are three elements of a game theoretic study. First, it is necessary to scrutinize the institutional environment in which the game is supposed to be played in order to obtain a plausible set of rules of the game and to select the relevant variables and their relationships. Next, a mathematical structure must be designed, a game theoretic model that reflects in a simplified way the pertinent aspects of the strategic problem. Third, the interesting properties of the model must be rigorously deduced.

3.3.2 Basic Noncooperative Game Theoretic Model

Noncooperative game theory uses two types of models: the strategic form and the extensive form. The strategic form includes the following three elements:

(1) A set of players $N = \{1,2,\ldots,N\}$.

(2) For each player $i \in N$ a set of feasible strategies U^i.

(3) For each player $i \in N$ a real-valued function J^i such that the value $J^i(u^1, u^2, \ldots, u^N)$ represents the payoff of player $i \in N$ if the N players use the strategies $(u^1, u^2, \ldots, u^N) \in U^1 \times U^2 \times \ldots \times U^N$.

The notion of a player's strategy is fundamental in game theory. We may think of a strategy as a player's contingent plan, to be determined before playing the game. A strategy is a function that tells the player how to select one of his feasible actions whenever he must make a move, for all possible events as the history of the game. Thus, a strategy is a mapping from the set of possible histories of the game to the set of feasible actions. It is important to note that a strategy prescribes a player's choice of action for all possible histories of the game, including those histories that will never be observed.

When the strategic form is used, the game theoretic model includes a list of all possible strategies of all players. Each player is supposed to select before the play of the game one of his feasible strategies. Each player makes this choice independently of any other player and there is no communication or cooperation among the players when they make their strategy choices. No player is informed about the choice of strategy of any other player and this is what causes the problem of strategic uncertainty.

There is no explicit element of time involved in a strategic form game. Nevertheless, a strategic form game can represent a game that is played over several time periods. In a game played over time, a rational player can determine in advance a complete, contingent plan for all his actions that he must take during the whole game. Such a plan, a strategy, specifies what particular action the player should take in any situation that may occur at any instant of time during the game. The actual play of the game then amounts to the implementation of the players' predetermined strategies.

The extensive form of a game is used for games played over time and is represented by a game tree. The extensive form includes a description of the sequence in which possible chance events will occur during the game. Although these questions of timing are only implicit in the strategic form, the concept of a player's strategy can be seen as an object of both an extensive and a strategic form game. In the extensive form, a player waits to take his action until the game has reached a certain instant. The rule by which he chooses his actions, depending on the information he has gathered up to that instant, is his strategy.

Depending on the specific game model one wishes to analyze, each of the two forms has its advantages and disadvantages. In most games that evolve over time, the extensive form is superior to the strategic form since the extensive form explicitly depicts the order of moves, which information is revealed during the course of the game, and how players take such information into account. On the other hand, in dynamic games of some complexity, the extensive form becomes unmanageable.

3.3.3 Dynamic Game

Many strategic problems in economics and international trade are not properly modeled as static games since policy makers can make decisions at more than one point of time. A first question would be: How does one distinguish between dynamic and static games? There is no general agreement on the use of the terms 'static game' and 'dynamic game'. One might say that a game in which time is not explicitly involved is a static game, supposing that 'dynamic' refers to the fact that variables are explicitly dated. However, let us consider a Cournot duopoly game played in the following way. The firms have to choose their respective output levels independently of each other at each of T successive time instants $1,2,\ldots,T$. After the firms have made their output choices at time instants $s \in \{1,2,\ldots,t\}$, these choices will be known to both firms when they have to choose their outputs at the subsequent time instant $t+1$. Now suppose that, before the game starts, each firm must make an irrevocable choice of every output quantity that the firm will produce at time instants $1,2,\ldots,T$. Thus, each firm must commit itself in advance to a fixed sequence of outputs. This game certainly includes time but one could maintain that such a game should not be called a dynamic game. The argument is that during the play of the game the firms get no opportunity to react strategically to the rival's actions, using incoming information on actions taken.

The following definition of a dynamic game takes into account the reasonable requirement that players should be able to select strategies that are based on information being revealed during the play of the game. A game is said to be dynamic if at least one player can use a strategy that conditions his single-period action at any instant of time on the actions taken previously in the game. Previous actions are those of the rivals but also a player's own actions.

To analyze a dynamic game, we need to start by describing in which order the players take their actions and what information is available to a player when he takes action. In what follows we confine our interest to dynamic games in which all players' actions are observable by all players. The game is said to be one of perfect information. Hence any player, when taking an action at time t, has perfect knowledge of all previous actions. These are his/her own past actions and those of his rivals, but can also include acts of nature if there are exogenous uncertainties in the game. In such a game we say that players move simultaneously at time *t* if no player knows about the actions that the other players take at time *t*. Notice that this terminology is not meant to exclude games in which no two players make decisions at the same time, since one can include ‘inaction’ as a feasible action at a particular instant.

Since all past actions till time *t*-1 are common knowledge among the players at decision time *t*, it makes sense to speak of the history of actions by time *t*. The history of actions by time *t* is a sequence of action profiles $u_1, u_2, ..., u_{t-1}$, where any such profile is a set of *N* individual actions of the players. The initial history is the history before the starting point of the game and is an empty set (Norman and Thisse, 2000; Sloof, 1998; Gul, 1997; Karp and McCalla, 1983). The terminal history is the one after which no more actions occur. Payoffs of the players can be defined as functions of the terminal history but could also be taken as sums of per period payoffs.

3.3.4 The Difference Game

The imperfections of the markets and the government interventions in the three countries raise questions about results obtained from models of the limiting cases of perfect competition. This kind of market involves power, reaction functions, strategies, and feedback and is inherently dynamic. The game theoretic approach, which models the interaction of two or more agents with conflicting objectives, provides a method for analyzing imperfectly competitive markets such as rice markets in Japan, South Korea, and the U.S.

In addition, in actual life the instruments of the economy can be under the control of different policymakers who each may have conflicting view on target values or the relative importance of the targets. In the U.S., for instance, it is unlikely that the Congress or the Administration, controlling fiscal policy, and the Federal Reserve Board, controlling monetary policy, hold the same views on what the targets of their policies should be. It is also not clear that much cooperation is taking place between these entities.

What particularly complicates the situation, is that one cannot just predict the policy of the other policymaker and go ahead taking that as a given. One must also, if one is rational, take into account the effect that one's own policy will have on the other policymaker's policies in the future. Since trade policies are interdependent, some sort of game framework is attractive (Dockner, *et.al*., 2000). If games are discarded, the model must assume that traders do not respond to their partners' policies (no interdependence) or assume that their response is known. The first assumption is unacceptable, and the second simply postulates reaction functions when the goal is to derive them.

The difference game addresses these criticisms described above. First, we can include any number of players, on either one side or on both sides of the market, as well as a residual sector which may be either a net importer or exporter. Second, the dynamic nature of supply and demand is explicitly taken into account by means of the state equation. Finally, the solution gives us endogenously determined reaction functions and resulting tariffs/taxes, prices, and quantities traded (Karp and McCalla, 1983).

There are n players, each with control vector $\mathbf{u}_{it}$ where $i = 1, 2, \ldots, n$ and $t = 1, 2, \ldots, T\text{-}1$, where T is the end of the game. The evolution of the state, y_t, is given by the difference equation

$$y_t = A_t y_{t-1} + \sum_{i=1}^{n} B_{it} u_{it} + C_t ; y_0 \text{ given} \qquad \text{`} \qquad (3.3.1)$$

The objective of player i is to maximize $V_i(y_0)$, where

$$V_i(y_0) = \sum_{t=1}^{T} (r_{it}' y_t + y_t' R_{it} y_t); \quad i = 1, 2, \ldots, n. \qquad (3.3.2)$$

The vectors and matrices A, B_i, C, r_i, and R_i are given. They indicate the effect on the current state of the previous state (A) the current controls (B_i), and the exogenous changes (C);

r_i and R_i give the effect of the current state on player *i*'s single-period payoff. Equation (3.3.1) is written as a first-order difference equation, but by imbedding previous values of y_t and u_t in the state vector, higher-order difference equations can be reduced to this form. The inclusion of the controls in the state vector allows the function V_i to depend on both the controls and the state (Karp and McCalla, 1983; Kydland, 1975).

In this game, we need to specify upon which information a player conditions his strategy. This issue is referred to as the choice of a strategy space or an information structure.

Suppose that player *i* chooses action u_{it} at time *t*. This choice can be based upon different sets of information, but we always assume that all players know the value of the initial state vector. An open-loop strategy is a strategy that is conditioned on current time only, that is, a minimal information. Like any other type of strategy, an open-loop strategy is fixed at the start of the game. This implies that each player believes that his actions have no effect on his opponents. In an open-loop Nash equilibrium each player is right about what his opponents will do, but he is wrong in that they would not respond to deviations from his strategy.

The use of open-loop strategies has been criticized for being static in nature, not allowing for genuine strategic interaction between the players during the play of the game (Sloof, 1998).

For feedback solution we assume that at each time period a noncooperative solution is chosen as a function of the state variable at that time. This means that each player, instead of taking as given a sequence of decisions for the other players, takes as given decision rules for each time period *t* that are functions of the state variables y_{t-1}. In making his decision, player *i* know that it will affect the state variables. A change in the state variables will change the other players' decisions in the future. This change in the other players' decisions will have an effect on future losses for player *i*. This fact is taken into account in the feedback solution when player *i* makes his decision.

Feedback controls incorporate a conjectural variation. Each player knows that his actions will affect his opponents' actions, and he considers this in choosing his rules. In a feedback Nash equilibrium each player's conjecture about how his opponents will respond to changes is correct (Karp and McCalla, 1983; Breshahan, 1981). Feedback controls allow the player more rationality and flexibility; therefore, we choose to use them rather than open-loop controls. A further advantage of the feedback controls is that in obtaining them we can derive the reaction functions $u^*_i(t, y_{t-1})$ (Paarlberg and Abbott, 1986).

It seems reasonable in many models to assume that each decision maker will determine the effect of his decision on the state variables and consider how other players will react in the future. For example, in an oligopolistic industry each firm may take into consideration the effect of its decision on market shares and assume that the other players will react in certain ways to different sizes of the market shares. This seems particularly reasonable if we think in terms of stability, that is, view the equilibrium solution as the end result of a process with all the players groping for decision rules that are such that, given the others' actions, nobody has any incentive to change the rule, and where forecasting errors are corrected as the players learn more about the other players' behavior.

It is known from control theory that when the objective function is quadratic and the equation of motion linear, optimal controls can be expressed as a linear function of the state (Dockner, *et.al*., 2000). Therefore, it is not surprising that in the difference game the Nash equilibrium reaction functions are also linear in the state. In fact, the algorithm used to determine these functions is a generalization of the method of dynamic programming used in the control problem. The stacked vector of controls in period t is determined by the reaction function

$$u_t = d_t + E_t y_{t-1} \tag{3.3.3}$$

where d_t and E_t are independent of the state which means the initial condition, y_0, does not affect the reaction function; it does, however, affect the value of the controls.

Let supply in any country be a linear function of last period's domestic price, and demand a linear function of this period's domestic price. Domestic price equals world price plus the tariff imposed by the nation. If we take the nation's single-period objective function to be the sum of consumer and producer surplus and tariff revenues, then that function is composed of linear and quadratic terms involving world price and the tariff in the current and the previous period. If we imbed the current and lagged controls and the lagged state in a new state vector, the single-period objective is the sum of a linear and quadratic term involving the augmented state. The total payoff is then the discounted sum of these single-period objective functions and has the form of equation (3.3.2). Excess supply or demand for any nation is linear in the current and previous period's price and tariff.

The linear-quadratic Nash difference game can be used to model trade of a commodity like rice. A simple case involves two players, each with a single control u_i, a unit tariff or export tax. The two active players can be both importers, both exporters, or one of each. There is a third, passive player, which comprises the rest of the world (ROW). The response of ROW is assumed known and exogenous. Domestic supply in country *i*, q_i^s, is a function of last period's producer price, and domestic demand in country *i*, q_i^d, is a function of the current period's domestic price as mentioned in section 3.1. These functions are given by equation (3.3.4).

$$q_{it}^{s} = \alpha_{it} + \beta_{it}(P_{wt-1} + u_{it-1})$$
$$q_{it}^{d} = a_{it} - b_{it}(P_{wt} + u_{it}) \tag{3.3.4}$$

World price in period t is given by P_{wt}, so that country i's domestic price is $P_{wt} + u_{it}$. Country i's objective is to maximize the discounted sum of producer and consumer surplus and tariff/tax revenue. The single-period payoff to country i involves terms which are linear and quadratic in $P_{wt}, P_{wt-1}, u_{it}, u_{it-1}$, plus a term that involves only intercepts and coefficients of (3.3.4).

The evolution of world price, P_w, is given by setting supply equal to demand. Therefore, if we rearrange equation (3.3.4), equation (3.3.5) can be derived (Karp and McCalla, 1983; Kydland, 1975).

$$P_{wt} = \theta P_{wt-1} + (\delta_1, \delta_2, \delta_3, \delta_4)\begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{1t-1} \\ u_{2t-1} \end{bmatrix} + h \tag{3.3.5}$$

where h is $(a_{it} - \alpha_{it})/b_{it}$, θ is $-\beta_{it}/b_{it}$, and $\delta_1 = -1, \delta_2 = -1, \delta_3 = -\beta_{1t}/b_{1t}$, and $\delta_4 = -\beta_{2t}/b_{2t}$. The parameters θ, δ_i, and h are obtained from the parameters in (3.3.4). Now we have a new state, $y_t' = f(P_{wt}, u_{1t}, u_{2t}, P_{wt-1}, u_{1t-1}, u_{2t-2})$. The equation of motion for y is given by

$$\boldsymbol{y_t} = \theta \boldsymbol{y_{t-1}} + \boldsymbol{\delta u_t} + \boldsymbol{h} \tag{3.3.6}$$ [1]

[1] The actual matrix is as follows: $y_t = \begin{bmatrix} \theta & \delta_3 & \delta_4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} P_{wt-1} \\ u_{1t-1} \\ u_{2t-1} \\ P_{wt-2} \\ u_{1t-2} \\ u_{2t-2} \end{bmatrix} + \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} + \begin{bmatrix} h \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

A supply utilization accounting identity, or trade balance in an open economy, captures the effects of producer and consumer behavioral adjustments to policy and, hence, prices on trade:

$$E_{it} = q_{it}^{s}(P_{wt-1} + u_{it-1}) - q_{it}^{d}(P_{wt} + u_{it}) \qquad (3.3.7)$$

where E_{it} is exports from country *i* (imports if negative); q_{it}^{s} is supply (production) in country *i*, which depends on $P_{wt-1} + u_{it-1}$, producer support prices (decoupled producer subsidy offered via price intervention) in country *i*, and q_{it}^{d} is demand (consumption) in country *i*, which depends on $P_{wt} + u_{it}$, the domestic market price in country *i*, according to a demand function. World market equilibrium requires

$$\sum E_{it} = 0. \qquad (3.3.8)$$

Price linkages relate border prices to domestic market prices using policy instrument settings (export subsidies and producer support via price interventions):

$$P_{d\,i} = P_{wt} + (Sw_i + u_{it} + C_i) \qquad (3.3.9)$$

where P_{wt} is the world price, Sw_i is the export subsidy (import tariff) offered by country *i*, and C is other government intervention via price control, and

$$P_{S\,i} = P_{d\,i} + (Sq_i + D_i) \qquad (3.3.10)$$

where Sq_i is a decoupled producer subsidy in country *i*, and D_i is other government support to rice producers via price intervention. Furthermore, we can incorporate political payoff functions into the dynamic game of each player to maximize each country's welfare. The reason is that each country would try to maximize its own welfare considering different interest groups political weights in the policy making process. Therefore, incorporating the dynamic game into the dynamic game political payoff functions gives equation (3.3.11).

$$
\begin{aligned}
Vp_i = & Wq_i V_i(y_0) Vs_i(P_{wt}, Sq_i, C_i) + Wd_i V_i(y_0) Vd_i(Pd_i, Sw_i, D_i) \\
& - Wg_i(Sw_i Q_i + Sq_i Q_i + C_i Q_i + D_i Q_i)
\end{aligned} \tag{3.3.11}
$$

where Vp_i is the political payoff in country *i*, Vs_i is producer surplus for region *i*, Vd_i is consumer surplus for region *i*, and Sq_i is decoupled producer support (or direct payment) in region *i* as mentioned earlier. Welfare weights are Wq_i for producer, Wd_i, for consumers, and Wg_i for government budget expense (Abbott and Kallio, 1996).

Initial equilibrium quantities, prices, and supply and demand elasticities are taken from the econometric estimation and the weights are taken from the political preference function (PPF) analysis for this game theoretic approach.

Solving this model, assuming that governments set export subsidies or tariffs to maximize political payoff in a manner corresponding to the UR agreement, may represent alternative institutional arrangements. The United States is examined by specifying objectives, which are related to exports. Nash equilibria will be found, assuming the United States, Japan, and Korea independently maximize their own welfare, with the subsidy or tariff level of its opponents as given. The GATT agreement is represented by imposing subsidy expenditure limits in each player's maximization problem. Nash equilibria are solved for the intersection of these best response functions by iteratively solving each region's problem given the opponents' strategies, subsidy, and tariff, using GAMS.

In addition, the goal of this analysis is to look at the implications of a change from minimum access to the tariffication of imports in Korea, continuation of tariffication in Japan at an alternative different tariff equivalent than the current tariff equivalent, and export policy options toward Japan and Korea for the U.S.

CHAPTER 4
EMPIRICAL ANALYSIS

This chapter presents and discusses the results of the empirical models for the three countries. This chapter will be divided into three sections, and organized as follows. The first section is devoted to a discussion of the empirical results of the econometric models. In particular, the section focuses on the estimation methods and evaluative statistics. The second section presents the derivation of the political weights for the three different interest groups for Japan and Korea, and for exporters from the U.S. An empirical game theoretic approach is presented and discussed in the final section.

4.1 Econometric Estimation

4.1.1 Empirical results and interpretation

Based on the theoretical considerations and the market structure concerning the dynamic commodity model in the previous section, the empirical econometric models for the three countries' rice markets are specified for the period 1960-1999.

According to economic theory, supply can be influenced by prices, technology, costs and other factors. For domestic consumption, it can be hypothesized to be influenced by prices, income levels, and the price of substitutes according to economic theory. For Japan and Korea, the model is composed of three equations: domestic acreage response, yield, and per capita consumption. Two identities are defined to impose the aggregate domestic production and consumption. Domestic production is defined by acreage response times yield, and domestic consumption is defined by multiplying population times the estimated equation for per capita consumption and adding in other use. The general functional forms and variables for the rice supply and demand estimation are presented as follows:

Japanese Yield:

$$JYIED = f(TECH, D, u_{1t}) \quad (4.1.1)$$

Japanese Area Harvested:

$$JARHV = f(JARHV_{t-1}, JPRODP_t/CPI_t, JPRODC_t/CPIt, u_{2t}) \quad (4.1.2)$$

Japanese Per Capita Consumption:

$$JPCCON = f(JRETP_t/CPI_t, JINCOM_t/CPI_t, JPCCON_{t-1}, u_{3t}) \quad (4.1.3)$$

Korean Yield:

$$KYIED = f(TECH, D, u_{4t}) \quad (4.1.4)$$

Korean Area Harvested:

$$KARHV = f(KARHV_{t-1}, KGPOP_{t-1}/CPI_{t-1}, KDIVR_t, u_{5t}) \quad (4.1.5)$$

Korean Per Capita Consumption:

$$KPCCON = f(KRETP_t/CPI_t, KINCOM_t/CPI_t, KPCCON_{t-1}, u_{6t}) \quad (4.1.6)$$

U.S. Export Demand:

$$UEXDEM = f(WOLDPJ_t/UPROPI_t, UGEXP_t, WENST_t, D, u_{7t}) \quad (4.1.7)$$

Production:

$$JPROD = JYIED * JARHV \quad (4.1.8)$$

$$KPROD = KYIED * KARHV \quad (4.1.9)$$

Consumption:

$$JCONP = JPCCON * JPOP + OTHER \quad (4.1.10)$$

$$KCONP = KPCCON * KPOP + OTHER \quad (4.1.11)$$

where TECH = Technology

$JARHV_{t-1}$ = Lagged Japanese Area Harvested (1000 ha)

$JPROP_t$ = Japanese Producer Price (yen/MT)

CPI_t = Consumer Price Index

$JPROC_t$ = Japanese Production Cost (yen/ha)

$JRETP_t$ = Japanese Retail Price (yen/MT)

$JINCOM_t$ = Japanese Income ($)

$JPCCON_{t-1}$ = Lagged Japanese Per Capita Consumption (kg)

$KARHV_{t-1}$ = Lagged Korean Area Harvested (1000 ha)

$KGPOP_{t-1}$ = Lagged Korean Government Purchase Price (won/MT)

$KDIVR_t$ = Lagged Korean Diversion program (ha)

$KRETP_t$ = Korean Retail Price (won/MT)

$KINCOM_t$ = Korean Income ($)

$KPCCON_{t-1}$ = Lagged Korean per capita Consumption (kg)

$WOLDPJ_t$ = World Price ($/MT)

$UPRODPI_t$ = U.S. Producer price ($/MT)

$UGEXP_t$ = U.S. Government Export Program (1000 MT)

$WENST_{t-1}$ = Lagged World Ending Stock (1000 MT)

D = Dummy Variables

u_{it} = Error Terms

POP = Population

OTHER = Other Consumption (1000 MT)

The structural model in this study is estimated based upon annual time series data from 1960 to 1999 with all prices and income variables deflated by the Consumer Price Index (CPI). The rice yield and area harvested equations are estimated by Two Stage Least Squares (2SLS) and the per capita consumption and U.S. export demand equations are estimated by conventional ordinary least squares (OLS) and the autoregressive degree of one (AR(1)) as an attempt to correct for autocorrelation.

The estimation results of the model are shown in table 4.1. The consumer price index is omitted for convenience. In addition, the value of the Durbin's *h* statistic is also given for each equation since the lagged dependent variable appears as an independent variable.

Equations (4.1.1) and (4.1.4) indicate that the yield is a function of technology and a dummy variable for Japan and Korea. The dummy variable is used to explain poor weather conditions in 1980 and 1993. A time trend is used as a proxy for technological developments and advancements. Japanese and Korean yield equations have a coefficient of adjusted R^2 of 0.80 and 0.87, respectively. All of the variables are statistically significant at the 5% level of significance. D-W statistics of the equations, 1.78 and 2.13, respectively, show that there is no autocorrelation in the equations.

The results of the acreage response estimation show the expected signs for all explanatory variables that are implied in the theory of production. Except for the constant terms, all parameter estimates are different from zero at the 5% level of significance. The prices received by rice farmers in both countries have a positive impact on the acreage response, as expected. The production costs for Japan and the diversion program for Korea have a negative impact on the supply response. The coefficient estimate of the lagged dependent variables show a stable geometric lag process and supports the existence of a lagged distribution of the dependent variables. The high estimates of the lagged acreage variables for Japan and Korea, 0.84 and 0.93 respectively, imply that it takes time for farmers to change the paddy land for rice cultivation in response to the price signals. The short-run supply elasticities with respect to the output at the mean for Japan and Korea are 0.11 and 0.13, respectively. However, the long-run supply elasticities are estimated as 0.75 and 0.89, respectively. The high values of the long-run elasticities are caused by a high estimate of the lagged dependent variables.

Except for the constant terms, all independent variables in the per capita consumption equations show strong statistical significance and expected signs. All coefficient estimates are significant at the 5% level of significance. Rice consumption is negatively related to own price as well as income, which implies that rice is an inferior good in Japan and Korea. This is a phenomenon, which has been experienced over the last decade in Japan and Korea as their income levels have risen. The coefficients on the one year lagged dependent variables are also significant at the 5% level of significance. It implies that there exist gradual changes in diet patterns, which impact rice consumption. In fact, the increases in the income levels have transformed the Japanese and Korean diet by substituting rice with consumption of meats, fruits, and vegetables.

The price elasticities for Japan and Korea are computed at -0.096 and -0.23, respectively. The income elasticities are also computed at -0.029 and -0.56, respectively.

For the equation of U.S. export demand, all of the independent variables are statistically significant at the 5% level except for government export program. U.S. export demand estimation shows the expected signs for all explanatory variables. A reduction in world price relative to the U.S. domestic price received by U.S. producers make U.S. rice less competitive in the world market. A dummy variable for the years of 1980 and 1994 is used to explain unusual high exports caused by Japan and Korea due to unexpected cold weather in 1980 and 1993. In addition, there is no autocorrelation in the equation (D-W = 1.7).

Table 4.1 Empirical Results of Production and Consumption.

Production:

$$JYIED = 3.5579 + 0.0313*TECH - 0.8874*DM8093$$

(54.84) (11.52) (-5.96)

$AdjR^2 = 0.80$ D-W = 1.78 Method = 2SLS

$$KYIED = 3.7415 + 0.0293*TECH - 0.8369*DM8093$$

(18.04) (4.10) (-4.41)

$AdjR^2 = 0.87$ D-W = 2.13 Method = 2SLS

$$JARHV = 294.176 + 0.843*JARHV_{t-1} + 0.175*JPRODP - 0.027*JPRODC$$

(1.63) (13.07) (2.35) (-2.57)

$AdjR^2 = 0.96$ D-h = 0.59 Method = 2SLS

$$KARHV = 50.76 + 0.932*KARHV_{t-1} + 0.000059*KGROP - 0.006*KDIVR$$

(0.42) (10.93) (2.34) (-4.34)

$AdjR^2 = 0.96$ D-h = 0.97 Method = 2SLS

Consumption:

$$LnJPCCON = 1.8133 + 0.8202*LnJPCCON_{t-1} - 0.0963*LnJRETP - 0.029*LnJINCOM$$

(4.77) (15.42) (-3.65) (-2.15)

$AdjR^2 = 0.99$ D-h = 1.25 Method = OLS/AR(1)

$$LnKPCCON = 5.461 + 0.7203*LnKPPCCON_{t-1} - 0.23*LnKRETP$$

(4.1) (10.27) (-2.42)

$$- 0.56*LnKINCOM + 0.2073*DM1$$

(-3.4) (2.96)

$AdjR^2 = 0.99$ D-h = 0.72 Method = OLS/AR(1)

U.S. Export Demand:

$$LUEXDEM = 2.681 + 0.4902*LWENSTK + 0.036*L(WOLDP/UPRODP)$$

(3.26) (6.09) (1.97)

$$+ 0.031*LUGEXP + 0.274*DM8094$$

(1.72) (3.2)

$AdjR^2 = 0.84$ D-W = 1.7 Estimator = OLS/AR(1)

Note: numbers in the parentheses represent t-statistics.

4.1.2 Model Specification and Validation

In this section, tests for detecting error structure in the single equation context are conducted to identify whether the estimators used in the models are appropriate. Statistical tests for autocorrelation, heteroscedasticity, and other specification problems are described.

Autocorrelation usually occurs in the analysis of economic time series where random shocks have effects that persist for more than one time period. Although estimates from the estimators, especially from the conventional OLS, and forecasts for those estimates are still unbiased and consistent with serially correlated errors, they are no longer minimum variance among all linearly unbiased estimators. There are several ways of testing for autocorrelation. By far the most widely used test is the Durbin-Watson (D-W) test. However, the D-W test is not likely to be valid here because of a lagged dependent variable in the equations. When one or more lagged endogenous variables are present, the D-W statistic will often be close to 2 even when the errors are serially correlated. Of course, one could simply look at the D-W statistic as providing an indicator of serial correlation when the D-W statistic is low, but this approach is strongly biased against finding serial correlation. Fortunately, there is a relatively easy alternative test provided by Durbin, which is strictly valid for large samples of data but can be used for small samples as well (Pindyck and Rubinfeld, 1991; Judge, *et. al*., 1988). In this circumstance, the Durbin's *h* statistic is used for the autocorrelation test.

Heteroscedasticity arises in numerous applications. In this study, the White's test for heteroscedasticity is conducted, which is the most common procedure for detecting heteroscedasticity in the error term. White's test for the general structure of heteroscedasticity is general since it does not require any prior knowledge of the structure of the heteroscedasticity. This test could be regarded as a general test for misspecification as it is likely to pick up other specification errors such as multicollinearity and zero mean of disturbance (Judge, *et.al.*, 1985).

In addition, it is convenient to assume that errors are distributed normally, but there exists justification for this normality assumption. When errors are not distributed normally, the estimators used in this study, particularly the OLS, are no longer efficient or asymptotically efficient. The respective distribution of the estimators is no longer normal and chi-squared, and consequently, the F and t test on the estimated parameters are not necessarily valid in finite sample. The consequences of non-normality of the fat-tailed kind, implying infinite variance, are quite serious since hypothesis testing and interval estimation cannot be undertaken meaningfully. Because of the possible consequences of non-normal disturbances, it is worth testing to see if the disturbances could have come from a normal distribution. Several tests for normality exist. In this study, Bera and Jarque test is used to test the normality assumption for the OLS residual (Judge, *et.al*., 1988).

Based upon these various statistical tests for autocorrelation, heteroscedasticity, and normality, the model specification tests are conducted in the single equation context.

A criterion that is commonly used to evaluate a simulation model is the fit of the individual variables in a simulation context. One would expect the results of a historical simulation to match the behavior of the real world rather closely. One way to test the performance of the model is to perform historical simulation and examine how closely each endogenous variable tracks its corresponding historical data series. It is therefore desirable to have some quantitative measure of how closely individual variables track their corresponding data series. The measure that is most often used is called the *rms* (root-mean-square) *simulation error*. The *rms* simulation error for the variable Y_t is defined as

$$rmse = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2} \qquad (4.1.12)$$

where Y_t^s = simulated value of Y_t

Y_t^a = actual value of Y_t

T = number of periods in the simulation

The *rms* error is thus a measure of the deviation of the simulated variable from its actual time path (Pindyck and Rubinfeld, 1991). Of course, the magnitude of this error can be evaluated only by comparing it with the average size of the variable in question.

Other measures of simulation fit exist and are often used. Another simulation error statistic is the *rms percent error*, which is defined as

$$rms\ percent\ e = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right)^2} \tag{4.1.13}$$

This is also a measure of the deviation of the simulated variable from its actual time path. but in percentage terms. Other measures are the mean simulation error, defined as

$$Mean\ e = \frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right) \tag{4.1.14}$$

and the mean percent error, defined as

$$Mean\ percent\ e = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right) \tag{4.1.15}$$

The problem with mean errors is that they may be close to 0 if large positive errors cancel out large negative errors. Therefore, the *rms* simulation error is considered to be a better measure of the simulation performance.

Low *rms* simulation errors are only one desirable measure of simulation fit. Another important criterion is how well the model simulates turning points in the historical data. A model must predict turning points to be judged better than a simple trend model (Pindyck and Rubinfeld, 1991). Thus the ability of a simulation model to duplicate turning points or rapid changes in the actual data is an important criterion for model evaluation.

A useful simulation statistic related to the *rms* simulation error and applied to the evaluation of historical simulations is Theil's inequality coefficient. Note that the numerator of

U is just the *rms* simulation error, but the scaling of the denominator is such that U will always fall between 0 and 1. If U = 0, $Y^s_t = Y^a_t$ for all t and there is a perfect fit. If U = 1, on the other hand, the predictive performance of the model is as bad as it possibly could be (Pindyck and Rubinfeld, 1991). The Theil's inequality coefficient can be shown with a little algebra that

$$\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2 = \left(\overline{Y^s} - \overline{Y^a}\right)^2 + \left(\sigma_s - \sigma_a\right)^2 + 2\left(1-\rho\right)\sigma_s\sigma_a \qquad (4.1.16)$$

where $\overline{Y^s}, \overline{Y^a}, \sigma_s$, and σ_a are the means and standard deviations of the series Y_t^s and Y_t^a, respectively, and ρ is their correlation coefficient. The proportions of inequality are defined as

$$U^M = \frac{\left(\overline{Y^s} - \overline{Y^a}\right)^2}{(1/T)\sum\left(Y_t^s - Y_t^a\right)^2} \qquad (4.1.17)$$

$$U^S = \frac{(\sigma_s - \sigma_a)^2}{(1/T)\sum\left(Y_t^s - Y_t^a\right)^2} \qquad (4.1.18)$$

$$U^C = \frac{2\left(1-\rho\right)\sigma_s\sigma_a}{(1/T)\sum\left(Y_t^s - Y_t^a\right)^2} \qquad (4.1.19)$$

The proportions, U^M, U^S, and U^C are called the bias, the variance, and the covariance proportions, respectively, and they are useful as a means of breaking the simulation error down into its characteristic sources (Pindyck and Rubinfeld, 1991).

The bias proportion U^M is an indication of systematic error, since it measures the extent to which the average values of the simulated and actual series deviate from each other. Whatever the value of the inequality coefficient U, it is preferred that U^M would be close to zero. A large value of U^M (above .1 or .2) would be quite troubling, since it would mean that a systematic bias is present, so that revision of the model is necessary.

The variance proportion U^S indicates the ability of the model to replicate the degree of variability in the variable of interest. If U^S is large, it means that the actual series has fluctuated considerably while the simulated series shows little fluctuation. Finally, the covariance proportion measures what we might call unsystematic error; i.e., it represents the remaining error after deviations from average values and average values have been accounted for. Since it is unreasonable to expect predictions that are perfectly correlated with actual outcomes, this component of error is less worrisome (Pindyck and Rubinfeld, 1991).

Table 4.2 Specification and Model Validation Test.

Specification Tests

	Autocorrelation		Heteroscadasticity		Normality
	D-W	D-h	White	Breusch-Pagan	Bera-Jarque
JYIELD	1.78		3.12(9.49)	4.10(5.99)	1.55(5.99)
JARHV	2.01	0.59(1.65)	1.23(9.49)	3.27(5.99)	1.41(5.99)
JPCCON	1.78	1.25(1.65)	2.02(9.49)	2.11(5.99)	2.41(5.99)
KYIELD	2.15		3.51(9.49)	1.14(5.99)	1.42(5.99)
KARHV	1.88	0.97(1.65)	4.31(9.49)	2.06(5.99)	1.41(5.99)
KPCCON	2.13	0.72(1.65)	4.51(9.49)	4.25(5.99)	1.50(5.99)
UEXDEM	1.70		4.65(9.49)	2.21(5.99)	0.94(5.99)

Model Validation Tests

	rms % error	U^M	U^S	U^C	Theil-U1	U
JYIELD	5.01	0.00	0.06	0.94	0.047	0.024
JARHV	3.18	0.00	0.01	0.99	0.030	0.015
JPCONP	0.26	0.00	0.00	1.00	0.003	0.001
KYIELD	4.05	0.00	0.04	0.96	0.065	0.032
KARHA	1.86	0.00	0.03	0.97	0.019	0.009
KPCCON	2.41	0.00	0.00	1.00	0.022	0.011
UEXDEM	1.44	0.00	0.04	0.96	0.014	0.007

Note: 1. numbers in the parentheses represent the critical values of each testing statistic.
2. we fail to reject the null hypothesis that there is no autocorrelation, heteroscadasticity, and the error terms are distributed normally in all of specification tests at the 5% level of significance.

This study uses two goodness-of-fit measures to evaluate the overall predictive ability of the model: 1) root-mean-square percent error (*rms* %) and 2) Theil's inequality coefficient (U).

The validation statistics show that the models basically do an excellent job of representing the rice economies. The *rms* and Theil-U measures indicate that the models simulate the data well over the historical period. The *rms* indicates that the models have *rms* from 0.26% root-mean-square error to 5.01%. And U^M, U^S, U^C and Theil-U illustrate that we are able to use the models to explain the historical rice economies with very low values for U^M reflecting no systematic bias in the models.

4.2 Derivation of Political Weights

To derive the political weights of interest groups in the three rice sectors, it is assumed that there are three interest groups: producers, consumers, and taxpayers. We are interested in the net effect on producers and consumers of price policies in the three countries. Hence if P_S and P_D are the prices for producers and consumers, then the net producer benefit from having a price P_S instead of P_W, which is defined as no intervention or border price, is measured by the change in producer surplus. Similarly, the net consumer welfare is measured by the change in consumer surplus. On the other hand, the taxpayers or government net expenditure is defined as: $GS= P_D*Q_D - P_S*Q_S - P_W*M$; where Q_S, Q_D and M denote the levels of production, consumption, and net imports, respectively. The first term on the right hand side of the equation is the government revenue from selling to consumers, the second term is the cost of purchasing from producers, and the third term is the payment for imported rice.

Now suppose that the policy maker seeks to maximize a political preference function consisting of producer's surplus, consumer's surplus and taxpayer's expenditures by choosing the optimal domestic producer and consumer prices. The political preference function for the policymaker in the three rice sectors is:

$$\underset{P_S, P_d}{Maximize} \text{ PPF}$$

$$= \lambda_P \int_{P_W}^{P_S} S(P)dP - \lambda_C \int_{P_W}^{P_d} D(p)dp + \lambda_G \{[P_D D(P_D) - P_S S(P_S)]$$

$$- [P_W(D(P_D) - S(P_S))]\}, \quad (4.2.1)$$

For simplicity, it is assumed that there is no intertemporal storage activity. Assuming no stock changes, the net imported quantity for Japan and South Korea (the net exported quantity for the U.S.) can be expressed as $D(P_D) - S(P_S)$. Consumer and producer prices are the policy variables. Then, the optimal price policy can be obtained by differentiating the political preference function with respect to producer price, P_S and consumer price, P_D, respectively. To solve the optimization problem, the governments must choose the instruments P_S and P_D so as to satisfy the following necessary conditions:

$$\frac{\partial PPF}{\partial P_S} = S(P_S)(\lambda_P - \lambda_G) - S'(P_S)^* \lambda_G (P_S - P_W) = 0 \quad (4.2.2)$$

$$\frac{\partial PPF}{\partial P_D} = D(P_D)(\lambda_G - \lambda_C) + D'(P_D)^* \lambda_G (P_D - P_W) = 0 \quad (4.2.3)$$

To be consistent with the maximization hypothesis, second-order conditions require that the Hessian matrix be negative semi-definite at the optimal producer price (P_S) and consumer price (P_D), i.e., $\frac{\partial^2 PPF}{\partial P_S^2} \leq 0$ *and* $\frac{\partial^2 PPF}{\partial P_D^2} \leq 0$. In addition, we have additional normalization equations such that $\lambda_P + \lambda_C + \lambda_G = 3$ and $\lambda_G = 1$ in order to compare with the social welfare function that has unit equal weight to each interest group ($\lambda_P = \lambda_C = \lambda_G = 1$) and for simplicity.

Once we have established functional relations between the political weights and the levels of rice policies, we can derive the formulas for describing endogenous domestic prices for producers and consumers. Arranging the above first order conditions (4.2.2) and (4.2.3), we have the following equations for endogenous price determination:

$$P_S^* = P_W + \frac{\lambda_P - \lambda_G}{\lambda_G} * \frac{S(P_S)}{S'(P_S)} \quad (4.2.4)$$

$$P_D^* = P_W + \frac{\lambda_C - \lambda_G}{\lambda_G} * \frac{D(P_D)}{D'(P_D)} \quad (4.2.5)$$

From these equations, it is possible to evaluate how political and economic factors contribute to the establishment of endogenous price levels. First, the border price for rice impacts domestic pricing policies. Second, the domestic market situations in terms of the production and consumption functions also have impacts on the formation of producer and consumer prices. Third, the above equations imply that political weights of the producer, consumer and taxpayer are all involved in the process of rice price decisions. For example, a larger political weight for producers relative to taxpayers would increase the producer price.

Moreover, if we move the border price variable to the left-hand side of equations (4.2.4) and (4.2.5), we can see how political economic factors influence the difference between the domestic and border prices in (4.2.6) and (4.2.7):

$$P_S^* - P_W = \frac{\lambda_P - \lambda_G}{\lambda_G} * \frac{S(P_S)}{S'(P_S)} \quad (4.2.6)$$

$$P_D^* - P_W = \frac{\lambda_C - \lambda_G}{\lambda_G} * \frac{D(P_D)}{D'(P_D)} \quad (4.2.7)$$

These equations suggest the potential role of the political weights in evaluating the level of domestic protection in the three rice sectors. For example, if the producers' welfare is valued higher than the taxpayers' welfare, the domestic producer price would be above the international price, which is likely to lead to an increase in the level of protection. In addition, we know that if all political weights are the same, $\lambda_P = \lambda_C = \lambda_G$, then $P_D^* = P_S^* = P_W$. In other words, the optimal domestic prices for consumer and producer are equal to the world price. Thus, if there are no special preferences among interests groups, free trade is the optimal policy. The difference between the domestic and world price only depends on the relative political weights. For example, if $\lambda_P > \lambda_G$ then it would imply that $P_S^* > P_W$, and $\lambda_C > \lambda_G$ implies that $P_W > P_D^*$.

The difference between producer and consumer prices is not affected by the world price in equation (4.2.8):

$$P_S^* - P_D^* = \frac{\lambda_P - \lambda_G}{\lambda_G} * \frac{S(P_S)}{S'(P_S)} - \frac{\lambda_C - \lambda_G}{\lambda_G} * \frac{D(P_D)}{D'(P_D)} \qquad (4.2.8)$$

The equation (4.2.8) implies that the price difference is purely determined by domestic supply and demand factors, and the relative political weights of producers and consumers to that of taxpayers. In particular, assuming supply and demand elasticities are constant, the optimal price wedges are derived as follows:

$$\alpha = (P_S^* - P_W) / P_S^* = (\lambda_P - \lambda_G)/\lambda_G * (1/\varepsilon) \qquad (4.2.9)$$

$$\beta = (P_D^* - P_W) / P_D^* = (\lambda_C - \lambda_G)/\lambda_G * (1/\eta) \qquad (4.2.10)$$

where α and β represent the optimal producer and consumer price wedge, ε and η denote the supply and demand elasticity. The optimal price wedges are simple forms of implicit political weights and elasticities of demand and supply. All of the elements of these optimal conditions, except the political weights, are typically observable either directly or from econometric estimates. Therefore, assuming that policymakers have chosen the optimal level of a given policy tool so as to maximize an implicit political preference, one can easily determine the political weights used by policymakers. The above equations show that the optimal price wedges depend not only on the elasticity of supply and demand but also on the political weights. The more inelastic the supply (or demand) and the more deviation of the producer (or consumer) political weight from the taxpayer weight, the more the optimal price wedges tend to diverge (Im, 2000, Gardner, 1987).

Given the estimated elasticities of demand and supply from the domestic production and consumption functions, we can derive the political weights of the three major interest groups in the three countries' rice economies. The estimated results from the rice market models are shown in Table 4.3. These estimates are the results of applying equations (4.2.9) and (4.2.10) with the normalization equations. To derive these estimates, supply and demand elasticities were combined with annual producer and consumer price, and world price data from 1960 to 1999.

The estimated political weights as shown in Table 4.3 indicate that the Japanese and Korean policies have favored rice producers more than the other interest groups. In the Japanese and Korean rice sectors, the political weights are particularly high for producers, lowest for consumers. The average weights for producers exceed unity while those for consumers are less than unity. Table 4.3 shows that a political willingness to redistribute income in favor of producers at the expense of consumers and taxpayers. This implies that rice producers have generally been preferred to consumers and taxpayers. In other words, the Japanese and Korean policymakers have placed more weights on the welfare of rice producers rather than those of consumers and taxpayers.

Table 4.3 Political Weights for the Three Countries.

	Japan		Korea		U.S.
Year	Producer	Consumer	Producer	Consumer	Exporter
1960	1.08	0.92	1.19	0.81	1.15
1961	1.06	0.94	0.92	1.08	1.15
1962	1.06	0.94	0.89	1.11	0.87
1963	1.08	0.92	1.14	0.86	0.86
1964	1.10	0.90	0.99	1.01	0.85
1965	1.12	0.88	0.81	1.19	0.84
1966	1.13	0.87	0.82	1.18	0.82
1967	1.13	0.87	0.87	1.13	0.82
1968	1.15	0.85	0.94	1.06	0.87
1969	1.16	0.84	1.04	0.96	0.80
1970	1.16	0.84	1.04	0.96	1.18
1971	1.16	0.84	1.10	0.90	1.17
1972	1.17	0.83	1.14	0.86	1.08
1973	1.09	0.91	0.68	1.32	1.19
1974	1.09	0.91	0.88	1.12	1.19
1975	1.16	0.84	1.07	0.93	1.32
1976	1.20	0.80	1.23	0.77	1.25
1977	1.19	0.81	1.16	0.84	1.24
1978	1.22	0.78	1.21	0.79	1.36
1979	1.21	0.79	1.24	0.76	1.19
1980	1.19	0.81	1.20	0.80	1.17
1981	1.22	0.78	1.34	0.66	1.30
1982	1.23	0.77	1.40	0.60	1.22
1983	1.24	0.76	1.39	0.61	1.19
1984	1.24	0.76	1.38	0.62	1.22
1985	1.24	0.76	1.38	0.62	1.31
1986	1.26	0.74	1.42	0.60	1.56
1987	1.26	0.74	1.40	0.57	1.31
1988	1.26	0.74	1.43	0.55	1.29
1989	1.26	0.74	1.45	0.56	1.25
1990	1.26	0.74	1.44	0.56	1.30
1991	1.26	0.74	1.44	0.56	1.29
1992	1.26	0.74	1.44	0.59	1.41
1993	1.26	0.74	1.41	0.55	1.33
1994	1.27	0.73	1.45	0.55	1.31
1995	1.27	0.73	1.44	0.56	1.24
1996	1.26	0.74	1.46	0.54	1.23
1997	1.26	0.74	1.46	0.54	1.23
1998	1.26	0.74	1.45	0.55	1.19
1999	1.25	0.75	1.37	0.63	1.30
Average	**1.19**	**0.81**	**1.21**	**0.79**	**1.17**

In the meantime, the political weight for the U.S. rice exporters is derived at 1.17 on average. It is higher than the weight for the taxpayers that we normalized at unity in order to compare with different interest groups. Overall, table 4.3 illustrates the time trend in the political weight. A change in the political weight could be interpreted as policymaker's preferences changing overtime.

4.3 Empirical Game Theoretic Analysis

4.3.1 Game Theoretic Procedure

In this section, the econometric estimation and the political weights are incorporated into the game theoretic analysis to obtain the Nash equilibrium as a base. Using the base as a foundation, a scenario analysis is conducted. The base is an analysis with respect to the existing import and export policies in the three countries, which include tariffication and export programs. The goal of this analysis is to look at the implications of changes from minimum access to tariffication of imports.

4.3.2 The Base

To develop the framework, it is necessary to determine the import tariff equivalents of Japan and Korea. Import tariffs are defined as the difference between the domestic price and the world price. For example, if the domestic price is $3000/MT and the world price is $500/MT, the tariff equivalent is the difference, which is $2500/MT. Depending upon the world price path, future domestic prices are likely to decrease because the Japanese and Korean governments will have to reduce the import tariffs annually. The domestic price is the world price plus the tariff equivalent, and the price that producers received is the government procurement price plus some type of producer support programs, such as direct payments for Japan and Korea. For the U.S. price, we consider the world price plus the difference between the loan rate and the world price for the base. The reason is that the target-price/deficiency payment program has been a major policy instrument for supporting producer income by paying directly the amount of deficiency payment to rice farmers during the 1976-1995 period. The level of deficiency payment, the difference between the announced target price and actual market price (or loan rate) for rice, has been much higher than for other program commodities such as wheat and corn. Due to the favorable incentives, the program participation rate has been over 90 percent for rice, which is much higher than for other program commodities. However, the 1996 FAIR Act terminated the target-price/deficiency payment program; the marketing loan program will continue to provide income support to rice producers by allowing them to pay back their nonrecourse loans at prices below the loan rate when USDA announces world trading prices are less than the loan rate (Childs, 1996).

In terms of surplus, this study considers consumer, producer, and government surpluses for Japan and Korea in the base. For the U.S., exporter surplus is considered in the base. The equations are as follows:

$$CSURP_{it} = \int_{Pw}^{Pd} D(p)dP \qquad (4.3.1)$$

$$PSURP_{it} = \int_{Pw}^{Ps} S(p)dP \qquad (4.3.2)$$

$$GSURP_{it} = (TARIF_{it}*IMPT_{it}) - \{(GPURP_{it}*GPUR_{it}) + (EQUIL_{it}*GPURP_{it})\} \qquad (4.3.3)$$

For U.S. exporter's surplus, U.S. export revenue from Japan and Korea is taken into account because this study specifically looks at U.S. exports to Japan and Korea only. The export surplus equation is the sum of exporter's surplus from Japan and Korea. The export surplus equation is as follows:

$$UEXSUR_t = \int_{Pw}^{Ps} E_J(p)dP + \int_{Pw}^{Ps} E_K(p)dP \tag{4.3.4}$$

where $\int_{Pw}^{Ps} E_J(p)dP$ and $\int_{Pw}^{Ps} E_K(p)dP$ are the U.S. exporter's surplus from Japan and Korea, respectively. In addition, the equilibrium is derived using the empirical econometric estimation equations for aggregated production and consumption for Japan and Korea and export demand for the U.S. The other variables are exogenously given within the equation. The equilibrium equation is as follows:

$$EQUIL_{it} = PROD_{it} + BESTK_{it} + IMPT_{it} - CONP_{it} - EXPOT_{it} - ENSTK_{it} \tag{4.3.5}$$

where $CSURP_{it}$ = consumer surplus at time t in country i

$PSURP_{it}$ = producer surplus at time t in country i

$GSURP_{it}$ = government surplus at time t in country i

$GPURP_{it}$ = government purchase price in country i

$GPUR_{it}$ = government purchase amount at time t in country i

$EQUIL_{it}$ = equilibrium quantity at time t in country i

$PROD_{it}$ = total production at time t in country i

$BESTK_{it}$ = beginning stock at time t in country i

$IMPT_{it}$ = import at time t in country i

$CONP_{it}$ = total consumption at time t in country i

$EXPOT_{it}$ = export at time t in country i

$ENSTK_{it}$ = ending stock at time t in country i

$UEXSUR_t$ = U.S. export surplus at time t

In economic theory, the equilibrium should be zero in equilibrium. However, in reality, that has not happened for the last four decades in Korea and Japan. Therefore, we consider the amount they need to import if the sign for the equilibrium is negative. If the sign for the equilibrium is positive we consider the amount either to be in year ending stock or for foreign aid. The reason is that there is no country that would be able to import rice from Japan and Korea due to the high prices, which are almost five to ten times higher than the world price. For U.S. equilibrium, this study incorporates equation (4.1.7) into the equilibrium identity including U.S. exports to Japan and Korea.

Depending upon the surplus and equilibrium, we consider the political weights derived in the previous section for the payoff functions. The payoff functions include surplus, equilibrium quantity, and political weights to obtain the Nash equilibrium for the base.

$$Vp_i = Wc_i * CSURP_{it}\,(P_{Di}) + Wp_i * PSURP_{it}\,(P_{Si}) + Wg_i * GSURP_{it}(S_{Qi}) \qquad (4.3.6)$$

where Vp_i is the political payoff in country i, S_{Qi} is decoupled producer support (or direct payment) in region i. Political weights are Wp_i for producer, Wc_i for consumers, and Wg_i for government.

Using GAMS, the simulation results for the base are presented in Table 4.4. GAMS is useful because it can substantially expand the extent and usefulness of mathematical programming applications in policy analysis and decision making.

The base year is 1999 because the year represents an important turning point for Japan and South Korea for the next negotiation, and because Japan adopted a tariffication policy in 1999. In the meantime, Korea is assumed to follow the tariffication policy since it has had tremendous political pressure from the major exporters. As a result, we assume that the two countries' major import policy is tariffication.

Table 4.4 Simulation Results of the Payoff Functions for the Base.

	Japan	Korea	U.S.
Production (1000MT)	8356	4635	6502
Consumption (1000MT)	8720	4750	3846
Export (1000MT)	200	0	1804*
Import (1000MT)	170**	52**	321
Ending Stock (1000MT)	1210	73	867
Beginning Stock (1000MT)	1302	137	694
Equilibrium Quantity (1000MT)	-22	99	600
Producer Surplus (Million $)	21.133	6.489	5.1***
Consumer Surplus (Million $)	38.25	7.2	N/A
Government Surplus (Million $)	54.853	13.369	N/A
Tariff Equivalent ($/MT)	3428	1385	N/A
Payoffs	2.508	0.572	6.63

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

As seen in Table 4.4, Japanese and Korean production is estimated at 8356 thousand MT and 4635 thousand MT, respectively. The 200 thousand MT of Japanese export is for foreign aid to North Korea and some countries in Africa. The Japanese and Korean imports are derived at 170 thousand MT and 52 thousand MT, respectively. The imports are from the U.S. only. This study does not take imports from the ROW into account because it focuses on trade flow between the U.S. and Japan and Korea. The equilibrium quantity for Japan, Korea, and the U.S. are –22 thousand MT, 99 thousand MT, and 600 thousand MT, respectively. The U.S. export quantity is derived at 1804 thousand MT, including exports to Japan, Korea, and the rest of the world (ROW). In the meantime, the payoffs for Japan and Korea are derived at 2.508 and 0.572, respectively. And the U.S. export payoff from U.S. exports to Japan and Korea is derived at 6.63.

4.3.3 Scenario Analysis

The next round of negotiations will likely require that the import requirements be made more transparent through tariffication. Based on these requirements, several realistic scenarios are developed. According to WTO agreement, Japan has to reduce import tariffs by 36%, and continue to reduce its import tariff by 6% annually. However, the tariff reduction will likely change in the next negotiation. The possible range of the reduction would be from 2% to 8% annually. Therefore, this possibility of reduction is taken into account for scenario analysis. Under MA, Japan would have increased imports by 8%-12% of domestic consumption, from 2001 to 2006, and 12%-14% by 2010. However, the Japanese government announced that they replaced the existing minimum access policy for tariffication beginning April 1, 1999. Thus, the import policy scenario for Japan focuses on tariffication. In the meantime, Korean government tends to maintain the minimum access policy until 2004. However, as mentioned earlier, the government has had tremendous political and economic pressure from major exporters such as the U.S. and CAIRNS group. Therefore, tariffication policy is considered in the scenario analysis for Korea as well. For the U.S., the existing CCC Credit Guarantee Programs (CCC), Market Access Program (MAP), and Foreign Market Development Program (FMDP) are considered in the scenario analysis to obtain the Nash equilibrium.

The normal-form representation of an extensive-form game is a summarized description of the extensive form. The normal form is a collection of the pure strategies available to each player at each of his/her information sets in the extensive form (Tirole, 1989). Therefore, the normal-form representation is used for the scenario analysis. In this study, there are three players in the game: the United States (US), Japan (JP), and Korea (KO). Let $\mathbf{A_k}$ denote the set of actions available to player k, for k = US, JP, and KO, and let A_k denote an arbitrary member of this action set. Let (A_{JP}, A_{KO}, A_{US}) denote a combination of actions, and let P_k denote player k's payoff function where $P_k(A_{JP}, A_{KO}, A_{US})$ is player k's payoff resulting from action (A_{JP}, A_{KO}, A_{US}).

Definition 4.1: The normal-form representation of a two-player game specifies the player's action spaces $\mathbf{A_1}$, $\mathbf{A_2}$ and their payoff functions $\mathbf{P_1}$, $\mathbf{P_2}$. This game is denoted by $G = \{\mathbf{A_1}, \mathbf{A_2} ; \mathbf{P_1}, \mathbf{P_2}\}$.

The solution to each game will involve the concept of elimination of strictly dominated strategies. At each stage, the elimination of dominated strategies for some players at the previous stage uncovers dominated strategies for other players. The process stops when no more dominated strategies can be found.

Definition 4.2: In the normal-form game $G = \{ \mathbf{A_1}, \mathbf{A_2} ; \mathbf{P_1}, \mathbf{P_2}\}$ let A^1_i, and A^1_j, $\forall$ $i \neq j$, be feasible strategies for player 1, i.e., A^1_i, and A^1_j are members of $\mathbf{A_1}$. Action A^1_j is strictly dominated by A^1_i if, for all actions available to the other player, player 1's payoff from playing A^1_j is strictly less than the payoff from playing A^1_i, such that: $P_1(A^1_j, A^2_i) < P_1(A^1_i, A^2_i) \ \forall \ A^2_i \in \mathbf{A_2}$.

If a unique solution to a two-player normal-form game non-cooperative game is to be found, it must be self-enforcing. Since there are no appropriate authorities to enforce international agreements, this is clearly the situation in any international trade negotiation. Thus, each player's predicted action must be that player's best response to the predicted action of the other player. This is the Nash equilibrium definition (Kennedy, 1994).

Definition 4.3: In the two-player normal-form game $G = \{\mathbf{A_1}, \mathbf{A_2} ; \mathbf{P_1}, \mathbf{P_2}\}$, the actions ($A^{1*}$, A^{2*}) are a Nash equilibrium if, for players 1 and 2, A1* is player 1's best response to the actions specified for the other player, 2, and vice versa, such that $P_1(A^1_j, A^2_i) < P_1(A^1_i, A^2_i)$ $\forall A^2_i \in \mathbf{A_2}$.

In this three-payer, normal-form, noncooperative dynamic game, defined by G = {$\mathbf{A_{JP}}$, $\mathbf{A_{KO}}$, $\mathbf{A_{US}}$; $\mathbf{P_{JP}}$, $\mathbf{P_{KO}}$, $\mathbf{P_{US}}$}, each country chooses some action $A_k \in \mathbf{A_k}$ in order to maximize its payoff function given the action choices of the other countries. The action space $\mathbf{A_{US}}$ = {CCC_{US}, MAP_{US}, FMP_{US}, CMP_{US}, CFP_{US}, MFP_{US}} for the U.S., and A_C = {$T2_C$, $T4_C$, $T6_C$, $T8_C$} for C = Japan, Korea. The scenario analysis includes six U.S. actions and four actions of Japan and Korea. The actions of each country are as follows:

CCC_{US}: U.S. Credit Guarantee Programs

MAP_{US}: U.S. Market Access Program

FMP_{US}: U.S. Foreign Market Development Program

CMP_{US}: combination of U.S. CCC and MAP

CFP_{US}: combination of U.S. CCC and FMP

MFP_{US}: combination of U.S. MAP and FMP

$T2_C$: 2% reduction of Japanese and Korean tariff equivalents

$T4_C$: 4% reduction of Japanese and Korean tariff equivalents

$T6_C$: 6% reduction of Japanese and Korean tariff equivalents

$T8_C$: 8% reduction of Japanese and Korean tariff equivalents.

The simulation results for the scenario analysis of each country's action are presented from Table 4.5 to Table 4.17. For the purpose of comparison, the payoffs for the two countries are presented under each U.S. action, and the Nash equilibrium is obtained for each U.S. action.

Moreover, ten-year average political weights are used, five years prior to WTO agreement implementation and five years after the implementation. The political weights used for Japan are 1.261 and 0.739 for the producer and consumer groups, respectively. For Korea, 1.436 and 0.564 for the producer and consumer groups, respectively, are used for the scenario analysis. The political weight for U.S. exporter group is 1.283.

Table 4.5 Simulation Payoffs under CCC_{US}.

	Korea				
	Action	$T2_{KO}$	$T4_{KO}$	$T6_{KO}$	$T8_{KO}$
	$T2_{JP}$	1.38 ; 0.24 (5.42)	1.38 ; 0.27 (5.47)	1.38 ; 0.28 (5.49)	1.38 ; 0.36 (5.52)
Japan	$T4_{JP}$	1.71 ; 0.24 (5.50)	1.71 ; 0.27 (5.53)	1.71 ; 0.28 (5.57)	1.71 ; 0.36 (5.62)
	$T6_{JP}$	1.72 ; 0.24 (5.85)	1.72 ; 0.27 (5.89)	1.72 ; 0.28 (5.92)	1.72 ; 0.36 (5.96)
	$T8_{JP}$	2.25 ; 0.24 (5.95)	2.25 ; 0.27 (6.01)	2.25 ; 0.28 (6.08)	**2.25 ; 0.36 (6.14)**

Note: numbers in a solution cell represent Japanese and Korean payoffs, respectively.
numbers in parentheses represent U.S. payoffs.

Under the U.S. action of CCC_{US}, this study considers U.S. export programs through the Commodity Credit Corporation Credit guarantee programs (CCC), including Export Credit Guarantee Program and Supplier Credit Guarantee Program with changes in Japanese and Korean tariff equivalents from 2% to 8% annually. The results of the simulation for the U.S. Credit guarantee programs are presented in Table 4.5. The results under the CCC credit guarantee programs, as indicated by the Nash equilibrium, show that the U.S. would be better off if Japan and Korea reduce their tariff equivalent by 8%. The Nash equilibrium solution is shown in bold letters of the results tables. In the Nash equilibrium, Japanese and Korean payoffs are 2.25 and 0.36, respectively, and U.S. payoff is 6.14.

Table 4.6 Simulation Results of the Nash Equilibrium under CCC_{US}.

	Japan	Korea	U.S.
Production (1000MT)	8173	4532	6502
Consumption (1000MT)	8306	4403	3846
Export (1000MT)	171	0	1804*
Import (1000MT)	97**	21**	321
Equilibrium Quantity (1000MT)	-23	50	320
Producer Surplus (Million $)	23.183	5.762	4.79***
Consumer Surplus (Million $)	34.247	6.455	N/A
Government Surplus (Million $)	52.291	11.555	N/A
Tariff Equivalent ($/MT)	3154	1274	N/A

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

Under the Nash equilibrium for U.S. action, CCC_{US}, Japanese and Korean production is derived at 8173 thousand MT and 4532 thousand MT, respectively (Table 4.6). The two importing countries' consumption is derived at 8306 thousand MT and 4403 thousand MT. In the meantime, Japanese and Korean imports are decreased by 73 thousand MT and 31 thousand MT, respectively, compared to the base. That causes U.S. exporter's surplus decrease slightly by 0.22 million dollars. However, Japanese and Korean total surpluses are increased by 0.61 and 0.342 million dollars, respectively. In addition, the U.S., Japanese, and Korean payoffs are decreased slightly by 0.49, 0.258, and 0.212, respectively.

In U.S. actions of MAP_{US}, this study considers Market Access Program (MAP) with changes in Japanese and Korean tariff equivalent from 2% to 8% annually. The results of MAP_{US} presented in Tables 4.7 and 4.8. A Nash equilibrium is obtained at an 8% reduction of Japanese and Korean tariff rate. The Japanese and Korean payoffs are derived at 16.1 and 3.7, respectively, and the U.S. payoff is derived at 16.74.

Table 4.7 Simulation Payoffs under MAP_{US}.

		Korea			
	Action	$T2_{KO}$	$T4_{KO}$	$T6_{KO}$	$T8_{KO}$
	$T2_{JP}$	13.5 ; 1.8 (15.1)	13.5 ; 3.2 (15.3)	13.5 ; 3.6 (15.5)	13.5 ; 3.7 (15.6)
Japan	$T4_{JP}$	14.8 ; 1.8 (15.5)	14.8 ; 3.2 (15.7)	14.8 ; 3.6 (15.9)	14.8 ; 3.7 (16.0)
	$T6_{JP}$	16.0 ; 1.8 (15.8)	16.0 ; 3.2 (16.0)	16.0 ; 3.6 (16.2)	16.0 ; 3.7 (16.26)
	$T8_{JP}$	16.1 ; 1.8 (16.3)	16.1 ; 3.2 (16.45)	16.1 ; 3.6 (16.57)	**16.1 ; 3.7 (16.74)**

Note: numbers in a solution cell represent Japanese and Korean payoffs, respectively.
numbers in parentheses represent U.S. payoffs.

Table 4.8 Simulation Results of the Nash Equilibrium under MAP_{US}.

	Japan	Korea	U.S.
Production (1000MT)	8154	4500	6502
Consumption (1000MT)	8210	4653	3846
Export (1000MT)	178	0	2484*
Import (1000MT)	116**	27**	321
Equilibrium Quantity (1000MT)	-20	101	295
Producer Surplus (Million $)	34.253	6.85	13.05***
Consumer Surplus (Million $)	32.547	6.92	N/A
Government Surplus (Million $)	51.15	10.04	N/A
Tariff Equivalent ($/MT)	3154	1274	N/A

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

Under the U.S. action, MAP_{US}, Japanese and Korean production is derived at 8154 thousand MT and 4500 thousand MT, respectively. Japanese and Korean production is decreased by 202 thousand MT and 135 thousand MT, respectively, compared to the base. Regarding the two countries' consumption, Japanese consumption is decreased to 8210 thousand MT. Also, Korean consumption is decreased to 4653 thousand MT from 4750 thousand MT, compared to the base. Meanwhile, U.S. total export is increased by 680 thousand MT. However, U.S. exports to Japan and Korea are decreased by 54 thousand MT and 25 thousand MT, respectively. Due to an increase in U.S. total export, U.S. exporter's surplus is increased to 13.05 million dollars from 5.1 million dollars, compared to the base.

Table 4.9 Simulation Payoffs under FDP_{US}.

		Korea			
	Action	$T2_{KO}$	$T4_{KO}$	$T6_{KO}$	$T8_{KO}$
Japan	$T2_{JP}$	**17.6 ; 3.4 (52.2)**	17.6 ; 3.1 (52.8)	17.6 ; 3.3 (53.1)	**17.6 ; 3.4 (53.3)**
	$T4_{JP}$	17.2 ; 3.4 (52.9)	17.2 ; 3.1 (53.4)	17.2 ; 3.3 (54.2)	17.2 ; 3.4 (54.9)
	$T6_{JP}$	14.2 ; 3.4 (53.0)	14.2 ; 3.1 (53.9)	14.2 ; 3.3 (54.7)	14.2 ; 3.4 (55.6)
	$T8_{JP}$	16.7 ; 3.4 (54.5)	16.7 ; 3.1 (55.1)	16.7 ; 3.3 (55.3)	16.7 ; 3.4 (56.0)

Note: numbers in a solution cell represent Japanese and Korean payoffs, respectively.
numbers in parentheses represent U.S. payoffs.

In the U.S action of FDP_{US}, a dominant strategy for Japan is obtained at the 2% of tariff reduction. The payoff is derived at 17.6. Also, two dominant strategies for Korea are obtained at both a 2% reduction and a 8% reduction with the payoff of 3.4. As a result, there exist multiple equilibria under the U.S. action of FDP_{US} at both a 2% and a 8% reduction of Japanese and Korean tariff equivalents. The FDP_{US} action has the largest payoffs for the U.S., compared to the base, CCC_{US}, and MAP_{US}, but the payoffs for Japan and Korea are almost the same as the other two U.S. actions and the base. Thus, the U.S. would be better off under the action of FDP_{US} dealing with Japanese and Korean import policies, compared to the previous two actions in terms of single policy action.

Table 4.10 Simulation Results of the Nash Equilibrium under FDP_{US}.

	Japan	Korea	U.S.($T2_C$)	U.S.(T8C)
Production (1000MT)	8146	4116	6502	6502
Consumption (1000MT)	8320	4550	3846	3846
Export (1000MT)	0	0	1906*	1973*
Import (1000MT)	475**	134**	321	321
Equilibrium Quantity (1000MT)	-20	49	453	386
Producer Surplus (Million $)	38.33	7.23	40.69***	41.54***
Consumer Surplus (Million $)	32.52	6.58	N/A	N/A
Government Surplus (Million $)	55.663	10.66	N/A	N/A

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

Table 4.10 shows the simulation results of the Nash equilibrium under the U.S. action of FDP_{US}. The results show that Japanese production is decreased slightly by 110 thousand MT, but Korean production is decreased dramatically by 513 thousand MT, compared to the base. Possibly, this dramatic change in production causes some structural changes in the Korean rice industry. For example, the Korean government would attempt to increase its target diversion program on the production side, which is basically an increase in planted area reduction program. The government diversion program has caused a positive impact on area harvested due to the fact that farmers tend to divert paddy fields of lower productivity from rice production, thus improving the average rice yields of the remaining rice land (Lee, 1997). However, as time has gone and they divert more paddy fields to plant high-revenue crops and vegetables, farmers had to divert higher productivity paddy fields. As a result, the government diversion program became a negative impact on rice production (MAFF, 2000).

Japanese and Korean total consumption is decreased substantially by 400 thousand MT and 200 thousand MT, respectively. Producer surplus in Japan and Korea is increased by 17.2

million dollars and 0.741 million dollars, respectively. However, consumer surplus in Japan and Korea is decreased by 5.73 million dollars and 0.62 million dollars, respectively. In the meantime, Japanese government surplus is increased slightly, but Korean government surplus is decreased by 2.709 million dollars, compared to the base.

For the U.S., the payoff with $T8_C$ is larger than that of $T2_C$ under FDP_{US}. In addition, U.S. total export is increased slightly with $T8_C$. This may reflect the fact that the higher tariff rates would result in lower exports.

Table 4.11 Simulation Payoffs under CMP_{US}.

		Korea			
	Action	$T2_{KO}$	$T4_{KO}$	$T6_{KO}$	$T8_{KO}$
Japan	$T2_{JP}$	9.9 ; 2.3 (30.8)	9.9 ; 3.0 (30.9)	9.9 ; 4.6 (31.1)	9.9 ; 2.5 (31.4)
	$T4_{JP}$	13.3 ; 2.3 (30.9)	13.3 ; 3.0 (31.4)	13.3 ; 4.6 (31.9)	13.3 ; 2.5 (32.2)
	$T6_{JP}$	21.1 ; 2.3 (31.6)	21.1 ; 3.0 (32.2)	**21.1 ; 4.6** **(32.7)**	21.1 ; 2.5 (32.7)
	$T8_{JP}$	17.1 ; 2.3 (32.0)	17.1 ; 3.0 (32.4)	17.1 ; 4.6 (32.55)	17.1 ; 2.5 (32.7)

Note: numbers in a solution cell represent Japanese and Korean payoffs, respectively.
numbers in parentheses represent U.S. payoffs.

Under the U.S. action of CMP_{US}, CCC and MAP with changes in Japanese and Korean tariff equivalent from 2% to 8% are taken into account. The results of the action are presented in Tables 4.11 and 4.12. The results under the action show that the U.S. would be better off if Japan and Korea reduce their tariff equivalent by 8% or 6%. The U.S. payoffs do not change under the 8% and 6% reduction with the payoff of 32.7. A dominant strategy for Japan is a 6% reduction of its tariff equivalent with a payoff of 21.1. In addition, a dominant strategy for Korea is a 6% reduction of tariff equivalent with a payoff of 4.6 as well. However, the Nash equilibrium is obtained at a 6% of reduction strategy for both the U.S. and the two importing countries with the payoffs of 32.7 and 25.7, respectively.

Table 4.12 Simulation Results of the Nash Equilibrium under CMP_{US}.

	Japan	Korea	U.S.
Production (1000MT)	8156	4432	6502
Consumption (1000MT)	8287	4518	3846
Export (1000MT)	0	0	2484*
Import (1000MT)	252**	32**	321
Equilibrium Quantity (1000MT)	-22	50	270
Producer Surplus (Million $)	36.23	6.42	25.49***
Consumer Surplus (Million $)	34.89	7.83	N/A
Government Surplus (Million $)	54.365	11.14	N/A
Tariff Equivalent ($/MT)	3222	1302	N/A

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

Japanese production as well as consumption is almost the same as under the single actions of CCC_{US} and MAP_{US}. However, the sum of payoffs for Japan and Korea is increased under the combination of CCC_{US} and MAP_{US}. That means the two importing countries would be better off under the U.S. action of both CCC_{US} and MAP_{US} together by a payoff of 3.29. In terms of total surplus, Japan and Korea would be worse off by 4.034 million dollars under the combination of CCC_{US} and MAP_{US}. However, the U.S. total exporter's surplus is increased by 7.65 million dollars. Moreover, U.S. export to Japan is increased by 39 thousand MT under the combination as opposed to Korea that would import 16 thousand MT less.

Comparing with the base, Japanese and Korean production is decreased by 200 thousand MT and 203 thousand MT, respectively. In addition, Japanese and Korean consumption is decreased as well, by 433 thousand MT and 232 thousand MT, respectively. However, the sum of the two countries' surplus is increased by almost 20 million dollars.

Table 4.13 Simulation Payoffs under CFP_{US}.

		Korea			
	Action	$T2_{KO}$	$T4_{KO}$	$T6_{KO}$	$T8_{KO}$
	$T2_{JP}$	16.7 ; 3.0 (68.1)	16.7 ; 3.4 (68.3)	16.7 ; 2.8 (68.6)	16.7 ; 2.6 (67.3)
Japan	$T4_{JP}$	17.5 ; 3.0 (68.2)	**17.5 ; 3.4 (69.8)**	17.5 ; 2.8 (70.6)	17.5 ; 2.8 (71.0)
	$T6_{JP}$	17.0 ; 3.0 (70.2)	17.0 ; 3.4 (70.5)	17.0 ; 2.8 (71.3)	17.0 ; 2.8 (71.9)
	$T8_{JP}$	17.1 ; 3.0 (71.6)	17.1 ; 3.4 (72.2)	17.1 ; 2.8 (72.5)	17.1 ; 2.8 (73.0)

Note: numbers in a solution cell represent Japanese and Korean payoffs, respectively.
numbers in parentheses represent U.S. payoffs.

In U.S. action CFP_{US}, CCC_{US} and FDP_{US} are taken into account with change in Japanese and Korean tariff equivalent from 2% to 8% annually. The results are presented in Tables 4.13 and 14. The Nash equilibrium under the action is obtained at a 4% reduction of Japanese and Korean tariff equivalents. The U.S. payoff in the Nash equilibrium is 69.8, and Japanese and Korean payoffs are 17.5 and 3.4, respectively. The U.S. payoff under CPF_{US} is increased substantially to 69.8 from 6.63 under the base. Even though Japanese and Korean payoffs are increased to 17.5 and 3.4, respectively, the payoffs are similar to those under FMP_{US}.

Looking at the Table 4.14, which presents the simulation results under CFP_{US}, we can realize that Japanese production is decreased slightly, but Korean production is decreased by 519 thousand MT along with an decrease in consumption by 333 thousand MT. However, the two countries' imports from the U.S. are increased substantially by 407 thousand MT. That causes U.S. exporter's surplus to increase by 50.47 million dollars, compared to the base. In addition, the sum of the two countries' surplus is increased by 13.21 million dollars, compared to the base.

Table 4.14 Simulation Results of the Nash Equilibrium under CFP_{US}

	Japan	Korea	U.S.
Production (1000MT)	8225	4116	6502
Consumption (1000MT)	8006	4417	3846
Export (1000MT)	200	0	1906*
Import (1000MT)	481**	148**	321
Equilibrium Quantity (1000MT)	-20	50	629
Producer Surplus (Million $)	51.83	8.32	55.57***
Consumer Surplus (Million $)	48.23	6.23	N/A
Government Surplus (Million $)	83.89	12.66	N/A
Tariff Equivalent ($/MT)	3222	1302	N/A

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

Under the final action, MFP_{US}, MAP and FMDP are taken into account with change in Japanese and Korean tariff equivalent from 2% to 8% annually. The outcome of the action is presented in Tables 4.15 and 4.16. MAP and FADP are major programs in U.S. market development program. These two programs benefit U.S. farmers, processors, and exporters by assisting their organizations in developing new markets and increasing market share in existing markets. These programs support growth in U.S. agricultural exports by enlisting private sector involvement and resources in coordinated efforts to promote U.S. products to foreign buyers.

In this action, the Nash equilibrium is obtained at a 4% reduction. The U.S. payoff is derived at 140.6, and Japanese and Korean payoffs are obtained at 45.0 and 14.7, respectively. Comparing to the base, the U.S. payoff is increased substantially by 133.97. Also, Japanese and Korean payoffs are increased dramatically by 42.5 and 14.128, respectively. However, a dominant strategy for the U.S. is an 8% reduction with a payoff of 147.1, and a dominant strategy for Japan and Korea is a 4% reduction with payoffs of 45.0 and 14.7, respectively.

Table 4.15 Simulation Payoffs under MFP_{US}.

		Korea			
	Action	$T2_{KO}$	$T4_{KO}$	$T6_{KO}$	$T8_{KO}$
	$T2_{JP}$	34.1 ; 8.2 (137.4)	34.1 ; 14.7 (138.3)	34.1 ; 13.7 (139.2)	34.1 ; 12.3 (140.3)
Japan	$T4_{JP}$	45.0 ; 8.2 (139.5)	**45.0 ; 14.7 (140.6)**	45.0 ; 13.7 (141.2)	45.0 ; 12.3 (142.0)
	$T6_{JP}$	43.9 ; 8.2 (142.2)	43.9 ; 14.7 (142.9)	43.9 ; 13.7 (143.8)	43.9 ; 12.3 (145.3)
	$T8_{JP}$	40.2 ; 8.2 (144.9)	40.2 ; 14.7 (145.7)	40.2 ; 13.7 (146.2)	40.2 ; 12.3 (147.1)

Note: numbers in a solution cell represent Japanese and Korean payoffs, respectively.
numbers in parentheses represent U.S. payoffs.

In terms of production and consumption in the two importing countries, some substantial changes can be found (Table 4.16). Firstly, both countries' production is decreased dramatically due to an increase in import. An increase in import primarily causes domestic production to decrease. If they would keep the levels of production in both countries, the governments would have to deal with over-supply, which is eventually becoming burdensome stock. A result of this burdensome stock would incur rice surpluses in both countries, requiring expensive acreage diversion programs to help curb the over-supply. However, secondly, the main beneficiary would be the U.S. since the exporter's surplus is increased substantially. Similarly, the two countries total surplus is increased dramatically as well, compared to the base.

Table 4.16 Simulation Results of the Nash Equilibrium under MFP_{US}.

	Japan	Korea	U.S.
Production (1000MT)	7760	3863	6502
Consumption (1000MT)	7953	4390	3846
Export (1000MT)	0	0	1906*
Import (1000MT)	659**	221**	321
Equilibrium Quantity (1000MT)	-18	40	456
Producer Surplus (Million $)	75.67	18.82	112.08***
Consumer Surplus (Million $)	48.93	11.94	N/A
Government Surplus (Million $)	87.69	20.05	N/A
Tariff Equivalent ($/MT)	3222	1302	N/A

*: total U.S. exports.
**: imports from the U.S.
***: U.S. exporter surplus.
N/A: not available.

Table 4.17 Payoff Summary.

		J & K*			
	Action	$T2_C$	$T4_C$	$T6_C$	$T8_C$
	CCC_{US}	5.42 ; 1.62	5.53 ; 1.98	5.92 ; 2.0	6.14 ; 2.61
	MAP_{US}	15.1 ; 15.3	15.7 ; 18.0	16.2 ; 19.5	16.4 ; 19.7
U.S.	FDP_{US}	52.2 ; 20.5	53.4 ; 20.3	54.7 ; 17.5	56.0 ; 20.1
	CMP_{US}	30.8 ; 12.2	31.4 ; 16.3	32.7 ; 25.7	32.7 ; 19.6
	CFP_{US}	68.1 ; 19.7	69.8 ; 20.4	71.3 ; 19.8	73.0 ; 19.9
	MFP_{US}	137.4 ; 42.3	**140.6 ; 59.7**	143.8 ; 57.6	147.1 ; 52.5

*: represents sum of Japanese and Korean payoffs.

Overall, Table 4.17 reports a summary of the entire U.S. actions. Each action has a Nash equilibrium with changes in Japanese and Korean tariff equivalents. Table 4.17 shows that the overall Nash equilibrium for both trade parties is obtained at a 4% tariff reduction under MFP_{US}.

For Japan and Korea, a dominant strategy is 4% reduction with the payoff of 59.7. Since they have tried to protect their import markets, they would try to keep their tariff rates as high as possible to restrict their import markets. For the U.S., a dominant strategy is 8% reduction with the payoff of 147.1. It is preferable for the U.S. to export to Japan and Korea with lower tariff rates because the higher tariff rates would result in lower U.S. exports to Japan and Korea.

Under the MAP and FMDP programs, according to USDA, the U.S. can advertise U.S. rice through the Japanese telecommunication channels, such as national television and radio commercials (USDA, 2000). That means the U.S. rice federation can promote U.S. rice throughout the nation, which increases opportunities for U.S. rice exports to Japan. Unfortunately, promotional activities are not yet allowed in Korea. However, the main question for U.S. exports to Japan and Korea is how to handle heavy competition with major exporters such as Australia, China, and other exporters in both markets and how to penetrate Japanese and Korean domestic markets and consumer table competition.

CHAPTER 5
SUMMARY AND CONCLUSIONS

This chapter summarizes the research, states conclusion remarks, and describes the research limitations and future research opportunities. The organization of the Chapter is as follows: section 5.1 summaries the entire research and makes some concluding remarks. In section 5.2, the limitations of the study and future research opportunities are stated.

5.1 Summary and Concluding Remarks

As a result of WTO agreement on agricultural commodities, the impact of trade liberalization on the international rice market is profound because rice trade has been highly restricted in both developed and developing countries. In addition, another round of the WTO trade negotiations has started and the impacts of potential policy changes on rice production and trade flows in the world rice industry are unknown.

The Uruguay Round negotiations resulted in an agreement by Japan and South Korea to relax their rice import bans with minimum access requirements. Japan agreed to imports equal to 4% of consumption in 1995, increasing to 8% by the year 2001. Korea agreed to a minimum access of 1% of consumption in 1995, increasing to 2% by 2000 and 4% by 2004 based on the consumption of the year of 1986-88.

However, in December 1998, the Japanese government notified the WTO of its decision to introduce rice tariffication beginning April 1, 1999. Under tariffication, a specific duty of 351.17 yen per kilogram (kg) was applied to imports outside of the MA volume. In and after Japanese fiscal year 2000, April to March, a specific duty of 341 yen per kg was applied to imports outside of MA.

The impact of the UR agreement on the U.S. rice industry has been favorable. The major benefit has been access to the Japanese market. The U.S. share of this market has been about

50% as opposed to the Korean market, in which its market share is zero. However, the U.S. share of the Japanese market has gradually decreased and been unstable due to strong competition with major exporters.

Nevertheless, the U.S. rice industry can potentially increase its market share in Japanese and Korean rice import markets, given that both countries will likely be required to expand their imports in the next round of the WTO negotiations. Expanded market access remains one of the most important issues for rice trade.

Looking at the historical and recent structural changes in both countries, it is useful for the U.S. rice industry, especially the export market, to examine how much market share the U.S. can potentially obtain in the Japanese and Korean markets. In addition, it is important to examine how changes in Japanese and Korean rice policies, as related to their WTO commitments, will impact U.S. export industry.

The general objective of this study was to determine the potential for U.S. rice exports to Japan and Korea. The goal of the analysis was to determine the implications for U.S. export policies. The specific objectives to accomplish this were to estimate econometric models of supply and consumption behavior, to determine the political weights of relevant interest groups, to conduct a game theoretic analysis to determine the optimal policy options for U.S. rice exports.

Chapter two described Japanese and Korean rice economies and U.S. export situation. A general feature of both countries is an aging farm population (generally over 55) with rice farming being mostly a part-time farming operation with high dependence on off-farm income. Currently these two countries have high rice production costs compared to border prices due to the small-scale of farming, relatively high labor costs, and high land costs. The farm structure is dominated by small-scale rice farms and mostly operator-owned rather than rented rice farms. They produce high quality japonica medium-grain rice as a staple food. During the past several decades, they have been experiencing a decrease in per capita rice consumption, and normally produce rice surpluses as a result of highly protectionist government programs.

Rice supply and demand in Japan and Korea share many similarities. The production structure and policies for the rice sector have many common characteristics. As these countries have become more wealthy industrial countries, they have experienced a similar long-term decline in per capita rice consumption.

In terms of production, rice is the major crop grown in Japan and Korea, accounting for 37 percent and 56 percent of the total planted acreage in 1999, respectively. Although rice production has been relatively stable during the past 20 years, it has come from improved yield. The supply of paddy land for rice production has been stable over time due to the limited availability of land, as well as the low substitutability in land use between paddy and upland. Improvements in rice yields are mainly due to the adoption of new varieties, mechanization, and improved production practices in both countries.

On the consumption side, an increase in per capita income created a change in food consumption patterns in both countries. In addition, as per capita income has grown, per capita consumption of rice has declined gradually. This is mainly due to the change in the dietary pattern of consumers in favor of protein food such as meat and vegetables. However, the total consumption in rice has been stable in both countries due to an increase in population and higher demand in processing industries.

The U.S. is a leading exporter of rice in the international market, accounting for about 12 percent of global rice trade although the U.S. accounts for less than 2 percent of global rice production. The U.S. currently ranks fourth among major exporters, behind Thailand, Vietnam, and China. More than 40 percent of the U.S. rice crop is exported each year, making the U.S. market sensitive to movements in international prices.

From 1967 to 1982, Korea imported 8 million metric tons (MMT) of rice and U.S. rice exports supplied 65% of that market-mostly from California. However, by the mid-1980's, Korea attained self-sufficiency in rice due to generous government programs, and imports were essentially banned. After losing its largest importer, Korea, in 1983, California accumulated rice stocks, relative to the southern states. Since 1983, the U.S. exported no rice to Korea.

In the meantime, Japan accounts for the bulk of U.S. medium grain brown rice exports. In 1999/2000, Japan imported nearly 150 thousand MT of medium grain brown rice from the U.S., down from a year earlier record 250 thousand MT. Japan divides its rice purchases between milled and brown rice, with each type's share varying each year. The U.S. typically supplies half of Japan's total rice purchases. The U.S. exports about 10 thousand to 14 thousand MT of short grain brown rice each year. Japan accounts for two-thirds, most of it sold under the Simultaneous-Buy-Sell (SBS) portion of their total WTO commitments.

There are four types of government programs for U.S. rice exports. First, under PL 480, the U.S. sells rice on concessional credit terms and donates rice to needy countries either bilaterally or through the World Food Program. Second, USDA provides Credit Guarantee Program such as export credit guarantees (GSM-102) and intermediate Export Credit Guarantee (GSM-103) for commercial financing of U.S. agricultural exports. Third, the Market Access Program facilitates U.S. rice sales to markets where the U.S. competes with subsidized exports from other countries. Finally, USDA funds Foreign Market Development Program, which is for the creation, expansion, and maintenance of foreign markets for U.S. agricultural products.

In Chapter three, the theoretical framework was considered. The dynamic econometric model specified in this study was characterized by a combination of a partial adjustment process both in supply and demand, and cobweb type price expectations in supply response. The long-run adjustment responses were embodied in this model due to factor fixity in supply and habit formation in demand.

Supply and demand responses for rice were specified in terms of domestic production and consumption. The dynamics and the relationship between short-run and long-run responses can be seen by the specified market model within the partial adjustment model framework.

For the study, the supply parameters were estimated using two-stage least squares (2SLS). The demand equations, per capita consumption and U.S. export demand, are estimated by ordinary least square (OLS).

Given the estimated elasticities of demand and supply from the domestic production and consumption functions, we could derive the political weights of the three major interest groups in the three countries' rice economies. The policy analysis in the game theoretic approach looked specifically at the behavior of the rice price, import policy, and export policy variables. This study addressed policy analysis including several reasonable scenarios with respect to tariff equivalents. Overall, a game theoretic approach was adopted to determine politically feasible policy options for U.S. exports on each policy change in Japan and Korea.

In Chapter four, the empirical results were presented. Based on the theoretical considerations and the market structure concerning the dynamic commodity model in the previous section, the empirical econometric models for the three countries' rice markets were specified for the period 1960-1999.

The results of the acreage response estimation showed the expected signs for all explanatory variables that were implied in the theory of production. Except for the constant terms, all parameter estimates were different from zero at the 5% level of significance. The prices received by rice farmers in both countries had a positive impact on the acreage response, as expected. The production costs for Japan and the diversion program for Korea had a negative impact on the supply response. The coefficient estimate of the lagged dependent variables showed a stable geometric lag process and supported the existence of a lagged distribution of the dependent variables. The short-run supply elasticities with respect to the output at the mean for Japan and Korea were 0.11 and 0.13, respectively. However, the long-run supply elasticities were estimated as 0.75 and 0.89, respectively.

Except for the constant terms, all independent variables in the per capita consumption equations showed strong statistical significance and expected signs. All coefficient estimates were significant at the 5% level of significance. Rice consumption was negatively related to own price as well as income, which implied that rice is an inferior good in Japan and Korea. This is a phenomenon, which has been experienced over the last decade in Japan and Korea as their income levels have risen. The coefficients on the one year lagged dependent variables were also significant at the 5% level of significance. It implies that there exist gradual changes in diet patterns, which impact rice consumption. In fact, the increases in the income levels have transformed the Japanese and Korean diet by substituting rice with consumption of meats, fruits, and vegetables. The price elasticities for Japan and Korea were -0.096 and -0.23, respectively. The income elasticities were also computed at -0.029 and -0.56, respectively.

For the equation of U.S. export demand, all of the independent variables were statistically significant at the 5% level except for government export program. U.S. export demand estimation showed the expected signs for all explanatory variables. When the gap between world price and domestic price received by producers are widened, the producers' willingness to export rice tends to be higher.

The validation statistics showed that the models basically did a good job of representing the rice economies. The *rms* and Theil-U measures indicated that the models simulated the data well over the historical period. The *rms* indicated that the models had *rms* from 0.26% root-mean-square error to 5.01%. And U^M, U^S, U^C and Theil-U illustrated that we were able to use the models to explain the historical rice economies with very low values for U^M reflecting no systematic bias in the models.

The estimated political weights as shown in Table 4.3 indicated that the Japanese and Korean policies have favored rice producers more than the other interest groups. In the Japanese and Korean rice sectors, the political weights were particularly high for producers, lowest for consumers. The average weights for producers exceeded unity while those for consumers were less than unity. Table 4.3 showed a political willingness to redistribute income in favor of producers at the expense of consumers and taxpayers. This implies that rice producers have generally been preferred to consumers and taxpayers. In other words, the Japanese and Korean policymakers have placed more weights on the welfare of rice producers rather than those of consumers and taxpayers. In the meantime, the political weight for the U.S. rice exporters was derived at 1.17 on average. It was higher than the weight for the taxpayers that we normalized at unity in order to compare with different interest groups. Overall, table 4.3 illustrated the time trend in the political weight. A change in the political weight could be interpreted as policymaker's preferences changing overtime.

Using GAMS, the simulation results for the base were presented in Table 4.4. The year 1999 was selected as the base because it was an important turning point for Japan and South Korea for the next negotiation is the year 1999 and because Japan has adopted tariffication policy in 1999. In the meantime, Korea was assumed to follow the tariffication policy since it has had tremendous political pressure from the major exporters. As a result, we assumed that the two countries' major import policy was the tariffication policy.

Under the base, Japanese and Korean production was estimated at 8356 thousand MT and 4635 thousand MT, respectively. The Japanese and Korean imports were derived at 450 thousand MT and 150 thousand MT, respectively. The imports were from the U.S. only. The equilibrium quantity for Japan, Korea, and the U.S. were –22 thousand MT, 99 thousand MT, and 600 thousand MT, respectively. The U.S. export quantity was derived at 1804 thousand MT, including exports to Japan, Korea, and the rest of the world (ROW). In the meantime, the payoffs for Japan and Korea were derived at 2.508 and 0.572, respectively. And the U.S. export payoff was derived at 6.63.

The scenario analysis included six U.S. actions. The actions were 1) CCC with 2% to 8% reduction in Japan and Korea (CCC_{US}), 2) Market Access Program with 2% to 8% reduction in Japan and Korea (MAP_{US}), 3) Foreign Market Development Program with 2% to 8% reduction in Japan and Korea (FDP_{US}), 4) CCC and Market Access Program with 2% to 8% reduction in Japan and Korea (CMP_{US}), 5) CCC and Foreign Market Development Program with 2% to 8% reduction in Japan and Korea (CFP_{US}), and 6) Market Access Program and Foreign Market Development Program with 2% to 8% reduction in Japan and Korea (MFP_{US}).

Moreover, ten-year average political weights were used, five years prior to WTO agreement implementation and five years after the implementation. The political weights used for Japan were 1.261 and 0.739 for producer group and consumer group, respectively. For Korea, 1.436 and 0.564 for producer group and consumer group, respectively, were used for the scenario analysis. The political weight for U.S. exporter group was 1.283.

The results under the CCC_{US} showed that a Nash equilibrium was obtained at an 8% reduction of Japanese and Korean tariff rate. In the Nash equilibrium, Japanese and Korean payoffs were 2.25 and 0.36, respectively, and U.S. payoff was 6.14. In U.S. action of MAP_{US}, a Nash equilibrium was obtained at an 8% reduction of Japanese and Korean tariff rate. The Japanese and Korean payoffs were derived at 16.1 and 3.7, respectively, and the U.S. payoff was derived at 16.74. Under the MAP_{US}, Japanese and Korean production was decreased by 202 thousand MT and 135 thousand MT, respectively. However, U.S. exports to Japan and Korea were decreased by 54 thousand MT and 25 thousand MT, respectively. Due to an increase in U.S. total exports, U.S. exporter's surplus was increased to 13.05 million dollars from 5.1 million dollars, compared to the base. In FDP_{US}, a dominant strategy for Japan was obtained at the 2% of tariff reduction. Also, two dominant strategies for Korea were obtained at both a 2% reduction and an 8% reduction with the payoff of 3.4. As a result, there existed multiple equilibria under FDP_{US} at both a 2% and an 8% reduction. The FDP_{US} action had the largest payoffs for the U.S., compared to the base, CCC_{US}, and MAP_{US}, but the payoffs for Japan and Korea were almost the same as the other two U.S. actions and the base. The results under FDP_{US} showed that Japanese production was decreased slightly by 110 thousand MT, but Korean production was decreased dramatically by 513 thousand MT, compared to the base. Possibly, this dramatic change in production causes some structural changes in the Korean rice industry. Under the U.S. action of CMP_{US}, the U.S. payoffs did not change under the 8% and 6% reduction with the payoff of 32.7. A dominant strategy for Japan was a 6% reduction of its tariff equivalent with a payoff of 21.1. In addition, a dominant strategy for Korea was a 6% reduction of tariff equivalent with a payoff of 4.6 as well. However, the Nash equilibrium was obtained at a 6% of reduction strategy for both the U.S. and the two importing countries with the payoffs of 32.7 and 25.7, respectively. In U.S. action of CFP_{US}, the Nash equilibrium under the action was obtained at a 4% reduction of Japanese and Korean tariff equivalents. The U.S. payoff in the Nash equilibrium was 69.8, and Japanese and Korean payoffs were 17.5 and 3.4, respectively. The U.S. payoff under CPF_{US} was increased substantially to 69.8 from 6.63 under the base. Under the final action, MFP_{US}, the Nash equilibrium was obtained at a 4% reduction. The U.S. payoff was derived at 140.6, and Japanese and Korean payoffs were derived at 45.0 and 14.7, respectively. Comparing to the base, the U.S. payoff was increased substantially by 133.97. Also, Japanese and Korean payoffs were increased dramatically by 42.5 and 14.128, respectively.

Table 4.17 showed that the overall Nash equilibrium for all trade parties was a 4% tariff reduction under MFP_{US}. For Japan and Korea, a dominant strategy was a 4% reduction with the payoff of 59.7. Since they have tried to protect their import markets, they would try to keep their tariff rates as high as possible to restrict their import markets. For the U.S., an 8% reduction on the part of Japan and Korea is preferable, given the payoff of 147.1. This is logical given that the U.S. would prefer to export to Japan and Korea with lower tariff rates because the higher tariff rates would result in lower U.S. exports to Japan and Korea.

Moreover, the U.S. actions that included the Foreign Market Development Programs (FMDP) dominated the other actions that did not include the FMDP. The payoffs of the actions with FMDP were larger than those of the actions without FMDP for the U.S. Even though, under the U.S. actions of CFP_{US} and MFP_{US}, the Nash equilibrium was obtained at a 4%

reduction, which is not preferable to the U.S., the payoffs were increased substantially, compared to the other actions and the base. In addition, under the single action scenarios, FDP_{US} dominated the other single policy scenarios, CCC_{US} and MAP_{US}. Therefore, the implication of the findings would be the U.S. policy priority on U.S. rice exports to Japan and Korea. These findings suggest that the U.S. policy makers on U.S. exports to Japan and Korea might need to weigh more on the U.S. export policy options than the tariff reduction of Japan and Korea.

This study has analyzed the impacts of Japanese and Korean import policies on U.S. exports, including various changes in Japanese and Korean tariff rates. In addition, it has analyzed the possible policy options for U.S. exports with respect to the changes in Japanese and Korean tariff rates, incorporating econometric estimation and political weights for the interest groups into a game theoretic analysis.

Since Japan and South Korea became regular importers by the WTO agreement, the two governments had to reallocate their agricultural resources due to either international pressures or internal problems, which exist within their rice industries. Therefore, the U.S. export industry has to take those changes into account. This study concludes with some suggestions regarding Japanese and Korean import policy changes for U.S. exports.

Both Korea and Japan strictly implemented the WTO commitments on rice. However, several issues arose from how these countries managed rice imported. The State Trading Enterprises (STEs) of both countries kept most imported rice away from domestic consumers. The Food Agency of Japan allocated rice across national suppliers with results roughly mimicking commercial trade. Japan also used markups to keep imported rice away from domestic consumers. In Korea, rice has been imported through tenders where the lowest bidder wins. This results in low-quality rice imports from suppliers who were unlikely to have been successful in commercial trade. As a result, consumer benefits are reduced, and allocation across import suppliers has been affected. The next round of WTO negotiations will face these issues if quantitative market access is to improve in the interim while tariffs are reduced. Subsequent meetings will also face STE issues regarding possible manipulations within approved market methods and the ways to encourage market results through market mechanisms.

The best export policy option from the scenario analysis turned out to be the combination of MAP and FMDP for U.S. exports to Japan and Korea. However, it depends on how the policies are implemented by the U.S. in Japanese and Korean domestic markets. There are many obstacles in the two markets such as STEs and implicit trade barriers. The implicit trade barriers are even worse than STEs because the consumers are willing to buy domestic rice at a higher price than the border price due to cultural and traditional backgrounds. To overcome those obstacles, the U.S. has to investigate some new marketing strategies in the domestic markets, including wide variety of advertisements and private commercial contract with franchise restaurants and convenient stores along with political and economic pressures on the Japanese and Korea governments. However, the U.S. could not be able to export any rice to Korea since 1980s. Korea has imported its WTO commitments mostly from India and China because of lower prices and transportation costs. Many international trade experts have expected that China will be a major exporter to Korea. However, according to WTO agreement, Korea is supposed to import from 154 thousand MT in 2002 to 205 thousand MT in 2004. That means that every rice exporters still have chances to export to Korea, including the U.S.

In addition, when making political decisions, economic studies of this nature can help policy makers to determine the welfare impacts of various policy actions. However, it must be kept in mind that empirical analyses are not the only criterion available in the policy making process. Empirical studies can provide input for policy makers facing various decision-makings. If the study suggests that a policy action causes changes that may be acceptable, alternative policies can be used as well.

5.2 Study Limitations and Further Research Opportunities

This study attempted to analyze U.S. export policy options to Japan and Korea. However, it has faced some limitations that must be considered for future research. One limitation was analyzing rice trade between the U.S. and the two countries by rice type and quality because there is no standard classification to differentiate among rice products in use and because of data unavailability on U.S. exports to Japan and Korea by type and quality.

The second limitation of the study is that it did not consider the entire U.S. rice industry. This study focused on the political and economic relationships between U.S. exports to Japan and Korea and the two importing countries. If this study considered the entire U.S. export industry, the world import markets would have had to be considered since the U.S. has exported rice to the world, including some countries in Europe, the Middle East, Latin America, and East Asia. That is not within the scope of this study. In addition, there needs to be a more detailed specification of U.S. export demand in the model. World ending stock and the relative price ratio could be endogenized by rice type and quality. However, due to data availability, this study considered those variables exogenous. Therefore, there remains considerable room to improve the specification of U.S. export demand.

The third limitation of the study is the data structure of the model. Although most of the data was obtained from USDA and Japanese and Korean Ministry of Agriculture, Fishery, and Forestry, some financial and specific regional data were very difficult to obtain due to some language barriers and official confidentiality.

The fourth limitation of the study is that it used a linear additive political preference function with unequal weights assigned to three interest groups. However, in principle, the nature and the number of interest groups that can be included in a political preference function is unrestricted. Thus, if possible, it is required to consider various functional forms and potential interest groups, which might be influenced by the policy.

Lastly, there is no previous research attempting to incorporate econometric estimation and PPF analysis into a game theoretic analysis. Therefore, it was hard to justify the framework theoretically and empirically. However, the idea of the combination of the three methodologies was worth performing the model for the export market. In addition, this study did not consider potential cooperative game behavior that might change the Nash equilibrium solution in the scenario analysis. For example, the overall Nash equilibrium would be at a 6% reduction under the cooperative game, which would be Pareto superior to the solution under the noncooperative game.

In addition to those limitations, this study can be extended to examine U.S. export policy options with respect to Japanese and Korean import policies if their import policies are known. As long as we can forecast econometric estimation and political weights, this study can examine any type of policy options for the exporting and the importing countries' policy options as well. However, examining additional policy options are beyond the scope of the study. It is now left for future research.

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APPENDIX 1. GAMS PROGRAM USED FOR THE MODEL

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$title game theoretic approach on U.S. rice exports to Japan and Korea
sets
i  country     /Japan, Korea, US/
y  year        /1960*1999/;

*****parameter declaration**********
parameters

********production parameters************
jarharvo         area harvested in Japan(1000ha)
jprodpo          Japanese producer price(yen MT)
jlarharvo        lagged area harvested in Japan(1000ha)
jprodco          Japanese production cost(yen MT)
jyieldo          yield in Japan(MT ha)
jtecho           Japanese technology
jydummyo         Japanese yield dummy
jprodo           Japanese production (1000MT)
karharvo         Korean area harvested (1000ha)
klarharvo        Korean lagged area harvested (1000ha)
kprodo           Korean production (1000MT)
kgpurpo          Korean government purchase price(won MT)
kdiverto         Korean diversion program (ha)
kyieldo          Korean yield (MT ha)
klyieldo         Korean lagged yield (MT ha)
ktecho           Korean technology
kydummyo         Korean yield dummy
uprodjo          us japonica production

*********Consumption parameters****************
jpconpo          Japanese per capita consumption(kg person)
ljpconpo         Japanese lagged per capita consumption(kg person)
jretpo           Japanese retail price(yen MT)
jincomo          Japanese income (billion yen)
jcothero         Japanese other consumption (1000MT)
jpoconpo         Japanese processing consumption(1000MT)
jadconpo         Japanese foreign aid consumption(1000MT)
jgovconpo        Japanese government use(1000MT)
jconpo           Japanese consumption (1000 MT)
jpopo            Japanese population(million)
lkpconpo         lagged Korean per capita consmption
kpconpo          Korean per capita consumption(kg person)
Kincomo          Korean income (billion won)
Kretpo           Korean retail price(won MT)
Kcdummyo         Korean consumption dummy
kcothero         Korean other consumption (1000MT)
kpoconpo         Korean processing consumption(1000MT)
kadconpo         Korean aid consumption (1000MT)
kconpo           Korean consumption (1000 MT)
kpopo            Korean population(million)
uconpo           us total consumption (1000MT)
uadconpo         us aid consumption (1000MT)
uexdemo          us export demand(1000MT)
woldpjo          world price of japonica($ MT)
```

uexotpjo us export price of japonica($ MT)
uexotpio us export price of indica($ MT)
woldpio world price of indica($ MT)
upl480o us PL480(1000MT)
uccco us CCC(1000MT)
ueepo us EEP(1000MT)
uothero us other programs(1000MT)
ugexpo us government export programs (1000MT)
uxdummyo us export dummy

*********price parameters****************
woldpjo world price of japonica($ MT)
jtarif1o Japanese tariff(percent)
jtarif2o Japanese tariff ($)
ktarif1o Korean tariff(percent)
ktarif2o Korean tariff ($)
jgpropo Japanese government procurement price(yen MT)
jdirecto Japanese direct payment (yen MT)
jgselpo J gov selling price
kprodpo Korean producer price (won MT)
kdirecto Korean direct payment (wonn MT)
kgselpo Korean gov selling price
uretpo us retail price ($ MT)
uprodpjo us producer price of japonica($ MT)
uprodpio us producer price of indica($ MT)
utarpo us target price($ MT)
uloano us loan rate ($ MT)
utranspo us transition payment($ MT)
uexpp1o us first export price ($ MT)
uexpp2o us second export price ($ MT)

**********welfare parameters****************
jpwelo Japanese producer welfare
jpprinto Japanese producer price intercept
jcwelo Japanese consumer welfare
jcprinto Japanese consumer price intercept
jgwelo Japanese government welfare
jgovpuro Japanese government purchase amount(MT)
jscosto Japanese social cost
kpwelo Korean producer welfare
kpprinto Korean producer price intercept
kcwelo Korean consumer welfare
kcprinto Korean consumer price intercept
kgwelo Korean government welfare
kgovpuro Korean government purchase amount(MT)
kscosto Korean social cost
uexwel1o us export welfare of the first
uexwel2o us export welfare of the second
uexwel3o us export welfare of the third
uexwel4o us export welfare of the fourth
jequilo Japanese equilibrium
kequilo Korean equilibrium
uexinto us export intercept
upwelo us producer welfare
upprinto us producer price intercept
ucwelo us consumer welfare

ucprinto	us consumer price intercept
ugwelo	us government welfare
ugovpuro	us government purchase amount(MT)
uscosto	us social cost

**********us export capacity parameters**********

uexpotjo	us export to Japan (1000MT)
uexpotko	us export to Korea (1000MT)
uexpotj1o	us export to Japan estimated
uexpotk1o	us export to Korea estimated
uexpotwo	us export to row
uprodo	us production (1000MT)
ubestko	us beginning stock (1000MT)
uimpoto	us imports (1000MT)
utconpo	us total consumption (1000MT)
uenstko	us ending stock (1000MT)
utexpto	us total exports (1000MT)
utexpt1o	us export demand
uojkto	us export capacity under tariff (1000MT)
uojkqo	us export capacity under quota (1000MT)
jquotao	Japanese quota (1000MT)
kquotao	Korean quota (1000MT)
woenstko	world ending stock(1000MT)
jimpotwo	J import from row
jimpotuo	J import from us
kimpotwo	k import from row
kimpotuo	k import from us

******equilibrium parameters**********

jprodo	Japanese production (1000MT)
jbestko	Japanese beginning stock (1000MT)
jimpoto	Japanese imports (1000MT)
jimpotuo	J import from row
jenstko	Japanese ending stock (1000MT)
jexpoto	Japanese exports (1000MT)
kprodo	Korean production (1000MT)
kbestko	Korean beginning stock (1000MT)
kimpoto	Korean imports (1000MT)
kenstko	Korean ending stock (1000MT)
kexpoto	Korean exports (1000MT)

**********payoff parameters*************

jpayo	Japanese payoff
jpoweico	Japanese consumer political weights
jpoweipo	Japanese producer political weights
jpoweigo	Japanese government political weights
kpayo	Korean payoff
kpoweico	Korean consumer political weights
kpoweipo	Korean producer political weights
kpoweigo	Korean government political weights
upayo	us payoff
upoweieo	export producer political weights
jquota1o	Japanese first quota(1000MT)
jquota2o	Japanese second quota(1000MT)
uexequilo	us export equil

******elasticity************
jpelaso Japanese price elasticity
jinelaso Japanese income elasticity
jimdelaso Japanese import demand elasticity
kpelaso Korean price elasticity
kinelaso Korean income elasticity
kimdelaso Korean import demand elasticity
uexdelaso us export demand elasticity

******demographic parameters********
jexchano Japanese exchange rate to a dollar(yen $)
jfpopo Japanese farm population(1000)
kexchano Korean exchange rate to a dollar(won $)
upopo us population(1000)
jgnpdo Japan gnp deflator
kgdpdo Korea gdp deflator

********fixed parameter declaration***********
jazero Japanese area harvested intercept
jaone Japanese area harvested parameter on lagged
jatwo Japanese area harvested parameter on producer price(cpi)
jathree Japanese area harvested parameter on prod cost(cpi)
kazero Korean area harvested intercept
kaone Korean area harvested parameter on lagged
katwo Korean area harvested parameter on diversion area
uxzero us export demand intercept
uxone us export demand parameter on log world ending stock
uxtwo us export demand parameter on w price(j) procuer price(J)
uxthree us export demand parameter on log export program(ccc+eep)
uxfour us export demand parameter on 8094 dummy
jyzero Japanese yield intercept
jyone Japanese yield parameter on tech
jytwo Japanese yield parameter on 8093 dummy
kyzero Korean yield intercept
kyone Korean yield parameter on tech
kytwo Korean yield parameter on 8093 dummy
jczero Japanese per capita consumption intercept
jcone Japanese per capita consumption parameter on log lagged
jctwo Japanese per capita parameter on log retail price(gnp defla)
jcthree Japanese per capita parameter on log income(nominal)
kczero Korean per capita consumption intercept
kcone Korean per capita parameter on log lagged
kctwo Korean per capita parameter on log income(cpi)
kcthree Korean per capita parameter on log retail(gdp defla)
uekzero us ex to ko intercept
uekone us ex to ko us japonica production
uektwo us ex to ko price difference
uekthree us ex to ko tariff
uejzero us ex to ja intercept
uejone us ex to ja price difference
uejtwo us ex to ja ccc+eep
uejthree us ex to ja tariff

parameter fixed(*) /jazero = 294.176, jaone = 0.843, jatwo = 0.175, jathree = -0.027, kazero = 50.76, kaone = 0.932, katwo = 0.000059, kathree = -0.006, uxzero = 2.680757, uxone = 0.490176, uxtwo = 0.036, uxthree = 0.031, uxfour = 0.274, jyzero = 3.5579, jyone = 0.0313,

```
                jytwo = -0.8874, kyzero = 3.741473, kyone = 0.02928, kytwo = -0.83687, jczero = 1.8133
                jcone   = 0.8202, jctwo = -0.0963, jcthree = -0.0291, kczero  = 5.461, kcone   = 0.7203,
                kctwo = -0.023, kcthree = -0.56, kcfour = 0.2073, uekzero = -38.5617, uekone = 6.6703,
                uektwo = 3.6268, uekthree = -1.3318, uejzero = -31.7671, uejone = 6.1103, uejtwo =
                3.7505, uejthree = 0.9217, jpprint = 802.6, kpprint = 76.6, kcprint = 157.4, jpelas  = -0.0291
                jinelas = -0.0963, kpelas = -0.0268, kinelas = -0.1064, uexprint = 73.3552, uexdelas =
                0.036/;

**********data tables**************
DATA

***************parameter assignment*******************
jarharvo(y) = arha("jarharv", y); jprodpo(y) = price("jprodp", y)/demo("jcpi",y);
jlarharvo(y) = arha("jlarharv", y); jprodco(y) = prodt("jprodc", y)/demo("jcpi", y);
jyieldo(y) = yield("jyield", y); jtecho(y)  = dummy("jtech", y);
jydummyo(y) = dummy("jydummy", y); jprodo(y)  = prodt("jprod", y);
karharvo(y) = arha("karharv", y); klarharvo(y) = arha("klarharv", y);
kdiverto(y) = arha("kdivert", y); kprodo(y) = prodt("kprod", y);
kgpurpo(y) = price("kgpurp", y)/demo("kcpi", y); kyieldo(y) = yield("kyield", y);
klyieldo(y) = yield("klyield", y); ktecho(y) = dummy("ktech", y);
kydummyo(y) = dummy("kydummy", y); uprodjo(Y)  = prodt("uprodj", y);
jpconpo(y)  = conp("jpconp", y); ljpconpo(y) = conp("ljpconp", y);
jretpo(y)   = price("jretp", y)/demo("jgnpd", y); jincomo(y)  = demo("jincom", y);
jpoconpo(y) = conp("jpoconp", y); jadconpo(y) = conp("jadconp", y);
jgovconpo(y) = conp("jgovconp", y); jconpo(y) = conp("jconp", y);
jpopo(y)   = demo("jpop", y); kpconpo(y) = conp("kpconp", y);
lkpconpo(y) = conp("lkpconp", y); kincomo(y)  = demo("kincom", y)/demo("kcpi", y);
kretpo(y)   = price("kretp", y)/demo("kgdpd", y);
kcdummyo(y) = dummy("kcdummy", y); kpoconpo(y) = conp("kpoconp", y);
kadconpo(y) = conp("kadconp", y); kconpo(y)   = conp("kconp", y);
utconpo(y)   = conp("utconp", y); uadconpo(y) = conp("uadconp", y);
utexpto(y)  = export("utexpt", y); uexdemo(y)  = export("uexdem", y);
jimpotwo(y)  = impot("jimpotw", y); utconpo(y)  = conp("utconp", y);
woldpjo(y)  = price("woldpj", y); uexotpio(y) = price("uexotpi", y);
upl480o(y)  = export("upl480", y); uccco(y)    = export("uccc", y);
ueepo(y)    = export("ueep", y); uothero(y)  = export("uother", y);
uxdummyo(y)  = dummy("uxdummy", y);
jgpropo(y)   = price("jgprop", y)/demo("jcpi", y);
jdirecto(y)  = price("jdirect", y)/demo("jcpi", y);
kprodpo(y)   = price("kprodp", y)/demo("kcpi", y);
kgpurpo(y)   = price("kgpurp", y)/demo("kcpi", y);
kdirecto(y)  = price("kdirect", y)/demo("kcpi", y);
uprodpjo(y)  = price("uprodpj", y); uprodpio(y)  = price("uprodpi", y);
utarpo(y)    = price("utarp", y); uloano(y)    = price("uloan", y);
utranspo(y)  = price("utransp", y); uretpo(y) = price("uretp", y);
kgselpo(y) = price("kgselp", y)/demo("kcpi", y);
jgselpo(y) = price("jgselp", y)/demo("jcpi", y);
uprodo(y)  = prodt("uprod", y); uexpotjo(y) = export("uexpotj", y);
uexpotj1o(y) = export("uexpotj1", y); uexpotko(y)  = export("uexpotk", y);
uexpotk1o(y) = export("uexpotk1", y); uexpotwo(y)  = export("uexpotw", y);
ubestko(y) = stock("ubestk", y); uimpoto(y) = impot("uimpot", y);
woenstko(y) = stock("woenstk", y); uenstko(y) = stock("uenstk", y);
utexpto(y) = export("utexpt", y); utexpt1o(y) = export("utexpt1", y);
jquota1o(y) = gdemo("jquota1", y); jquota2o(y) = gdemo("jquota2", y);
kquotao(y)  = gdemo("kquota", y); jtarif1o(y)  = gdemo("jtarif1", y);
jtarif2o(y)  = gdemo("jtarif2", y); ktarif1o(y)  = gdemo("ktarif1", y);
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```
ktarif2o(y)  = gdemo("ktarif2", y); jexpoto(y)  = export("jexpot", y);
kexpoto(y)  = export("kexpot", y); uexequilo(y) = export("uexequil", y);
kimpotwo(y)  = impot("kimpotw", y); kimpotuo(y)  = impot("kimpotu", y);
jbestko(y) = stock("jbestk", y); jimpoto(y) = impot("jimpot", y);
jenstko(y) = stock("jenstk", y); jexpoto(y) = export("jexpot", y);
kbestko(y) = stock("kbestk", y); kimpoto(y) = impot("kimpot", y);
kenstko(y) = stock("kenstk", y); kexpoto(y) = export("kexpot", y);
jexchano(y) = demo("jexchan", y); kexchano(y) = demo("kexchan", Y);
jpoweico(y) = polweights("jpoweic", y); jpoweipo(y) = polweights("jpoweip", y);
jpoweigo(y) = polweights("jpoweig", y); kpoweico(y) = polweights("kpoweic", y);
kpoweipo(y) = polweights("kpoweip", y);
kpoweigo(y) = polweights("kpoweig", y);
upoweieo(y) = polweights("upoweie", y);
jazero = fixed("jazero"); jaone = fixed("jaone"); jatwo   = fixed("jatwo");
jathree = fixed("jathree"); kazero = fixed("kazero"); kaone = fixed("kaone");
katwo = fixed("katwo"); uxzero = fixed("uxzero"); uxone = fixed("uxone");
uxtwo = fixed("uxtwo"); uxthree = fixed("uxthree"); uxfour = fixed("uxfour");
jyzero = fixed("jyzero"); jyone = fixed("jyone"); jytwo = fixed("jytwo");
kyzero = fixed("kyzero"); kyone = fixed("kyone"); kytwo = fixed("kytwo");
jczero = fixed("jczero"); jcone = fixed("jcone"); jctwo = fixed("jctwo");
jcthree = fixed("jcthree"); kczero = fixed("kczero"); kcone = fixed("kcone");
kctwo = fixed("kctwo"); kcthree = fixed("kcthree"); uekzero = fixed("uekzero");
uekone = fixed("uekone"); uektwo = fixed("uektwo"); uekthree = fixed("uekthree");
uejzero = fixed("uejzero"); uejone = fixed("uejone"); uejtwo = fixed("uejtwo");
uejthree = fixed("uejthree");

**************Variable Definition********
VARIABLES
Z                    objective function
JARHARV(y)           area harvested in Japan(1000ha)
JPRODP(y)            Japanese producer price(yen MT)
JLARHARV(y)          lagged area harvested in Japan(1000ha)
JPRODC(y)            Japanese production cost(yen MT)
JYIELD(y)            yield in Japan(MT ha)
JTECH(y)             Japanese technology
JYDUMMY(y)           Japanese yield dummy
JPROD(y)             Japanese production (1000MT)
KARHARV(y)           Korean area harvested (1000ha)
KLARHARV(y)          Korean lagged area harvested (1000ha)
KPROD(y)             Korean production (1000MT)
KDIVERT(Y)           Korean divertion area(ha)
KGPURP(y)            Korean government purchase price(won MT)
KYIELD(y)            Korean yield (MT ha)
KLYIELD(y)           Korean lagged yield (MT ha)
KTECH(y)             Korean technology
KYDUMMY(y)           Korean yield dummy
UPRODJ(y)            U.S. japonica production
JPCONP(y)            Japanese per capita consumption(kg person)
JLPCONP(y)           Japanese log per capita consumption(kg person)
LJPCONP(y)           Japanese lagged per capita consumption
JRETP(y)             Japanese retail price(yen MT)
JINCOM(y)            Japanese income (billion yen)
JCOTHER(y)           Japanese other consumption (1000 MT)
JPOCONP(y)           Japanese processing consumption(1000MT)
JADCONP(y)           Japanese foreign aid consumption(1000MT)
JGOVCONP(y)          Japanese government use(1000MT)
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JCONP(y)	Japanese consumption (1000 MT)
JTCONP(y)	Japanese total consumption (1000 MT)
JPOP(y)	Japanese population(million)
KLPCONP(y)	Korean log per capita consumption(kg person)
LKPCONP(y)	lagged Korean per capita consumption
KPCONP(y)	Korean per capita consumption(kg person)
KCONP(y)	Korean consumption (1000MT)
KINCOM(y)	Korean income (billion won)
KRETP(y)	Korean retail price(won MT)
KCDUMMY(y)	Korean consumption dummy
KCONTHER(y)	Korean other consumption (1000MT)
KPOCONP(y)	Korean processing consumption(1000MT)
KADCONP(y)	Korean foreign aid consumption(1000MT)
KCONP(y)	Korean consumption (1000 MT)
KTCONP(y)	Korean total consumption (1000 MT)
KPOP(y)	Korean population(million)
UTEXPT(Y)	U.S. total export (1000MT)
UEXDEM(y)	U.S. export demand(1000MT)
WOLDPJ(y)	world price of japonica($ MT)
UEXOTPJ(y)	U.S. export price of japonica($ MT)
UEXOTPI(y)	U.S. export price of indica($ MT)
WOLDPI(y)	world price of indica($ MT)
UPL480(y)	U.S. PL480(1000MT)
UCCC(y)	CCC(1000MT)
UEEP(y)	EEP(1000MT)
UOTHER(y)	other programs(1000MT)
UGEXP(y)	government export programs (1000MT)
UXDUMMY(y)	export dummy
JRETP(y)	Japanese domestic retail price (yen MT)
WOLDPJ(y)	world price of japonica($ MT)
JTARIF1(y)	Japanese tariff(percent)
JTARIF2(y)	Japanese tariff($)
KRETP(y)	Korean domestic retail price (won MT)
KTARIF1(y)	Korean tariff(percent)
KTARIF2(y)	Korean tariff($)
JPRODP(y)	Japanese producer price (yen MT)
JGPROP(y)	Japanese government procurement price(yen MT)
JGSELP(y)	J GOV SELLING PRICE
JDIRECT(y)	Japanese direct payment (yen MT)
KPRODP(y)	Korean producer price (won MT)
KGPURP(y)	Korean government purchase price(won MT)
KGSELP(y)	K GOV SELLING PRICE
KDIRECT(y)	Korean direct payment (won MT)
URETP(y)	U retail price ($ MT)
UPRODPJ(y)	U producer price of japonica($ MT)
UPRODPI(y)	U producer price of indica($ MT)
UTARP(y)	U target price($ MT)
ULOAN(y)	U loan rate ($ MT)
UTRANSP(y)	U transition payment($ MT)
UEXPP1(y)	U first export price ($ MT)
UEXPP2(y)	U second export price ($ MT)
KIMPOTW(y)	K IMPORT FROM ROW
KIMPOTU(Y)	K IMPORT FROM US
JIMPOTW(y)	J IMPORT FROM ROW
JPWEL(y)	Japanese producer welfare
JCWEL(y)	Japanese consumer welfare

JGWEL(y)	Japanese government welfare
JGOVPUR(y)	Japanese government purchase amount(MT)
JSCOST(y)	Japanese social cost
JTOWEL(y)	Japanese total welfare
KPWEL(y)	Korean producer welfare
KCWEL(y)	Korean consumer welfare
KGWEL(y)	Korean government welfare
KGOVPUR(y)	Korean government purchase amount(MT)
KSCOST(y)	Korean social cost
KTOWEL(y)	Korean total welfare
UEXWEL1(y)	us export welfare of the first
UEXWEL2(y)	us export welfare of the second
UEXWEL3(y)	us export welfare of the third
UEXWEL4(y)	us export welfare of the fourth
JEQUIL(y)	Japanese equilibrium
KEQUIL(y)	Korean equilibrium
UEXEQUIL(y)	us export equilibrium
UEXINT(y)	us export intercept
UPWEL(y)	us producer welfare
UPPRINT(y)	us producer price intercept
UCWEL(y)	us consumer welfare
UCPRINT(y)	us consumer price intercept
UGWEL(y)	us government welfare
UGOVPUR(y)	us government purchase amount(MT)
USCOST(y)	us social cost
UEXPOTJ(y)	us export to Japan (1000MT)
UlEXPOTJ(y)	us log
UEXPOTJ1(y)	us export to Japan estimated
UEXPOTK(Y)	us export to Korea (1000MT)
UleXPOTK(y)	us log to Korea
UEXPOTK1(y)	us export to Korea estimated
UEXPOTW(y)	us export to row
UPROD(y)	us production (1000MT)
UBESTK(y)	us beginning stock (1000MT)
UIMPOT(y)	us imports (1000MT)
UTCONP(y)	us total consumption (1000MT)
UENSTK(y)	us ending stock (1000MT)
UTEXPT(y)	us total exports (1000MT)
UlTEXPT(y)	us log ex demand
UTEXPT1(y)	us export demand
UOJKT(y)	us export capacity under tariff (1000MT)
UOJKQ(y)	us export capacity under quota (1000MT)
JQUOTA1(y)	Japanese first quota (1000MT)
JQUOTA2(y)	Japanese second quota (1000MT)
KQUOTA(y)	Korean quota (1000MT)
JEXPOT(y)	Japanese export(1000MT)
KEXPOT(y)	Korean export (1000MT)
JPROD(y)	Japanese production (1000MT)
JBESTK(y)	Japanese beginning stock (1000MT)
JIMPOT(y)	Japanese imports (1000MT)
JTCONP(y)	Japanese total consumption (1000MT)
JENSTK(y)	Japanese ending stock (1000MT)
JTEXPT(y)	Japanese total exports (1000MT)
KPROD(y)	Korean production (1000MT)
KBESTK(y)	Korean beginning stock (1000MT)
KIMPOT(y)	Korean imports (1000MT)

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KTCONP(y)          Korean total consumption (1000MT)
KENSTK(y)          Korean ending stock (1000MT)
KTEXPT(y)          Korean total exports (1000MT)
WOENSTK(y)         world ending stock (1000MT)
JPAY(y)            Japanese payoff
JPOWEIC(y)         Japanese consumer political weights
JPOWEIP(y)         Japanese producer political weights
JPOWEIG(y)         Japanese government political weights
KPAY(y)            Korean payoff
KPOWEIC(y)         Korean consumer political weights
KPOWEIP(y)         Korean producer political weights
KPOWEIG(y)         Korean government political weights
UXPAY(y)           us export payoff
UPOWEIE(y)         export producer political weights
JEXCHAN(y)         Japanese exchange rate to a dollar(yen $)
JFPOP(y)           Japanese farm population(1000)
KEXCHAN(y)         Korean exchange rate to a dollar(won $)
KFPOP(y)           Korean farm population (1000)
UPOP(y)            us population(1000);

**********varialbe initialization****************
JARHARV.L(y) = JARHARVO(y); JPRODP.L(y) = JPRODPO(y);
JLARHARV.L(y) = JLARHARVO(y); JPRODC.L(y) = JPRODCO(y);
JYIELD.L(y) = JYIELDO(y); JTECH.L(y) = JTECHO(y);
JYDUMMY.L(y) = JYDUMMYO(y); JPROD.L(y) = JPRODO(y);
KARHARV.L(y) = KARHARVO(y); KLARHARV.L(y) = KLARHARVO(y);
KPROD.L(y) = KPRODO(y); KDIVERT.L(y) = KDIVERTO(y);
KGPURP.L(y) = KGPURPO(y); KYIELD.L(y) = KYIELDO(y);
KLYIELD.L(y) = KLYIELDO(y); KTECH.L(y) = KTECHO(y);
KYDUMMY.L(y) = KYDUMMYO(y);
JPCONP.L(y) = JPCONPO(y); LJPCONP.L(y) = LJPCONPO(y);
JRETP.L(y) = JRETPO(y); JINCOM.L(y) = JINCOMO(y);
JPOCONP.L(y) = JPOCONPO(y); JADCONP.L(y) = JADCONPO(y);
JGOVCONP.L(y) = JGOVCONPO(y); JCONP.L(y) = JCONPO(y);
JPOP.L(y) = JPOPO(y); LKPCONP.L(y) = LKPCONPO(y);
KPCONP.L(y) = KPCONPO(y); KINCOM.L(y) = KINCOMO(y);
KRETP.L(y) = KRETPO(y); KCDUMMY.L(y) = KCDUMMYO(y);
KPOCONP.L(y) = KPOCONPO(y); KADCONP.L(y) = KADCONPO(y);
KCONP.L(y) = KCONPO(y); UEXDEM.L(y) = UEXDEMO(y);
WOLDPJ.L(y) = WOLDPJO(y); UTEXPT.L(y) = UTEXPTO(y);
UEXOTPI.L(y) = UEXOTPIO(y); UPL480.L(y) = UPL480O(y);
UCCC.L(y) = UCCCO(y); UEEP.L(y) = UEEPO(y); UOTHER.L(y) = UOTHERO(y);
UXDUMMY.L(y) = UXDUMMYO(y);
JRETP.L(y) = JRETPO(y); WOLDPJ.L(y)  = WOLDPJO(y);
JTARIF1.L(y) = JTARIF1O(y); JTARIF2.L(y) = JTARIF2O(y);
KRETP.L(y) = KRETPO(y); KTARIF1.L(y) = KTARIF1O(y);
KTARIF2.L(y) = KTARIF2O(y); JPRODP.L(y) = JPRODPO(y);
JGPROP.L(y) = JGPROPO(y); JGSELP.L(y) = JGSELPO(y);
JDIRECT.L(y) = JDIRECTO(y); KPRODP.L(y) = KPRODPO(y);
KGPURP.L(y) = KGPURPO(y); KGSELP.L(y) = KGSELPO(y);
KDIRECT.L(y) = KDIRECTO(y); URETP.L(y) = URETPO(y);
UPRODPJ.L(y) = UPRODPJO(y); UPRODPI.L(y) = UPRODPIO(y);
UTARP.L(y) = UTARPO(y); ULOAN.L(y) = ULOANO(y);
UTRANSP.L(y) = UTRANSPO(y);
UPROD.L(y) = UPRODO(y); UPRODJ.L(y) = UPRODJO(y);
UEXPOTJ.L(y) = UEXPOTJO(y); UEXPOTJ1.L(y) = UEXPOTJ1O(y);
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UEXPOTK.L(y) = UEXPOTKO(y); UEXPOTK1.L(y) = UEXPOTK1O(y);
UEXPOTW.L(y) = UEXPOTWO(y); UBESTK.L(y) = UBESTKO(y);
UIMPOT.L(y) = UIMPOTO(y); UTCONP.L(y) = UTCONPO(y);
UENSTK.L(y) = UENSTKO(y); UTEXPT.L(y) = UTEXPTO(y);
UTEXPT1.L(y) = UTEXPT1O(y); JIMPOTW.L(y) = JIMPOTWO(y);
JQUOTA1.L(y) = JQUOTA1O(y); JQUOTA2.L(y) = JQUOTA2O(y);
KQUOTA.L(y) = KQUOTAO(y); UEXEQUIL.L(y) = UEXEQUILO(y);
JBESTK.L(y) = JBESTKO(y); JIMPOT.L(y) = JIMPOTO(y);
JENSTK.L(y) = JENSTKO(y); KPROD.L(y) = KPRODO(y);
KBESTK.L(y) = KBESTKO(y); KIMPOT.L(y) = KIMPOTO(y);
KENSTK.L(y) = KENSTKO(y); WOENSTK.L(y) = WOENSTKO(y);
JEXPOT.L(y) = JEXPOTO(y); KEXPOT.L(y) = KEXPOTO(y);
KIMPOTW.L(y) = KIMPOTWO(y); KIMPOTU.L(y) = KIMPOTUO(y);
JEXCHAN.L(y) = JEXCHANO(y); KEXCHAN.L(y) = KEXCHANO(y);
JPOWEIC.L(y) = JPOWEICO(y); JPOWEIP.L(y) = JPOWEIPO(y);
JPOWEIG.L(y) = JPOWEIGO(y); KPOWEIC.L(y) = KPOWEICO(y);
KPOWEIP.L(y) = KPOWEIPO(y); KPOWEIG.L(y) = KPOWEIGO(y);
UPOWEIE.L(y) = UPOWEIEO(y);

equations
EQZ                objective function
eJARHARV(y)        area harvested in Japan(1000ha)
eJYIELD(y)         yield in Japan(MT ha)
eJPROD(y)          Japanese production (1000MT)
eKARHARV(y)        Korean area harvested (1000ha)
eKPROD(y)          Korean production (1000MT)
eKYIELD(y)         Korean yield (MT ha)
eJPCONP(y)         Japanese per capita consumption(kg person)
eJLPCONP(y)        Japanese log per capita consumption
eJCONP(y)          Japanese consumption (1000MT)
eJTCONP(y)         Japanese total consumption (1000 MT)
eKLPCONP(y)        Korean log per capita consumption
eKPCONP(y)         Korean per capita consumption(kg person)
eKCONP(y)          Korean capita consumption
eKTCONP(y)         Korean total consumption (1000 MT)
eUGEXP(y)          us govt export program (1000MT)
eULEXDEM(y)        us log export demand (1000MT)
eUEXDEM(y)         us export demand(1000MT)
eUEXPOTK(Y)        us export to Korea(1000MT)
eULEXPOTK(y)       log of export to Korea
eULEXPOTJ(y)       log of export to Japan
eUEXPOTJ(y)        us export to Japan(1000MT)
eJRETP(y)          Japanese domestic retail price (yen MT)
eKRETP(y)          Korean domestic retail price (won MT)
eJPRODP(y)         Japanese producer price (yen MT)
eKPRODP(y)         Korean producer price (won MT)
eUEXPP1(y)         us first export price ($ MT)
eUEXPP2(y)         us second export price ($ MT)
ejequil(y)         Japanese equilibrium (1000MT)
ekequil(y)         Korean equilibrium (1000MT)
euexequil(y)       us export equilibrium (1000MT)
eJPWEL(y)          Japanese producer welfare
eJCWEL(y)          Japanese consumer welfare
eJGWEL(y)          Japanese government welfare
eJSCOST(y)         Japanese social cost
eJTOWEL(y)         Japanese total welfare
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eKPWEL(y)         Korean producer welfare
eKCWEL(y)         Korean consumer welfare
eKGWEL(y)         Korean government welfare
eKSCOST(y)        Korean social cost
eKTOWEL(y)        Korean total welfare
eUEXWEL1(y)       us export welfare
eUEXWEL2(y)       us export welfare to Korea ;
eJPAY(y)          Japanese payoff
eKPAY(y)          Korean payoff;
eUXPAY(y)         us export payoff;

EQZ..          Z =e= (uexwel1(y)*upoweie(y));
ejprodp(y)..   JPRODP(y) =e= JGPROP(y) + DIRECT(y);
ekprodp(y)..   KPRODP(y) =e= KGPURP(y) + KDIRECT(y);
ejarharv(y)..  JARHARV(y) =e= jazero + jaone*JLARHARV(y) + jatwo*JPRODP(y) + jathree*JPRODC(y);
ejyield(y)..   JYIELD(y) =e= jyzero + jyone*JTECH(y) + jytwo*jydummy(y);
ejprod(y)..    JPROD(y) =e= JARHARV(y)*JYIELD(y);
ekarharv(y).. KARHARV(y) =e= kazero + kaone*KLARHARV(y) + katwo*KDIVERT(y);
ekyield(y)..   KYIELD(y) =e= kyzero + kyone*KTECH(y) + kytwo*kydummy(y);
ekprod(y)..    KPROD(y) =e= KARHARV(y)*KYIELD(y);
ejretp(y)..    JRETP(y) =e= WOLDPJ(y) + JTARIF2(y);
ekretp(y)..    KRETP(y) =e= WOLDPJ(y) + KTARIF2(y);
ejlpconp(y).. JLPCONP(y)  =e=jczero+(jcone*log(LJPCONP(y))) + (jctwo*log(JRETP(y)))
                              + (jcthree*log(JINCOM(y)));
ejpconp(y)..  JPCONP(y) =e= exp(JLPCONP(y));
ejconp(y)..   JCONP(y) =e= JPCONP(y)*JPOP(y);
ejtconp(y)..  JTCONP(y) =e= JCONP(y)+ JGOVCONP(y) + JPOCONP(y) +JADCONP(y);
eklpconp(y)..    KLPCONP(y) =e= kczero+kcone*log(LKPCONP(y)) + kctwo*log(KINCOM(y))
                              + kcthree*log(KRETP(y));
ekpconp(y)..   KPCONP(y) =E= EXP(KLPCONP(y));
ekconp(y)..    KCONP(y) =e= KPCONP(y)*KPOP(y);
ektconp(y)..   KTCONP(y) =e= KCONP(y)+ KADCONP(y) + KPOCONP(y);
eugexp(y)..    UGEXP(y) =e= UCCC(y) + UEEP(y);
euexpp1(y)..   UEXPP1(y) =e= ULOAN(y);
euexpp2(y)..   UEXPP2(y) =e= ULOAN(y) + UTRANSP(y);
eulexdem(y).  ULTEXPT(y) =e= uxzero + uxone*log(WOENSTK(y)) + uxtwo*log(WOLDPJ(y)/UPRODPJ(y))
                              + uxthree*log(UGEXP(y))+ uxfour*(UXDUMMY(y));
euexdem(y)..   UTEXPT(y) =E= EXP(ULTEXPT(y));
euLexpotj(y).. ULEXPOTJ(y) =e= uejzero + uejone*log(WOLDPJ(y)/UPRODPJ(y)) + uejtwo*log(UGEXP(y))
                              + uejthree*log(JTARIF2(y));
euexpotj(y)..    UEXPOTJ(y) =e= exp(ulexpotj(y));
euLexpotk(y).. ULEXPOTK(y) =e= uekzero + uekone*log(UPRODJ(y))
                              + uektwo*log(WOLDPJ(y)/UPRODPJ(y)) + uekthree*log(KTARIF2(y));
euexpotk(y)..    UEXPOTK(y) =e= exp(ulexpotk(y));
ejequil(y)..     JEQUIL(y) =e= JPROD(y) - JTCONP(y) + JBESTK(y) - JENSTK(y) + UEXPOTJ1(y)
                              + JIMPOTW(y) - JEXPOT(y);
ekequil(y)..     KEQUIL(y) =e= KPROD(y) - KTCONP(y) + KBESTK(y) - KENSTK(y) + UEXPOTK1(y)
                              + KIMPOTW(y) - KEXPOT(y);
euexequil(y).. UEXEQUIL(y) =e= UPROD(y) + UIMPOT(y) + UBESTK(y) – UTCONP(y) - UENSTK(y)
                              - UEXPOTK1(y)-UEXPOTJ1(y) - UEXPOTW(y);
ejpwel(y)..   JPWEL(y) =e= (JPRODP(y)*JPROD(y));
ejcwel(y)..   JCWEL(y) =e= (JRETP(y)*JCONP(y));
ejgwel(y)..   JGWEL(y) =e= (JTARIF2(y)*UEXPOTJ1(y))
                         - ((JGSELP(y)-JGPROP(y))*(JPROD(y)*0.15)*(jequil(y)));
ejscost(y)..  JSCOST(y) =e= (JRETP(y) - JPRODP(y))*0.5*(JPROD(y) - JTCONP(y));
ekpwel(y)..   KPWEL(y) =e= (KPRODP(y)*KPROD(y));
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ekcwel(y)..  KCWEL(y) =e= (KRETP(y)*KCONP(y));
ekgwel(y)..  KGWEL(y) =e= (KTARIF2(y)*UEXPOTK1(y)) + ((KGPURP(y)
                                    - KGSELP(y))*(KPROD(y)*0.15)*(kequil(y)));
ekscost(y)..  KSCOST(y) =e= (KRETP(y) - KPRODP(y))*0.5*(KPROD(y) - KTCONP(y));
ejtowel(y)..   JTOWEL(y) =e= JCWEL(y) + JPWEL(y) - JGWEL(y);
ektowel(y)..  KTOWEL(y) =e= KCWEL(y) + KPWEL(y) - KGWEL(y);
euexwel1(y)..  UEXWEL1(y) =e= (UEXPOTK1(y)+ UEXPOTJ1(y))*WOLDPJ(y);
euexwel2(y)..  UEXWEL2(y) =e= (UEXPP1(y) - UEXPRINT)*UEXPOTK(y)*0.5;
ejpay(y)..    JPAY(y) =e= (jpoweic(y)*jcwel(y)) + (jpoweip(y)*jpwel(y)) - (jpoweig(y)*jgwel(y));
ekpay(y)..   KPAY(y) =e= (kpoweic(y)*kcwel(y)) + (kpoweip(y)*kpwel(y)) - (kpoweig(y)*kgwel(y));
euxpay(y).. UXPAY(y) =e= (UEXPOTJ(y) + UEXPOTK(y)*upoweie(y)) + (uexwel1(y));

********variable bounds********
ARHARV.LO(y)  = 0.001; JPRODP.LO(y) = 0.001; JLARHARV.LO(y) = 0.001;
JPRODC.LO(y) = 0.001; JYIELD.LO(y) = 0.001; JTECH.LO(y) = 0.001;
JYDUMMY.LO(y) = 0.001; JPROD.LO(y) = 0.001; KARHARV.LO(y) = 0.001;
KLARHARV.LO(y) = 0.001; KPROD.LO(y) = 0.001; KDIVERT.LO(y) = 0.001;
KGPURP.LO(y) = 0.001; KYIELD.LO(y) = 0.001; KLYIELD.LO(y) = 0.001;
KTECH.LO(y) = 0.001; KYDUMMY.LO(y) = 0.0001;
JPCONP.LO(y)   = 0.001; LJPCONP.LO(y) = 0.001; JRETP.LO(y) = 0.001;
JINCOM.LO(y) = 0.001; JPOCONP.LO(y) = 0.001; JADCONP.LO(y) = 0.001;
JGOVCONP.LO(y) = 0.001; JCONP.LO(y) = 0.001; JPOP.LO(y) = 0.001;
LKPCONP.LO(y) = 0.001; KPCONP.LO(y) = 0.001; KINCOM.LO(y) = 0.001;
KRETP.LO(y) = 0.001; KCDUMMY.LO(y) = 0.001; KPOCONP.LO(y) = 0.001;
KADCONP.LO(y) = 0.001; KCONP.LO(y) = 0.001; KPOP.LO(y) = 0.001;
UEXDEM.LO(y) = 0.001; WOLDPJ.LO(y) = 0.001; UTEXPT.LO(y) = 0.001;
UEXOTPI.LO(y)  = 0.001; UPL480.LO(y) = 0.001; UCCC.LO(y) = 0.001;
UEEP.LO(y) = 0.001; UOTHER.LO(y) = 0.001; UXDUMMY.LO(y) = 0.001;
JTARIF1.LO(y) = 0.001; JTARIF2.LO(y) = 0.001; KTARIF1.LO(y) = 0.001;
KTARIF2.LO(y) = 0.001; JGPROP.LO(y) =0.001; JGSELP.LO(Y) = 0.001;
JDIRECT.LO(y) = 0.001; KPRODP.LO(y) = 0.001; KGPURP.LO(y) = 0.001;
KGSELP.LO(y) = 0.001; KDIRECT.LO(y) = 0.001; URETP.LO(y) = 0.001;
UPRODPJ.LO(y) = 0.001; UPRODPI.LO(y) = 0.001; UTARP.LO(y) = 0.001;
ULOAN.LO(y) = 0.001; UTRANSP.LO(y) = 0.001;
PROD.LO(y) = 0.001; UPRODJ.LO(y) = 0.001; UEXPOTJ.LO(y) = 0.001;
UEXPOTJ1.LO(y) = 0.001; UEXPOTK.LO(y) = 0.001; UEXPOTK1.LO(y) = 0.001;
UBESTK.LO(y) = 0.001; UIMPOT.LO(y) = 0.001; UTCONP.LO(y) = 0.001;
UENSTK.LO(y) = 0.001; UTEXPT1.LO(y) = 0.001; JIMPOTW.LO(y) = 0.001;
JQUOTA1.LO(y) = 0.001; JQUOTA2.LO(y) = 0.001; KQUOTA.LO(y) = 0.001;
UEXEQUIL.LO(y) = 0.001;
JBESTK.LO(y) = 0.001; JIMPOT.LO(y) = 0.001; JENSTK.LO(y) = 0.001;
KBESTK.LO(y) = 0.001; KIMPOT.LO(y) = 0.001; KENSTK.LO(y) = 0.001;
WOENSTK.LO(y) = 0.001; JEXPOT.LO(y) = 0.001; KEXPOT.LO(y) = 0.001;
KIMPOTW.LO(y) = 0.001; KIMPOTU.LO(y) = 0.001;
JEXCHAN.LO(y) = 0.001; KEXCHAN.LO(y) = 0.001; JPOWEIC.LO(y) = 0. 0.001;
JPAY.LO(y) = 0.0001; KPAY.LO(y) = 0.0001; Z.LO  = 0.0001;

option limrow = 0;
option limcol = 0;
option reslim = 2000;
option iterlim = 1000;
option solprint = off;
model SBASE99/all/;
option decimals = 4;
Sbase99.optfile = 1;
solve SBASE99 using NLP maximizing Z;
```

DISPLAY JARHARV.L, JARHARV.L, JPRODP.L, LARHARV.L JPRODC.L, JYIELD.L, JTECH.L, JYDUMMY.L, JPROD.L, KARHARV.L, KLARHARV.L, KPROD.L, KDIVERT.L, KGPURP.L, KYIELD.L, KLYIELD.L, KTECH.L, KYDUMMY.L, JPCONP.L, LJPCONP.L, JRETP.L, JINCOM.L, JPOCONP.L, JADCONP.L, JGOVCONP.L, JCONP.L, JPOP.L, LKPCONP.L, KPCONP.L, KINCOM.L, KRETP.L, KCDUMMY.L, KPOCONP.L, KADCONP.L, KCONP.L, UEXDEM.L, WOLDPJ.L, UTEXPT.L, UEXOTPI.L, UPL480.L, UCCC.L, UEEP.L, UOTHER.L, JRETP.L, WOLDPJ.L, JTARIF1.L, JTARIF2.L, KRETP.L, KTARIF1.L, KTARIF2.L, JPRODP.L, JGPROP.L, JGSELP.L,
JDIRECT.L, KPRODP.L, KGPURP.L, KGSELP.L, KDIRECT.L, URETP.L, UPRODPJ.L, UPRODPI.L, UTARP.L, ULOAN.L, UTRANSP.L, UPROD.L, UPRODJ.L, UEXPOTJ.L, UEXPOTJ1.L, UEXPOTK.L, UEXPOTK1.L, UEXPOTW.L, UBESTK.L, UIMPOT.L, UTCONP.L, UENSTK.L, UTEXPT.L, UTEXPT1.L, JIMPOTW.L, JQUOTA1.L, JQUOTA2.L, KQUOTA.L, UEXEQUIL.L,
JBESTK.L, JIMPOT.L, JENSTK.L, KPROD.L, KBESTK.L, KIMPOT.L, KENSTK.L, WOENSTK.L, JEXPOT.L, KEXPOT.L, KIMPOTW.L, KIMPOTU.L, JEXCHAN.L, KEXCHAN.L, JPOWEIC.L, JPOWEIP.L, JPOWEIG.L, KPOWEIC.L, KPOWEIP.L, KPOWEIG.L, UPOWEIE.L;

APPENDIX 2. SAS PROGRAM USED FOR THE ECONOMETRIC ESTIMATION

Appendix 2. SAS Program for Japan

```
dm 'log;clear;output;clear';
data Japan;
input x1 x2 x3 x4 x5 x6 x7 x8 x9 x10 x11 x12 x13 x14 x15 x16 x17 x18 x19 x20 x21 x22 x23 x24 x25 x26 x27
x28 x29 x30 x31 x32 x33 x34 x35 x36 x37 x38 x39 x40 x41 x42;
tech = x1-1959; x2_=lag(x2); x3_=lag(x3); if x1=1980 then dm80=1; else dm80=0;
if x1=1993 then dm93=1; else dm93=0; dm8093=dm80+dm93; x10_=x10/x36; x19_=x19/x36;
x19r = lag(x19_); lx42=log(x42); lx42_=lag(lx42); x42_=lag(x42); x11_=x11/x35; lx11_=log(x11_);
x34_=x34/x36; lx34_=log(x34_); X34R = LOG(X34);
cards;
;
run;
data test;
set japan;
keep X11 X11_ X34 x42 LX11_ X34r;
run;
proc print data=test;
run;

proc model data=japan;
parameters a1-a5 b1-b5 c1-c5;
model1: x3 = a1 + a2*tech + a3*dm8093;
model2: x2 = b1 + b2*x2_ + b3*x10_ + b4*x19r;
fit x3 x2 /2sls DW gf=1 white breusch=(tech dm8093 x2_ x10_ x19r lx42_ lx11_ x34r) normal
OUTEST=OUTEST1;
proc autoreg data=japan;
model lx42 =lx42_ lx11_ x34r/normal nlag=1 dw=1 dwprob lagdep=lx42_ archtest godfrey=1;
solve x3 x2 lx42/DYNAMIC THEIL  DETAILS  STATS  OUTACTUAL  OUTPREDICT OUT=OUT1 ;
run;

/*proc syslin 2sls data=japan outest=x3;
endogenous x2 x3;
instruments tech x2_ x3_ x4 x10;*/
/*proc autoreg data=japan;
model x3 = dm8093 tech/normal dw=1 dwprob archtest godfrey=1;
    hetero x3/link=linear std=nonneg test=lm;
model x2 = x2_ x10_ x19r/normal nlag=1 dw=1 dwprob lagdep=x2_ archtest godfrey=1;
    hetero x2/link=linear std=nonneg test=lm;*/
goptions reset=(axis,legend,pattern,symbol,title,footnote) hpos=0
norotate vpos=0 htext= ctext= target= gaccess= gsfmode=;
goptions device=win ctext=black interpol=join;
symbol1 c=default l=1 ci=blue v=plus cv=blue;
symbol2 c=default l=1 ci=red v=plus cv=red;
axis1 major=(n=2) minor=(n=2) color=black order=1960 to 2000 by 2 width=2.0 style=1;
axis2 color=black width=2.0 style=1;
axis3 color=black width=2.0;
proc gplot data=work.japan;
plot x3*x1;
plot x2*x1;
plot x42*x1;
run;
quit;
```

Appendix 2. SAS Program for Korea

```
dm 'log;clear;output;clear';
data korea;
input x1 x2 x3 x4 x5 x6 x7 x8 x9 x10 x11 x12 x13 x14 x15 x16 x17 x18 x19 x20 x21 x22 x23 x24 x25 x26 x27
x28 x29 x30 x31 x32 x33 x34 x35 x36 x37 x38 x39 x40 x41 x42 x43 x44 x45 x46 x47 x48 x49 x50 ;
tech = x1-1959; x2_=lag(x2); x3_=lag(x3); x4_ = lag(x4); X10_ = lag(x10); x17_ = x17/x33;
x33_ = lag(x33); x10r = x10_/x33_; x15_ = x15/x33; lx27= log(x27); x27r = lag(lx27); lx28 = log(x28);
x28_ = lag(x28); x28r = log(x28_); x18_ = x18/x31; lx18_ = log(x18_); rx32 = log(x32); x32_=x32/x33;
x42_=x42/x33; x29_=x29/x31; x43_ = x43/x33; lx43_ = log(x43_); x48_=x48/x33; lx48_=log(x48_);
rx28=1/x28_; lx29_=log(x29_); lx32=log(x32_); lx42_=log(x42_); x26_=x26/x33;
if x1=1970 then dm70=1; else dm70=0; if x1=1971 then dm71=1; else dm71=0;
if x1=1972 then dm72=1; else dm72=0; if x1=1973 then dm73=1; else dm73=0;
if x1=1974 then dm74=1; else dm74=0; if x1=1975 then dm75=1; else dm75=0;
if x1=1976 then dm76=1; else dm76=0; if x1=1977 then dm77=1; else dm77=0;
dm1=dm70+dm71+dm72+dm73+dm74+dm75+dm76;
dm7677=dm76+dm77;
if x1=1980 then dm80=1; else dm80=0; if x1=1993 then dm93=1; else dm93=0;
dm8093=dm80+dm93; if x1=1996 then dm96=1; else dm96=0; if x1=1997 then dm97=1; else dm97=0;
dm9697=dm96+dm97;
cards;
run;
;
data test;
set korea;
keep lx27 x27r  x18 x18_ lx18_ lx32;
run;
proc print data=test;
run;
proc model data=korea;
parameters a1-a5 b1-b5 d1-d5;
model1: x3 = a1 + /*a2*x3_ +*/ a3*tech + a4*dm8093;
model2: x2 = b1 + b2*x2_ /*+ b3*x16*/ + b4*x38;
model: lx27 =d1 + d2*x27r + d3*lx32 + d4*lx18_;
fit x3 x2 lx27/2sls DW=1 gf=1 white breusch=(tech dm8093 x2_ x38) normal OUTEST=OUTEST1;
solve x3 x2 lx27/DYNAMIC THEIL  DETAILS  STATS  OUTACTUAL  OUTPREDICT OUT=OUT1 ;
run;
/*proc syslin 2sls data=korea outest=x3;
endogenous x2 x3;
instruments tech x2_ x3_ x4 x10;*/
/*proc autoreg data=korea;
model lx27 = x27r lx32 lx18_ /normal nlag=1 dw=1 dwprob lagdep=x28r archtest godfrey=1;
run;
quit;*/
goptions reset=(axis,legend,pattern,symbol,title,footnote) hpos=0
norotate vpos=0 htext= ctext= target= gaccess= gsfmode=;
goptions device=win ctext=black interpol=join;
symbol1 c=default l=1 ci=blue v=plus cv=blue;
symbol2 c=default l=1 ci=red v=plus cv=red;
axis1 major=(n=2) minor=(n=2) color=black order=1960 to 1999 by 2 width=2.0 style=1;
axis2 color=black width=2.0 style=1;
axis3 color=black width=2.0;
proc gplot data=work.korea;
plot x3*x1;
plot x2*x1;
polt x27*x1;
```

```
/*parameters ko1-ko10;
x3 = ko1 + ko2*x3_ + ko3*tech + ko4*dm8093;
x2 = ko6 + ko7*x2_ + ko8*x17_ + ko9*x38;
fit x3 x2/2sls hausman dw=1 dwprob lagdep=x2 godfrey=1  ;*/
/*model x3=x3_ tech/stats dw ;*/
/*proc reg data=korea;
model x2=x2_ x4 x10;
output out=b p=x2hat;
data c;
x2hatlag=x2hat;
set b;
retain x2hat;
proc autoreg data=c;
model x2=x2hatlag x4 x10/nlag=1;*/
run;
quit;
```

Appendix 2. SAS Program for the U.S.

```
dm 'log;clear;output;clear';
data us;
input x1 x2 x3 x4 x5 x6 x7 x8 x9 x10 x11 x12 x13 x14 x15 x16 x17 x18 x19 x20 x21 x22 x23 x24 x25 x26 x27
x28 x29 x30 x31 x32 x33 x34;
tech = x1-1959; lx6 = log(x6); x23_ = x23/x24; lx23_ = log(x23_); x15_ = x23/x15; lx15_ = log(x15_);
lx30 = log(x30); x30_=x28+x30+x31; lx30_ = log(x30_); if x1=1960 then lx6=1;
if x1=1960 then lx12_=1; if x1=1980 then dm80=1; else dm80=0; if x1=1991 then dm91=1; else dm91=0;
if x1=1985 then dm85=1; else dm85=0; if x1=1994 then dm94=1; else dm94=0;
dm1=dm80+dm85; dm2=dm91+dm94; dm3=dm80+dm94; lx6 =log(x6); lx23_ = log(x23_);
lx30_ = log(x30_); lx12 = log(x12); lx28 = log(x28); lx30 = log(x30); lx31 = log(x31);
x33_ = x33+x34;

cards;
;
run;

data test;
set us;
keep lx6 lx12 lx23_ lx30_ ;
run;
proc print data=test;
run;
/*proc autoreg data=us;
model lx6 = lx12 lx23_ lx30_ dm3/normal nlag=1 dw=2 dwprob archtest godfrey=1;*/

proc model data=us;
parameters a1-a5;
model1: lx6 = a1 + a2*lx12 + a3*lx23_ + a4*lx30 + a5*dm3;
fit lx6/OLS  DETAILS  DW=1 gf=1 white breusch=(lx12 lx23_ lx30 dm3) normal OUTEST=OUTEST1;
solve lx6/DYNAMIC THEIL  DETAILS  STATS ;
/*goptions reset=(axis,legend,pattern,symbol,title,footnote) hpos=0
norotate vpos=0 htext= ctext= target= gaccess= gsfmode=;
goptions device=win ctext=black interpol=join;
symbol1 c=default l=1 ci=blue v=plus cv=blue;
symbol2 c=default l=1 ci=red v=plus cv=red;
axis1 major=(n=2) minor=(n=2) color=black order=1960 to 1999 by 2 width=2.0 style=1;
axis2 color=black width=2.0 style=1;
roc gplot data=work.us;
plot x6*x1;
run;
quit;*/
run;
quit;
```

APPENDIX 3. DATA USED IN THE STUDY

Table 1 Appendix 3. Japanese Data.

YEAR	JARHAV	JYIELD	JPROD	JIMOPT	JEXPOT	JCONP	JENSTK
1960	3308	3.54	11700	140	0	11900	1426
1961	3301	3.42	11301	173	0	11090	991
1962	3285	3.60	11838	177	0	12115	891
1963	3272	3.56	11659	410	0	12061	899
1964	3260	3.51	11451	880	0	12186	1044
1965	3255	3.47	11292	893	0	11880	1349
1966	3254	3.56	11598	475	0	11700	1722
1967	3263	4.03	13152	298	0	11555	3617
1968	3280	4.01	13148	52	300	11187	5330
1969	3274	3.89	12743	15	508	10480	7100
1970	2923	3.95	11547	10	910	11690	6057
1971	2695	3.68	9907	0	217	12459	3288
1972	2640	4.10	10819	24	572	11829	1730
1973	2622	4.22	11056	57	305	11017	1521
1974	2724	4.11	11186	35	42	10924	1776
1975	2764	4.33	11980	20	0	10700	3076
1976	2779	3.85	10713	21	0	10466	3344
1977	2757	4.32	11916	64	91	10026	5207
1978	2584	4.43	11456	18	467	10299	5915
1979	2497	4.36	10882	14	648	10102	6061
1980	2377	3.73	8873	75	909	10100	4000
1981	2278	4.10	9337	66	304	10642	2457
1982	2257	4.14	9346	14	223	10774	820
1983	2273	4.15	9433	169	230	10192	0
1984	2315	4.67	10809	18	0	10199	628
1985	2342	4.53	10612	20	0	10150	1110
1986	2303	4.60	10599	17	0	9706	2020
1987	2146	4.51	9671	16	0	9805	1902
1988	2110	4.31	9041	16	0	9619	1340
1989	2097	4.49	9416	18	0	9720	1054
1990	2074	4.61	9554	17	0	9620	1005
1991	2049	4.27	8740	18	0	9523	240
1992	2106	4.57	9621	18	0	9500	379
1993	2139	3.33	7129	2623	0	9400	731
1994	2212	4.93	10903	250	410	9350	2534
1995	2118	4.62	9781	500	200	9300	3354
1996	1977	4.76	9413	500	30	9320	3246
1997	1953	4.67	9123	499	574	9200	3094
1998	1801	4.53	8154	554	210	9100	2492
1999	1788	4.67	8350	639	200	9450	1831

JARHAV = area harvested(1000ha), JYIELD = yield(MT/ha), JPROD = production(1000MT), JIMOPT = import(1000MT), JEXPOT = export(1000MT), JCONP = consumption(1000MT), JENSTK = ending stock(100MT).

Table 2 Appendix 3. Japanese Data.

YEAR	JPRODP	JRETP	JGSELP	JEXCHAN	JGPROP	JDIVERT	JPRODC
1960	N/A	99000	72517	360	69367	0	177120
1961	N/A.	97000	72100	360	73683	0	N/A
1962	55000	98000	71900	360	81100	0	N/A
1963	65000	110000	80317	360	87800	0	N/A
1964	72000	118000	79717	361.97	99750	0	N/A
1965	83000	136000	93867	361.49	108967	0	292445
1966	87000	146000	101783	362.35	119000	0	N/A
1967	93000	151000	100150	362.15	129950	0	N/A
1968	102000	170000	115650	360.55	137600	0	N/A
1969	108000	181000	124950	358.37	137600	0	N/A
1970	109000	186000	124033	358.07	137867	0	534599
1971	108000	188000	122950	347.86	142350	541	N/A
1972	114000	192000	130767	303.17	149233	566	N/A
1973	109000	207000	130100	271.7	171683	562	672186
1974	167000	232000	170933	292.08	226917	313	865433
1975	193000	299000	203417	296.79	259500	264	1022738
1976	216000	342000	224183	296.55	276200	194	1220303
1977	238000	379000	246183	268.51	287200	212	1289654
1978	246000	403000	256517	210.44	287517	438	1416261
1979	242000	408000	264850	219.14	287983	472	1487741
1980	253000	414000	264850	226.74	294567	585	1580378
1981	273000	425000	273183	220.54	295933	668	1660005
1982	278000	440000	283883	249.08	299183	672	1698227
1983	281000	448000	294550	237.51	304433	639	1745699
1984	294000	464000	305450	237.52	311133	620	1740072
1985	293000	479000	309967	238.54	311133	594	1766866
1986	263000	483000	309967	168.52	311133	618	1777043
1987	259000	483000	302167	144.64	292617	791	1773142
1988	258000	477000	302167	128.15	279050	794	1755655
1989	279050	478000	306600	137.96	279050	795	1735190
1990	275000	496300	306600	144.11	275000	849	1748910
1991	272870	494466	303383	134.43	274100	852	1683110
1992	271090	548900	302050	126.53	273200	751	1670290
1994	271090	564400	302050	111.20	273200	713	1726330
1994	271090	695300	302050	102.21	273200	588	1667990
1995	271090	570000	302050	94.06	273200	659	1692045
1996	271090	537400	302050	108.78	270280	673	1689245
1997	268200	521800	297180	120.99	263420	685	1678978
1998	262350	499500	294100	130.91	258800	955	1678930
1999	259170	487800	294100	130.91	256820	950	1700270

JPRODP = producer price(yen/MT), JRETP = retail price(yen/MT), JGSELP = government selling rice(yen/MT), JEXCHAN = exchange rate(yen/$), JGPROP = government procurement price(yen/MT), JDIVERT = diversion program(ha), JPRODC = production costs(yen/ha)

Table 3 Appendix 3. Japanese Data.

YEAR	JPCONP	JPOP	JPOCONP	JINCOM	JGCONP	JADCON	JTARIF	JCPI
1960	114.9	93.4	470	17859	0	0	78	45.9
1961	117.4	94.3	535	18965	0	0	58	47.0
1962	118.3	95.2	536	21547	0	0	53	47.3
1963	117.3	96.2	597	26512	0	0	85	48.6
1964	115.8	97.2	609	29895	0	0	108	49.9
1965	111.7	98.3	606	33765	0	0	154	50.3
1966	105.8	99.1	636	38085	0	0	179	52.0
1967	103.4	100.2	714	44629	0	0	188	52.1
1968	100.1	101.4	707	52922	0	300	238	55.2
1969	97	103.0	640	62260	0	508	271	56.8
1970	95.1	103.7	712	75299	252	910	282	59.6
1971	93.1	105.0	718	80701	1474	217	297	61.3
1972	91.5	107.3	744	92394	1254	572	373	67.6
1973	90.8	108.7	807	122498	480	305	228	69.0
1974	89.7	110.1	754	134244	0	42	234	70.6
1975	88	111.9	758	152362	0	0	552	71.2
1976	86.2	112.2	729	166573	0	0	783	72.5
1977	83.4	113.2	676	185622	0	91	931	73.1
1978	81.6	114.3	685	204404	0	467	1473	73.5
1979	79.8	115.3	685	221547	0	648	1349	74.3
1980	78.9	117.1	711	245547	0	909	1215	76.3
1981	77.8	117.0	697	257363	192	304	1465	80.0
1982	76.4	118.0	671	269629	829	223	1416	82.3
1983	75.7	119.0	671	280257	510	230	1546	93.8
1984	75.2	119.3	625	297948	10	0	1617	85.7
1985	74.6	121.1	570	324159	33	0	1663	87.4
1986	73.4	121.0	628	330024	75	0	2580	88.0
1987	71.9	121.4	643	343422	0	0	2968	88.0
1988	71	122.0	677	365087	0	0	3355	88.6
1989	70.4	123.0	671	402311	0	0	3107	90.7
1990	70	123.6	650	432588	0	0	3089	93.5
1991	69.9	123.6	659	455888	0	0	3282	96.5
1992	69.7	124.5	643	464191	0	0	3943	98.1
1993	69.2	124.0	665	466764	0	0	4589	99.4
1994	66.3	124.3	602	470030	0	410	6412	100.1
1995	67.8	125.5	598	514390	0	200	5595	100.0
1996	67.3	125.4	359	459550	208	30	4509	100.1
1997	66.7	125.6	461	419510	24	574	3900	100.9
1998	65.2	126.3	543	419510	0	210	3323	102.5
1999	64.5	126.8	621	419510	0	200	3428	102.2

JPCONP = per capita consumption(kg/person), JPOP = population (million people), JPOCONP = processing Consumption(1000MT), JINCOM =income(billion yen), JGCONP = government consumption(1000MT), JADCON = additional consumption(1000MT), JTARIF = tariff equivalent($/MT), JCPI = consumer price index.

Table 4 Appendix 3. Korean Data.

YEAR	KARHAV	KYIELD	KPROD	KIMOPT	KEXPOT	KCONP	KENSTK
1960	1121	2.72	3047	5	4	3121	39
1961	1128	3.07	3463	0	60	3442	0
1962	1139	2.65	3015	117	5	3127	0
1963	1155	3.25	3758	0	13	3740	5
1964	1195	3.31	3954	0	19	3913	27
1965	1228	2.85	3501	18	40	3444	62
1966	1231	3.18	3919	139	0	4119	1
1967	1235	2.92	3603	247	0	3811	40
1968	1151	2.78	3195	631	0	3866	0
1969	1220	3.35	4090	254	0	4271	73
1970	1203	3.27	3939	937	0	4945	4
1971	1190	3.36	3998	584	0	3973	613
1972	1191	3.32	3957	437	0	4296	711
1973	1182	3.56	4212	206	0	4641	488
1974	1204	3.69	4445	489	0	4707	715
1975	1218	3.83	4669	168	0	4699	906
1976	1215	4.29	5215	55	0	5100	1076
1977	1230	4.88	6006	0	80	5784	1218
1978	1230	4.71	5797	501	0	6764	752
1979	1233	4.17	5136	580	0	5786	682
1980	1233	3.24	4000	2245	0	5402	1495
1981	1224	4.14	5063	269	0	5404	423
1982	1188	4.36	5175	216	0	5404	1511
1983	1228	4.40	5404	7	135	5303	1247
1984	1231	4.62	5682	0	0	5540	1432
1985	1237	4.55	5626	0	0	5501	1251
1986	1236	4.54	5607	0	0	5805	1158
1987	1262	4.35	5493	1	0	5617	1146
1988	1260	4.80	6053	2	0	5611	1610
1989	1257	4.69	5898	11	1	5602	2050
1990	1244	4.51	5606	2	17	5444	2151
1991	1209	4.45	5385	1	2	5478	2141
1992	1157	4.61	5331	1	2	5524	1999
1993	1136	4.18	4750	4	0	5509	1820
1994	1103	4.59	5060	3	150	5414	1156
1995	1056	4.45	4694	115	0	5244	245
1996	1050	5.07	5320	0	0	5178	390
1997	1052	5.18	5450	77	0	5112	805
1998	1059	4.82	5100	113	0	5038	980
1999	1066	4.94	5263	115	0	5003	1355

KARHAV = area harvested(1000ha), KYIELD = yield(MT/ha), KPROD = production(1000MT), KIMOPT = import(1000MT), KEXPOT = export(1000MT), KCONP = consumption(1000MT), KENSTK = ending stock(100MT).

Table 5 Appendix 3. Korean Data.

YEAR	KPRODP	KRETP	KGPURP	KGSELP	KPRODC	KPCONP	KINCOM
1960	12000	19000	10000	11597	N/A	N/A	243
1961	15000	23000	14000	12000	N/A	N/A	291
1962	16000	24000	15000	15000	N/A	110	352
1963	25000	38000	19000	16000	58630	110	500
1964	31000	46000	24000	25000	80660	127	711
1965	29000	44000	28000	31000	93450	121.8	798
1966	34000	46000	30000	29000	97070	113.9	1024
1967	40000	50000	32000	31000	109230	131.1	1259
1968	49000	58000	38000	34000	126600	117.8	1630
1969	55000	72000	46000	40000	145870	119.7	2130
1970	69000	80000	63000	49000	171600	130.4	2771
1971	88000	100000	79000	55000	200080	134.8	2898
1972	133000	135000	89000	69000	241780	134.5	4210
1973	168000	135000	102000	88000	271850	129.4	5420
1974	203000	187000	142000	133000	376440	127.8	7669
1975	224000	253000	197000	162500	532910	123.6	10302
1976	263000	303000	243750	209125	706350	120.1	14101
1977	341000	324000	290000	243750	889200	126.4	18074
1978	441000	343000	325000	280000	1036030	134.7	24327
1979	501000	438000	375000	331250	1254300	135.6	31323
1980	518000	574000	457500	400000	1437520	132.4	38041
1981	642000	811000	571875	550000	1781690	131.5	47482
1982	667939	888000	652000	666000	1999930	130.2	54443
1983	742300	865000	699625	653500	2274440	129.5	62574
1984	758675	865000	699625	650000	2394210	130.1	71332
1985	764550	928000	720625	678250	2521400	128.1	79170
1986	810525	999000	756625	612500	2640820	127.7	92638
1987	890650	1043000	802000	689000	2778850	126.2	109588
1988	926912	1142000	914250	620125	3231700	124.8	131061
1989	1224210	1192000	1060500	597125	3603140	121.4	147770
1990	1073550	1213520	1209000	694000	3858510	119.6	178628
1991	1189450	1302150	1329875	1150000	4000650	116.3	216303
1992	1216140	1402000	1423000	1207500	3972960	112.9	245388
1993	1246025	1473750	1508375	1207500	3975340	110.2	277108
1994	1341350	1549583	1583750	1306250	4005020	108.3	322812
1995	1430375	1638917	1583750	1306250	4119750	106.5	376316
1996	1708600	1858333	1583750	1550000	4424410	104.9	417108
1997	1773950	1984250	1647125	1562500	4582400	102.4	450853
1998	1857400	2067250	1647125	1650000	5107920	99.2	437871
1999	1998425	2211500	1737750	1815000	5227000	96.9	478251

KPRODP = producer price(won/MT), KRETP = retail price(won/MT), KGPURP = government purchase price(won/MT), KGSELP = government selling price(won/MT), KPRODC = production costs(won/ha), KPCONP = per capita consumption(kg/person), KINCOM = income(billion won).

Table 6 Appendix 3. Korean Data.

YEAR	KPOP	KGDPD	KCPI	KEXCHAN	KDIVRT	KPOCON	KADCON	KTARIF
1960	24.70	N/A	11.1	63.13	0	0	4	103.65
1961	25.42	N/A	11.3	124.79	0	0	60	0
1962	26.51	N/A	11.5	130.00	0	0	5	0
1963	26.90	N/A	11.7	130.00	0	0	13	71.85
1964	27.68	N/A	12.0	213.85	0	0	19	0
1965	28.70	N/A	12.2	266.40	0	0	40	0
1966	28.96	N/A	12.8	271.34	0	0	0	0
1967	30.13	N/A	13.2	270.52	0	0	0	0
1968	30.84	N/A	13.5	276.65	0	0	0	0
1969	31.54	N/A	14.0	288.16	0	0	0	16.17
1970	32.24	N/A	15.2	310.56	0	0	0	20.60
1971	32.88	5.50	16.2	340.15	0	0	0	50.38
1972	33.51	6.42	16.5	392.89	0	0	0	83.46
1973	34.10	7.98	17.0	398.32	0	0	0	0
1974	34.69	9.80	17.6	404.47	0	0	0	0
1975	35.28	12.40	18.2	484.00	515	0	0	67.48
1976	35.85	14.20	23.2	484.00	590	0	0	255.88
1977	36.41	18.60	27.8	484.00	690	0	80	188.82
1978	36.97	23.40	32.2	484.00	774	0	0	267.10
1979	37.53	28.20	36.5	484.00	869	0	0	391.73
1980	38.12	31.80	40.4	607.43	975	0	0	333.63
1981	38.72	35.80	43.9	681.03	1521	0	0	729.2
1982	39.33	38.20	49.0	731.08	1233	0	0	863.67
1983	39.93	43.90	54.3	775.75	1987	0	135	774.66
1984	40.46	46.40	55.5	805.98	1933	0	0	737.03
1985	40.80	48.50	56.8	870.02	2122	0	0	721.18
1986	41.18	51.00	58.4	881.45	2563	0	0	846.98
1987	41.58	53.90	60.2	822.57	3542	16	0	896.72
1988	41.98	58.00	64.5	731.47	4844	29	0	1193.73
1989	42.38	61.30	68.2	671.46	7096	21	1	1417.87
1990	42.87	67.90	74.0	707.76	10593	33	17	1360.09
1991	43.30	75.20	80.9	733.30	11861	114	2	1379.57
1992	43.75	81.00	86.0	780.60	12255	245	2	1400.77
1993	44.20	86.70	90.1	802.60	13207	304	0	1349.44
1994	44.64	93.30	95.7	803.60	11984	278	150	1538.09
1995	45.09	100.00	100.0	771.00	16274	144	0	1660.75
1996	45.55	103.90	104.9	804.80	16611	140	0	1878.28
1997	45.99	107.20	109.6	951.10	15395	150	0	1673.79
1998	46.43	112.60	117.8	1398.90	15141	123	0	985.04
1999	46.86	110.80	118.8	1189.50	12017	210	0	1384.53

KPOP = population(million people), KGDPD = GDP deflator, KCPI = consumer price index, KEXCHAN = exchange rate(won/$), KDIVRT = diversion program(ha). KPOCON = processing consumption(1000MT), KADCON = additional consumption(1000MT), KTARIF = tariff equivalent($/MT).

Table 7 Appendix 3. U.S. Data.

YEAR	UARHAV	UYIELD	UPROD	UIMOPT	UEXPOT	UCONP	UENSTK
1960	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1961	643	2.74	1763	13	936	997	173
1962	718	2.97	2133	1	1119	937	251
1963	717	3.20	2295	1	1385	917	245
1964	723	3.30	2386	15	1387	1008	251
1965	725	3.44	2497	22	1418	1081	271
1966	796	3.52	2805	0	1719	1079	278
1967	797	3.70	2950	0	1816	1190	222
1968	952	3.63	3459	0	1729	1420	532
1969	861	3.49	3003	7	1786	1220	536
1970	734	3.81	2796	48	1461	1308	611
1971	736	3.86	2838	36	1804	1309	372
1972	736	3.84	2828	17	1726	1324	167
1973	878	3.46	3034	7	1604	1349	255
1974	1024	3.58	3667	0	2194	1496	232
1975	1140	3.60	4099	0	1732	1394	1205
1976	1004	3.77	3781	3	2097	1618	1274
1977	910	3.43	3120	3	2270	1248	879
1978	1202	3.55	4271	3	2431	1708	1014
1979	1161	3.72	4324	3	2706	1794	841
1980	1340	3.61	4838	7	3028	2113	545
1981	1535	3.89	5974	13	2682	2248	1602
1982	1320	3.75	4948	21	2219	2049	2303
1983	878	3.66	3216	27	2272	1793	1481
1984	1134	3.86	4382	51	1960	1911	2043
1985	1008	4.30	4332	70	1885	2078	2482
1986	955	4.51	4307	83	2719	2493	1660
1987	944	4.35	4109	95	2289	2580	995
1988	1174	4.42	5186	121	2786	2649	867
1989	1087	4.68	5087	139	2537	2690	866
1990	1142	4.46	5098	151	2331	2981	803
1991	1125	4.53	5096	169	2128	3064	876
1992	1267	4.50	5704	195	2515	3008	1252
1993	1146	4.57	5240	220	2564	3283	865
1994	1342	4.95	6648	256	3322	3396	1051
1995	1252	4.49	5628	245	2694	3420	810
1996	1135	4.80	5453	334	2488	3243	866
1997	1256	4.58	5750	294	2755	3278	877
1998	1318	4.40	5798	336	2730	3587	694
1999	1421	4.58	6502	321	2804	3846	867

UARHAV = area harvested(1000ha), UYIELD = yield(MT/ha), UPROD = production(1000MT), UIMOPT = import(1000MT), UEXPOT = export(1000MT), UCONP = consumption(1000MT), UENSTK = ending stock(100MT).

Table 8 Appendix 3. U.S. Data.

YEAR	UPRDI	URPDJ	WESTK	UPODPI	UPODPJ	ULOAN	UDIRT	UEXPOTK
1960	842	904	N/A	138.92	139.55	97.44	N/A	0
1961	803	969	8500	163.80	150.57	103.84	N/A	0
1962	943	1215	12500	160.65	160.97	103.84	N/A	0
1963	845	1453	16300	154.98	159.71	103.84	N/A	0
1964	896	1494	17200	153.41	154.98	103.84	N/A	0
1965	1072	1421	18100	156.87	153.72	99.21	N/A	0
1966	1156	1623	18600	151.20	149.63	99.21	N/A	67
1967	1426	1515	21300	161.28	152.46	100.31	N/A	235
1968	1603	1822	24500	154.35	173.57	101.41	N/A	376
1969	1472	1532	26400	167.58	151.20	104.06	N/A	251
1970	1350	1388	28800	170.42	158.13	107.14	N/A	397
1971	1474	1328	28000	177.03	165.06	111.77	N/A	500
1972	1402	1390	23800	226.80	215.15	116.18	N/A	245
1973	1400	1631	28800	481.95	349.65	133.82	N/A	252
1974	1829	1844	28000	359.10	368.55	166.23	N/A	415
1975	2159	1922	38800	269.01	240.98	187.83	N/A	156
1976	2290	1489	37800	209.48	217.67	136.46	N/A	54
1977	1977	1176	44200	252.63	288.23	136.46	N/A	0
1978	2695	1558	54100	265.86	222.39	141.10	17.20	144
1979	2639	1673	53700	343.35	333.90	149.69	0	787
1980	2877	1966	48500	393.75	418.95	156.96	0	859
1981	3607	2365	43300	305.55	253.89	176.59	6.17	223
1982	3053	1913	43500	269.64	217.67	179.46	59.74	216
1983	2066	1182	47900	294.84	224.60	179.46	61.07	0
1984	3052	1358	55600	272.79	209.79	176.36	82.90	0
1985	3235	1128	54400	212.63	184.91	176.36	85.98	0
1986	3129	1185	50700	120.33	111.83	158.73	103.62	1
1987	2829	1289	44800	244.76	200.34	150.79	106.26	0
1988	3844	1327	48800	219.24	203.81	146.16	95.02	0
1989	3570	1479	54500	239.09	211.37	143.30	78.48	11
1990	3525	1576	59200	218.61	194.99	143.30	91.71	0
1991	3517	1580	57200	246.65	220.50	143.30	67.68	1
1992	4070	1638	55200	184.91	186.17	143.30	92.81	0
1993	3414	1759	52500	249.80	254.84	143.30	87.74	0
1994	4424	2136	50400	216.41	211.05	143.30	83.55	0
1995	3978	1705	50400	295.16	277.83	143.30	70.99	8
1996	3610	1843	51200	333.90	263.66	143.30	61.07	18
1997	3954	1860	54700	321.30	268.38	143.30	59.75	14
1998	4425	1436	60000	321.30	268.38	143.30	64.37	0
1999	4825	1722	62600	189.00	201.60	143.30	62.17	0

UPRDI = indica production(1000MT), URPDJ = japonica production(1000MT), WESTK = world ending Stock(1000MT), UPODPI = producer price of indica($/MT). UPODPJ = producer price of japonica($/MT), ULOAN = loan rate($/MT), UDIRT = direct payment($/MT), UEXPOTK = export to Korea(1000MT).

Table 9 Appendix 3. U.S. Data.

YEAR	WOLDPJ	UPL480	UCCC	UEEP	UMAP	UFMDP	UEPOTJ
1960	197.3	N/A	N/A	N/A	N/A	N/A	0
1961	211.6	N/A	N/A	N/A	N/A	N/A	0
1962	219.4	N/A	N/A	N/A	N/A	N/A	0
1963	220.5	N/A	N/A	N/A	N/A	N/A	106
1964	218.3	N/A	N/A	N/A	N/A	N/A	290
1965	222.7	N/A	N/A	N/A	N/A	N/A	156
1966	223.8	N/A	N/A	N/A	N/A	N/A	99
1967	229.3	N/A	N/A	N/A	N/A	N/A	2
1968	233.7	N/A	N/A	N/A	N/A	N/A	2
1969	233.7	N/A	N/A	N/A	N/A	N/A	1
1970	237.0	N/A	N/A	N/A	N/A	N/A	0
1971	243.6	N/A	N/A	N/A	N/A	N/A	0
1972	260.1	N/A	N/A	N/A	N/A	N/A	0
1973	533.5	N/A	N/A	N/A	N/A	N/A	9
1974	560.0	N/A	N/A	N/A	N/A	N/A	16
1975	455.2	745	48	0	795	1419	11
1976	370.2	509	60	0	569	1315	11
1977	480.6	676	15	0	691	1570	3
1978	441.6	502	50	0	552	1645	2
1979	513.2	442	42	0	484	1849	3
1980	611.3	500	168	0	668	2191	1
1981	461.6	320	452	0	772	2225	0
1982	351.0	332	14	0	346	2430	2
1983	340.4	429	328	0	757	1452	1
1984	336.2	366	571	0	986	1226	1
1985	345.5	500	359	0	1039	869	0
1986	286.4	411	476	23	887	1350	18
1987	371.3	370	636	28	1066	1346	1
1988	367.5	338	443	120	810	1315	1
1989	357.4	355	826	20	1181	1069	1
1990	354.5	276	663	0	939	1562	2
1991	396.2	210	183	76	397	2020	2
1992	395.3	382	220	358	623	1656	30
1993	486.8	421	235	278	832	1878	481
1994	390.2	315	155	46	476	1958	66
1995	465.0	131	321	113	463	3300	215
1996	430.8	200	141	23	353	2473	232
1997	412.5	204	80	0	298	2262	213
1998	492.7	184	499	0	694	2616	311
1999	474.7	536	192	0	777	2299	350

WOLDPJ = world japonica price($/MT), UPL480 = PL480(1000MT), UCCC = credit guarantee(1000MT), UEEP = export enhancement(1000MT), UMAP = export program(1000MT), UFMDP = outside specified export program (1000MT), UEPOTJ = export to Japan(1000MT).

VITA

Dae-Seob Lee, the youngest child of Seon-Ok Lee and Jeong-Sook Choi, received his bachelor of science in animal science from Kangwon National University, Chuncheon, Republic of Korea. He continued his academic career in M.B.A at the same university, under advisor former Chancellor Seo-Hyun Ha and Professor Kyung-Ryang Kim. He wrote a M.B.A. thesis titled "Improvement of Committed Farming Company in Kangwon Province."

He served in the Korean Army for two and a half years and was a unit leader in the first defense distribution transportation unit. He came to the United States of America in 1994. He took the intensive language course provided by the University of Arkansas at Fayetteville, Arkansas. After that, he enrolled in the master's program in the University of Arkansas and finished it in 1997. He conducted master's thesis titled "East Asian Rice Economies," under advisor Professor Eric J. Wailes.

He got married to his wife, Young-Hee Jeong, in 1997 and entered a doctoral program at the Texas Tech University, Lubbock, Texas, in 1998. However, he decided to transfer to the Louisiana State University in 1998. In addition, he was blessed to have a baby named Hana Lee in 1998 and another baby named Jeong-Hee Lee in 2000.

He started pursuing his doctoral studies at the Louisiana State University in 1998, under Minnesota graduate Associate Professor Dr. P. Lynn Kennedy. Dr. Kennedy recognized some academic achievements in his work and decided to let him receive his degree in Spring 2002.