AN ABSTRACT OF THESIS OF

Endah Murniningtyas for the degree of Master of Science in Agricultural and Resource Economics presented on October 12, 1989.

Tittle : Does Japan Exert Market Power in the World Wheat Market ?.

Redacted for Privacy

Abstract approved : ________________________

H. Alan Love

Hypothesis tests are developed for the exertion of market power by the Japanese government in the world and domestic wheat markets. The results indicate that the Japanese government is pursuing a more restrictive import policy for wheat than would be indicated by an optimal tariff strategy. Results also indicate that the Japanese government does not impose a restrictive policy on resale of wheat in the domestic market. An analysis of the welfare impacts of Japanese import restrictions suggests that the Japanese government may be pursuing a policy of collecting tariff revenues sufficient to cover domestic producer subsidies. The redistribution effects of Japanese import restrictions on the rest-of-world are sizeable.

Does Japan Exert Market Power in the World Wheat Market ?

by

Endah Murniningtyas

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of
Master of Science

Completed October 12, 1989

Commencement June 1990

APPROVED

Redacted for Privacy

Assistant Professor of the Department of Agricultural and Resource Economics, in charge of major

Redacted for Privacy

Head of the Department of Agricultural and Resource Economics

Redacted for Privacy

Dean of Graduate School

Date thesis presented October 12, 1989.

Typed by Endah Murniningtyas for Endah Murniningtyas.

ACKNOWLEDGEMENTS

I would like to thank to Dr. H. Alan Love, my major professor, whose continued interest and optimism provided the inspiration for this research; Dr. Steven T. Buccola and Dr. Patricia J. Lindsey, members of my graduate committee, whose valuable criticisms and suggestions improved the quality of my work; Prof. William Wick who served as Graduate Council Representative and Diana Burton for her valuable comments. I also would like to thank OTO/BAPPENAS for providing the scholarship and faculty, staff and friends in the Department of Agricultural and Resource Economic who made my time in Corvallis a "pleasant experience". Finally, I would like to dedicate this thesis to my mother and to the memory of my father, Sumitro Koesoemowijoto, for their loving and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

DOES JAPAN EXERT MARKET POWER IN THE WORLD WHEAT MARKET ?

I. INTRODUCTION

Many countries administer agricultural imports and exports through government trade agencies. This has led a number of authors to pay increasing attention to the interaction of market participants and the possibility of imperfect competition. For example, McCalla [1966], Kolstad and Burris [1986] and Alaouze, et.al [1978] have proposed oligopoly models for the world wheat market. A duopsony model of international wheat trade has been proposed by Carter and Schmitz [1979]. While these studies helped provide new insight about the nature of agricultural trade, they have not as yet incorporated a statistical test for market structure. The purpose of this study is to develop a statistical test for identifying market structure in the international wheat market. The test developed in this study is adopted from methodologies used in industrial organization to identify monopoly power [Bresnahan, 1982; Appelbaum, 1979].

The Japanese wheat market is selected for empirical analysis because Japan is a major importer of wheat and it relies on a government trade agency for all imports and domestic resale of foreign wheat. Two statistical hypothesis tests are constructed. One test is for the exertion of market power by Japan as a buyer in the international market. The other test is for the existence of market power in the Japanese domestic market through monopoly resale of foreign and domestic wheat.

A review of previous studies is presented in Chapter two. Japanese wheat policy is described in Chapter three. A model of market structure is developed in Chapter four. The econometric estimation is presented in Chapter five. Chapter six gives econometric results and an economic interpretation of those results. Chapter seven summarizes results from the study.

II. REVIEW OF LITERATURE

During the past two decades a number of authors have proposed alternative models of market structure for the international wheat market. McCalla [1969] constructed a model of wheat trade based on the assumption of duopoly between the U.S and Canada. He found that outcomes in the world wheat market are determined by the sales-maximization behavior of the Canada-U.S duopoly with Canada acting as a leader. Alaouze, Watson and Sturgess [1978] later added Australia as a player in a joint U.S-Canada-Australia triopoly.

Based on the fact that most importing countries restrict their trade, Carter and Schmitz [1979] argue that importers take advantage of their market power in the world wheat market by imposing an optimal import tariff. They assert that the European Economic Community (EEC) and Japan exert joint market power by operating as a duopsony. Kolstad and Burris [1986] admit the possibility of imperfect competition among buyers and sellers and model Japan and the EEC as a duopsony facing a Canadian-U.S-Australian triopoly.

Empirical results from these various models have not been conclusive. In many cases these various studies provide contradictory evidence. For instance, Kolstad and Burris agreed with the duopoly and triopoly models proposed by McCalla and Alaouze-Watson-Sturgess but rejected the duopsony model proposed by Carter and Schmitz. Part of the difficulty in resolving the differences in outcomes among the various studies is that those studies have not been conducted to empirically test for market structure. For example, McCalla utilized a Stackelberg duopoly model and simulated each possible outcome. These outcomes were then compared with the actual data. Carter and Schmitz based their conclusion on a simple comparison between actual and predicted prices in the presence of an optimal tariff imposed on the market by the EEC and Japan. Kolstad and Burris used Theil's inequality and Spearman rank correlations to measure the consistency between actual and simulated market outcomes. A common thread in all these studies is that their methodologies do not permit the possibility of forming testable nested hypotheses within a structural model context.

Tests for market structure have been constructed for other industries. Appelbaum [1979] tested for price taking behavior in the U.S crude petroleum and natural gas industries. Using cost functions of those industries to get derived demands for inputs, the hypothesis of whether the industry equalized its output price with its marginal cost was tested. The significance of the markup terms was used to distinguish monopoly and price taking behavior. The methodology of Appelbaum was adopted to U.S-Canada trade by Appelbaum and Kohli [1979]. A hypothesis test was performed to examine whether Canada behaves as a monopsonist with respect to its import demand and as a monopolist with respect to its exports to the U.S. They estimated the Canadian demand for imports and supply of exports to calculate markup terms that were then used to identify price taking behavior in the import and export markets.

Later, Bresnahan [1982] constructed a simple model of supply and demand to test for the existence of monopoly power. He proposed a demand function which contains an interaction between own-price and an exogenous substitute price. This interaction of variables allows a markup term to be incorporated directly into the estimated model. While Appelbaum calculated the value of the markup used to identify market structure outside the estimated model, Bresnahan parameterized the coefficient of the markup directly into the structural model.

III. JAPAN'S WHEAT POLICY

Since World War II, agricultural policy in Japan has been designed to encourage domestic production, maintain low consumer prices and minimize outflow of foreign exchange [Coyle, 1981]. The Food Staple Control Act of 1942 gave the government the authority to directly control prices and imports of food staples (mainly rice, wheat and barley). To maintain government objectives, the Japanese government intervenes in both the consumption and production of wheat through the auspices of the Japan Ministry of Agriculture, Forestry and Fishery (JMAFF).

To encourage domestic wheat production in Japan, a government purchasing price for producers is set well above the world level. This price is implemented through the JMAFF via wheat buying operations. The JMAFF must buy all wheat offered by farmers at the set producer price. Farmers are also free to sell wheat they produce directly to the market.

Adequate wheat for consumption is assured by the JMAFF which provides wheat from both domestic production and imports. The consumer price is maintained at a certain level by setting the government resale price of wheat to the wholesaler. Ninety percent of available wheat is imported, so the government selling price policy is heavily influenced by wheat import policy.

While wheat imports are provided by private traders, the government fully controls wheat importation by issuing import licenses to traders. The quantity of wheat imported is set to clear the market at the set resale price [OECD, 1987]. All imported wheat has to be sold to the JMAFF which then resells wheat to domestic wholesale consumers at the set government resale price. While the resale price charged to domestic consumers is well below the government purchasing price paid to producers, both prices are set above the world price. The government purchasing price mechanism means that farmers are likely to sell all wheat they produce to the government. Currently about ninety percent of domestically produced wheat is sold to the government. During the past few years, the government purchasing price for wheat has remained twice its resale price and four times world price.

IV. CONCEPTUAL FRAMEWORK

Theory

Market power is defined by McCalla [1981] as the ability to influence market outcome, which could be possessed by either the buyer (monopsony power) or the seller (monopoly power). Such power might arise because of the size of a firm relative to the total market (market share), or superior information possessed or control over channels in the marketing system. In the international market, market power can be possessed by a country with a large market share (large country assumption), a state trading arrangement or a large multinational firm which controls a substantial share of total trade. While firms use their market power to maximize profit, state traders may use market power for a variety of purposes [Just, Schmitz and Zilberman, 1979]. Carter and Schmitz [1979] have investigated the possibility of imposing an optimal tariff strategy to improve total welfare in an importing country. McCalla [1966] and others have investigated the possibility that exporting countries impose monopoly power to benefit producer groups. However, in an international setting, government-sponsored trade agencies may have motives other than those that are purely trade related. Government intermediaries like JMAFF, which regulates all wheat trade in Japan, may have multiple objectives including: price stabilization, enhancement of producers returns and provision of tax revenues to the government. Three possible objectives at JMAFF are evaluated: execution of an optimal tariff strategy, enhancing returns to domestic Japanese producers by restricting domestic trade, and maximizing producer returns through joint intervention in the domestic and international markets. Throughout the analysis it will be assumed that perfect competition prevails in the markets outside of Japan.

The monopoly and monopsony models are well developed in the literature [Lerner, 1934; Enke, 1944]. Monopoly power is possible when a monopolist faces a decreasing price as the sales increase. A monopolist will set price to maximize profit (marginal revenue = marginal cost) and let buyers decide the quantities they purchase at the set price [Lerner, 1934].

According to Enke [1944], a country which has an increasing import supply function, so that a disparity exists between marginal cost and supply price of each unit imported, will find it profitable to act as a monopsonist with respect to the commodity it imports. When the tariff rate is equivalent to the perfect monopsony buying power solution, the tariff is considered to be optimal. Enke has demonstrated that the imposition of an optimal tariff may have potential net welfare gains for the society imposing the tariff.

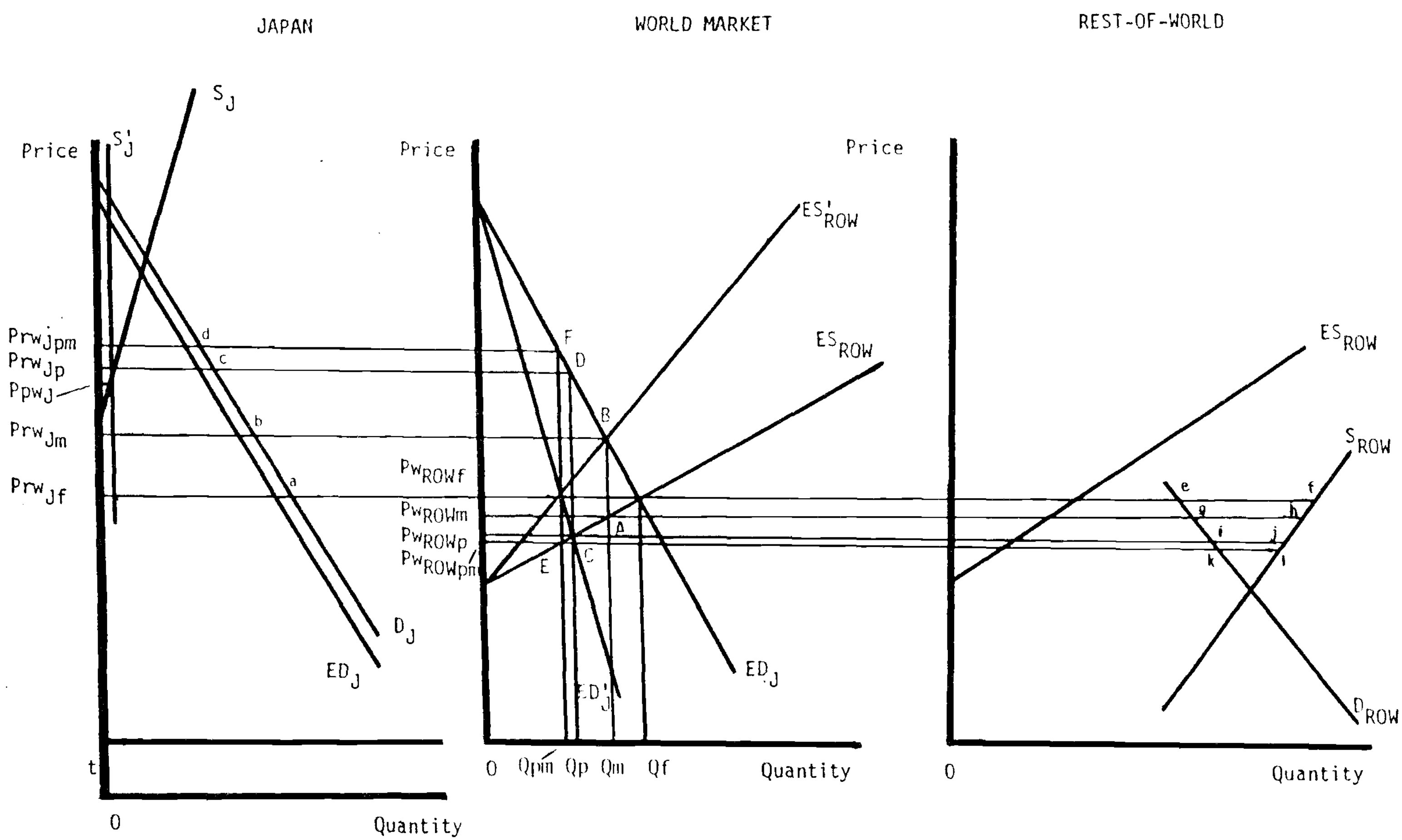
The possibility of simultaneously imposing both monopsony and monopoly power (pure middleman solution), is raised by both Lerner [1934] and Enke [1944] and examined by Just, et.al [1979]. A pure middleman extracts surplus from both domestic consumers and foreign producers. Profits can then be redistributed to producers and consumers or used by the government to provide other social services. The economic impact of a pure middleman solution can be measured by calculating changes in consumer and producer surplus and the tariff revenue collected. The net benefit to the state trading agency generated by the pure middleman solution will be greater than that resulting from either a pure monopoly or pure monopsony solution executed independently [Just, et.al, 1982].

Graphic Formulation of Alternative Market Solutions

As the sole buyer of all imported wheat in Japan, potentially the JMAFF can impose monopsony buying power in the world wheat market by establishing a wedge (tariff) between domestic and world prices. At the same time, as the sole seller in the domestic market, potentially the JMAFF can exert monopoly selling power by establishing a difference between the selling price and buying price from the world market. Such policies can be exerted individually or jointly. The analytical framework is displayed in Figure 1.

On the left hand side are the supply (S_J) and demand (D_J) curves for wheat in Japan. Normally excess demand is determined as the horizontal difference between demand and supply. However, producer price of wheat in Japan is set exogenously. As a result, domestic supply of wheat does not respond to price fluctuations in the market, so the excess demand curve (ED_J) in Japan is given by the difference between total wheat demanded and the quantity supplied at the fixed producer price (Ppw_J). The fixed quantity of wheat supplied in Japan is represented by the vertical supply curve, S_J'.

On the right hand side are the rest-of-world wheat supply (S_{ROW}) and demand (D_{ROW}) curves for the international market outside Japan. The excess supply of wheat from rest-of-world (ES_{ROW}) is the horizontal difference between domestic wheat supply and demand in the rest-of-world. In the middle of Figure 1 the Japanese excess demand curve, ED_J, is superimposed on the excess supply curve from rest-of-world, ES_{ROW}. The horizontal axis of the world market is shifted up to integrate transportation cost (t) into the analysis. In a free-trade environment, the import price would be Pw_{ROWf}, domestic resale price would be Prw_{Jf}, and the quantity traded would be Q_f. The difference between these two prices is transportation cost. Under free trade



S_J = wheat supply in Japan

D_J = wheat demand in Japan

ED_J = excess demand of wheat from Japan

ES_{ROW} = excess supply of wheat in the ROW

S_{ROW} = wheat supply in the ROW

D_{ROW} = wheat demand in the ROW

Figure 1

the JMAFF does not collect any tariff revenue.

If the JMAFF faces an upward sloping supply curve from rest-of-world it will be able to act as a monopsonist. The marginal cost of imports for the monopsonist is represented by the marginal excess supply curve from rest-of-world (ES_{ROW}'). The perfect monopsonist solution then will be given by the intersection of ED_J and ES_{ROW}'. The resale price of wheat in Japan would be Prw_{Jm}, the world price would be Pw_{ROWm}, and the quantity traded would be Q_m. The price differential, $Prw_{Jm} - Pw_{ROWm}$, multiplied by quantity traded represents tariff revenue collected by JMAFF and is given by the area ■$Prw_{Jm}Pw_{ROWm}AB$. The deadweight loss in Japan is given by tariff revenue, ■$Prw_{Jm}Pw_{ROWm}AB$ minus the change in consumer surplus, ■$Prw_{Jf}abPrw_{Jm}$. Change in producer surplus is zero in the calculation of Japan's deadweight loss since producer price in Japan is fixed by the government and is assumed to remain unchanged across alternative market solutions. The deadweight loss in rest-of-world is given by gain in consumer surplus, ■$Pw_{ROWf}egPw_{ROWm}$, minus the loss in producer surplus, ■$Pw_{ROWf}fhPw_{ROWm}$. Enke [1944] has demonstrated that the monopsonist solution may result in a net welfare gain in the importing country.

If the JMAFF faces a downward sloping excess demand curve in the domestic market it has the potential to behave as a monopolist. The marginal revenue for the monopolist is given by the marginal Japanese excess demand curve (ED_J'). The pure monopolist solution is given by the intersection of ED_J' and ES_{ROW}. Price in the world market would be Pw_{ROWp}, resale price in the Japanese market would be Prw_{Jp} and the quantity traded would be Q_p. The monopolist buying power premium is the difference between Prw_{Jp} and Pw_{ROWp} and monopoly rent collected by the JMAFF would be ■$Prw_{Jp}Pw_{ROWp}CD$. The deadweight loss in Japan is given by monopoly rent, ■$Prw_{Jp}Pw_{ROWp}CD$, minus the loss in consumer surplus, ■$Prw_{Jf}acPrw_{Jp}$. The deadweight loss in rest-of-world is given by the gain in consumer surplus, ■$Pw_{ROWf}eiPw_{ROWp}$, minus the loss in producer surplus, ■$Pw_{ROWf}fjPw_{ROWp}$.

If the JMAFF faces a downward sloping excess demand curve in the domestic market and an upward sloping excess supply curve in the world market, it would potentially be able to impose both monopoly and monopsony market power (pure middleman solution). The intersection of the ED_J' and ES_{ROW}' in the middle of Figure 1 gives the equilibrium solution for the pure middleman. The resale price in Japan would be Prw_{Jpm}, Pw_{ROWpm} would be the world price and the quantity traded would be Q_{pm}. The distance between Prw_{Jpm} and Pw_{ROWpm} would be the price wedge (tariff) created by simultaneous execution of monopsony and monopoly power by the pure middleman. Tariff revenue collected by the JMAFF would be equal to area ■$Prw_{Jpm}Pw_{ROWpm}EF$. The deadweight loss in Japan is the tariff revenue, ■$Prw_{Jpm}Pw_{ROWpm}EF$, minus the loss in consumer surplus, ■$Prw_{Jf}adPrw_{Jpm}$. The deadweight loss in rest-of-world is the gain in consumer surplus, ■$Pw_{ROWf}ekPw_{ROWpm}$, minus the loss in producer surplus, ■$Pw_{ROWf}flPw_{ROWpm}$.

Algebraic Formulation of Alternative Market Solutions

Assuming that producers and consumers behave as price takers, a constant exchange rate and that transportation cost is the only transfer cost, the profit function for the pure middleman can be defined as:

$$\max_{M} \pi = \beta * Prw_J(M) * M - Pw_{ROW}(M) * M + \beta * Prw_J(M) * S_J - \beta * Ppw_J * S_J - t * M \qquad (1)$$

where: M is the quantity of wheat imported by Japan ($ED_J = ES_{ROW}$ when the world market clears), $Prw_J(M)*M$ is the revenue from the sale of imported wheat (Yen), $Pw_{ROW}(M)*M$ is the cost of imported wheat (U.S. dollars), $Prw_J(M)*S_J$ is the revenue from sale of the domestically produced wheat (Yen), Ppw_J*S_J is the cost of domestically produced wheat (Yen) and $t*M$ is the transportation cost of imported wheat (U.S. dollars). $Prw_J(M)$ represents price-dependent excess demand for wheat from Japan and $Pw_{ROW}(M)$ represents price-dependent excess supply from rest-of-world. All prices are converted into a common currency unit, U.S. dollars, because it is commonly used in international trade. This conversion is obtained by multiplying all Yen prices by the coefficient ß, which represents the exchange rate from Yen into U.S. dollars.

Domestic wheat is included in the profit function because both domestic and imported wheat are sold at the resale price. There is a small difference between the resale price for domestic wheat and imported wheat but this is due to quality difference, domestic wheat being somewhat lower in quality compared with imported wheat [OECD, 1987].

Profit will be at a maximum when:

$$\delta\pi/\delta M = \beta*(\delta Prw_J/\delta M)*M + \beta*Prw_J - (\delta Pw_{ROW}/\delta M)*M - Pw_{ROW} + \beta*(\delta Prw_J/\delta M)*S_J - t = 0 \qquad (2)$$

where:

$\delta Prw_J/\delta M$ is the slope of the price-dependent excess demand curve for Japan.

$\delta Pw_{ROW}/\delta M$ is the slope of the price-dependent excess supply curve from rest-of-world.

Equation (2) can be manipulated into the equilibrium condition:

$$\beta*Prw_J+\sigma^D*\beta*(\delta Prw_J/\delta M)*(M+S_J)-t=Pw_{ROW}+\sigma^F*(\delta Pw_{ROW}/\delta M)*M \qquad (3)$$

Equation 3 states that, at equilibrium, marginal benefit of wheat imports plus the monopoly selling premium (represented by $\sigma^D*\beta*(\delta Prw_J/\delta M)$) minus transportation cost must be equal to the marginal cost of wheat importation plus the monopsony buying premium (represented by $\sigma^F*(\delta Pw_{ROW}/\delta M)$).

Equilibrium condition 3 can also be expressed as:

$$Pw_{ROW}+t=\beta*Prw_J-\sigma^F*(\delta Pw_{ROW}/\delta M)*M+\sigma^D*\beta*(\delta Prw_J/\delta M)*(M+S_J) \quad (4)$$

and

$$\beta*Prw_J-t=Pw_{ROW}+\sigma^F*(\delta Pw_{ROW}/\delta M)*M-\sigma^D*\beta*(\delta Prw_J/\delta M)*(M+S_J) \quad (5)$$

The coefficients σ^D and σ^F are added to the equilibrium condition to admit the possibility of alternative market solutions including: pure middleman, monopsony, monopoly and free trade. The coefficient σ^D represents Japan's market power (monopoly) in the domestic wheat resale market. The coefficient σ^F represents Japan's market power (monopsony) in the international wheat market. The values of these coefficients can range from 0 to ∞. Values of $\sigma^F=\sigma^D=0$ indicate that the market is at a competitive equilibrium. The perfect monopsony solution is given by the value of $\sigma^F=1$ and $\sigma^D=0$. A perfect monopoly outcome is given by a value of $\sigma^F=0$ and $\sigma^D=1$. Pure middleman solution is indicated when $\sigma^F=\sigma^D=1$. Values of $0<\sigma^i<1$ i=D, F, indicate that some monopoly or monopsony power is being imposed in the market. If the values of $\sigma^i>1$ i=D, F, policies more restrictive than perfect monopsony or monopoly solutions are being exercised in the market.

Model Specification

To facilitate estimation of the parameters of market power σ^D and σ^F, it is necessary to specify a behavioral model for wheat supply and utilization for Japan and rest-of-world. The United States, Canada and Australia are the primary countries exporting wheat to Japan, supplying about 60, 25 and 15 percent of Japan's total wheat imports respectively. To simplify the analysis however, all countries outside of Japan will be modeled as aggregate rest-of-world.

Based on standard results from the theory of the firm [Henderson and Quandt, 1971], wheat supply in Japan is specified as a function of producer price of wheat (Ppw_J), producer price of rice (Ppr_J) and cost of production (C_J). Previous wheat production, $S_{J(-1)}$, is also included in the Japanese wheat supply equation to represent the partial adjustment process of agricultural supply. Based on standard results from consumer theory [Henderson and Quandt, 1971], wheat demand in Japan is influenced by the resale price of wheat (Prw_J), income (Y_J) and the resale price of rice (Prr_J). Price of rice in Japan is used in both the supply and demand functions since rice is a substitute for wheat in both production and consumption [Riethmuller and Roe, 1986]. An interaction term between the price of wheat and the price of rice (Prw_J*Prr_J) is included in the demand function to make the monopoly power coefficient (σ^D) econometrically identifiable [Bresnahan, 1982].

Japanese supply of wheat is given by:

$$S_J = a_0+a_1*(Ppw_J/C_J)+a_2*(Ppr_J/C_J)+a_3*S_{J(-1)}+e_{SJ} \qquad (6)$$

Japanese demand for wheat is given by:

$$D_J = b_0+b_1*Prw_J+b_2*Y_J+b_3*Prr_J+b_4*(Prw_J*Prr_J)+e_{DJ} \qquad (7)$$

where:

S_J is domestic wheat supply in Japan

Ppw_J is the real government purchasing price for wheat in Japan

C_J is an index of price paid by farmers for inputs in Japan

Ppr_J is the real government purchasing price for rice in Japan

$S_{J(-1)}$ is lagged domestic production

D_J is quantity of wheat demanded in Japan

Prw_J is the real resale price for wheat in Japan

Prr_J is the real resale price for rice in Japan

Y_J is the real income in Japan

e_{SJ}, e_{DJ} are the error terms

a_0, a_1, a_2, a_3, b_0, b_1, b_2, b_3, b_4 are parameters.

Excess demand in Japan is the difference between demand and supply. In price-dependent form this is:

$$Prw_J = [1/(b_1+b_4*Prr_J)]\ [ED_J+a_0-b_0+a_1*(Ppw_J/C_J) +a_2*(Ppr_J/C_J)+a_3*S_{J(-1)}-b_2*Y_J-b_3*Prr_J]+e_{EDJ} \qquad (8)$$

where e_{EDJ} is the error term.

Excess supply of wheat in rest-of-world is derived similarly. Supply of wheat in rest-of-world is expected to be influenced by its own-price (Pw_{ROW}), lagged supply ($S_{ROW(-1)}$), the price of corn as a substitute in wheat production (Pc_{ROW}) and cost of production (C_{ROW}). Demand for wheat is assumed to be influenced by its own-price (Pw_{ROW}), income (Y_{ROW}) and the price of rice (Pr_{ROW}) as a substitute in wheat consumption. An interaction term between price of wheat and price of rice in rest-of-world ($Pw_{ROW}*Pr_{ROW}$) is included in the rest-of-world demand function so that the monopsony power coefficient (σ^F) will be econometrically identified [Bresnahan, 1982]. The stock of wheat in rest-of-world fluctuates year to year and is expected to be influenced by wheat price (Pw_{ROW}) and beginning wheat stocks ($ST_{ROW(-1)}$).

The supply of wheat in rest-of-world is given by:

$$S_{ROW} = d_0+d_1*(Pw_{ROW}/C_{ROW})+d_2*S_{ROW(-1)}+d_3*(Pc_{ROW}/C_{ROW})+e_{SROW} \qquad (9)$$

The demand equation for wheat in rest-of-world is given by:

$$D_{ROW} = e_0+e_1*Pw_{ROW}+e_2*Y_{ROW}+e_3*Pr_{ROW}+e_4*(Pw_{ROW}*Pr_{ROW})+e_{DROW} \quad (10)$$

The stock of wheat in rest-of-world is given by:

$$ST_{ROW} = f_0+f_1*Pw_{ROW}+f_2*ST_{ROW(-1)}+e_{STROW} \quad (11)$$

where:

S_{ROW} is the quantity of wheat supplied in rest-of-world

Pw_{ROW} is the real world price of wheat

C_{ROW} is an index of price paid by farmers for inputs in rest-of-world

$S_{ROW(-1)}$ is lagged wheat supply for rest-of-world

Pc_{ROW} is the real price of corn in rest-of-world

D_{ROW} is the quantity wheat demanded in rest-of-world

Y_{ROW} is rest-of-world income

Pr_{ROW} is the real price of rice in rest-of-world

ST_{ROW} is wheat stocks in rest-of-world

$ST_{ROW(-1)}$ is the lagged stock in rest-of-world

e_{SROW}, e_{DROW}, e_{STROW} are error terms

d_0, d_1, d_2, d_3, e_0, e_1, e_2, e_3, e_4 , f_0, f_1, f_2, are parameters.

Excess supply from rest-of-world in price-dependent form is given by:

$$Pw_{ROW} = [1/((d_1/C_{ROW})-e_1-e_4*Pr_{ROW}-f_1)]\ [ES_{ROW}+e_0-d_0+f_0$$
$$+e_2*Y_{ROW}-d_2*S_{ROW(-1)}-d_3*(Pc_{ROW}/C_{ROW})$$
$$+(f_2-1)*ST_{ROW(1)}+e_3*Pr_{ROW}]+e_{ESROW} \qquad (12)$$

where e_{ESROW} is the error term.

V. ECONOMETRIC ESTIMATION

To facilitate estimation of σ^F and σ^D, the excess demand equation for Japan (8) is substituted into equilibrium condition (4) to obtain an estimable excess demand equation, ED_J. The excess supply equation in price-dependent form (12) is substituted into equilibrium condition (5) to obtain an estimable excess supply equation, ES_{ROW}. The monopoly and monopsony markup terms, $(\delta Prw_J/\delta M)$ and $(\delta Pw_{ROW}/\delta M)$ are replaced by $[1/(b_1+b_4*Prr_J)]$ and $[1/((d_1/C_{ROW})-e_1-e_4*Pr_{ROW}-f_1)]$ respectively. The two resulting equations are then combined with the structural equations for Japan and rest-of-world markets (6, 7, 9, 10, 11) forming a system of simultaneous equations. This system then can be jointly estimated to obtain a full set of parameter estimates including both σ^F and σ^D.

Econometric identification of nonlinear simultaneous equations subject to nonlinear constraints has been investigated by Rothenberg [1971]. Identification of structural parameters can be checked by determining the rank of the information matrix augmented with the Jacobian matrix of the constraints. If the rank of this augmented matrix, calculated in the neighborhood of the parameter estimates, is equal to the number of unknown parameters, the system is locally identifiable [Rothenberg, 1971]. This condition can be numerically checked using TSP4.1B [Hall, Scnake and Cummins, 1987].

Nonlinear three-stage least squares (NL3SLS) developed by Amemiya [1977] and implemented in the TSP4.1B [Hall, Scnake and Cummins, 1987] is used to obtain the parameter estimates. Parameters estimated using NL3SLS are generally less efficient than those obtained using full information maximum likelihood (FIML) estimation. However, if the errors are not normally distributed, NL3SLS is more robust than FIML estimators. If errors are nonnormally distributed, NL3SLS estimates are still consistent so long as the error terms have zero mean and finite higher moments, while those resulting from FIML estimation may not be consistent [Amemiya, 1977]. Lacking any a apriori information about the distribution of the error terms, the NL3SLS estimator is chosen.

Data

Data for the Japanese wheat market used in the estimation are mostly obtained from the Statistical Yearbook of the Japan Ministry of Agriculture, Forestry and Fishery (JMAFF). Wheat supply for Japan (S_J) is represented by wheat production. Beginning and ending stocks in Japan are negligible. However, since data for total wheat consumed in Japan are not available, wheat stock data are utilized to calculate quantity of wheat demanded, $D_J=S_J+M+ST_{J(-1)}-ST_J$. Japanese production cost of wheat (C_J) is represented by an index of prices paid by farmers for production requisites from the Food and Agriculture Organization (FAO). Japanese income data (Y_J) come from the United Nations (UN). Government wheat purchasing and resale prices for wheat (Ppw_J, Prw_J) and rice (Ppr_J, Prr_J), cost of production (C_J) and income (Y_J) are deflated by the Japanese consumer price index (CPI_J) to exclude the influence of inflation in price fluctuations.

Rest-of-world production (S_{ROW}) and consumption (D_{ROW}) data come from the United States Department of Agriculture (USDA) and generally are total world wheat production and consumption with Japan removed. Rest-of-world wheat prices (Pw_{ROW}) and cost of transportation (t) are the average wheat export prices from the United States, Canada and Australia and transportation cost from each exporting country to Japan weighted by each countries wheat exports. The United States export price for rice is used to represent rest-of-world rice price (Pr_{ROW}) since the United States is the biggest world rice market supplier. Rest-of-world income (Y_{ROW}) is total income in developed and developing countries which comes from the United Nations (UN). Price of corn (Pc_{ROW}) is the average export prices of corn in the United States, Canada and Australia weighted by corn production in each country. Rest-of-world cost of production (C_{ROW}) is a weighted average of the price index paid by farmers in the United States, Canada and Australia, weighted by wheat production in each country. Exchange rate data come from the United Nations and the United States Department of Commerce.

Annual data between 1964-1985 were utilized for the estimation. A detailed description of all data used is presented in Appendix C.

VI. ECONOMETRIC RESULTS

The parameters were estimated using the Nonlinear Three-Stage Least Squares (NL3SLS) routine in TSP4.1B [Hall, Scnake and Cummins 1987]. Econometric identification of the parameters was checked using TSP4.1B. The resulting parameter estimates are presented in Table 1.

Estimated coefficients in the model have the expected signs and most are statistically significant at the 0.5 percent level. Coefficients for world wheat and corn prices in rest-of-world supply functions are significant at the 15 percent level and the world wheat price coefficient in the rest-of-world stock function is significant at the 5 percent level.

Parameter estimates for the monopsony and monopoly coefficients are σ^F=10.192 and σ^D=.001 respectively. A number of formal hypothesis tests can be constructed concerning monopoly and monopsony power. Alternative hypothesis tests are:

i). Test for no market power (free trade):

H_o: $\sigma^F=0$ and $\sigma^D=0$,

versus H_a: $\sigma^F=0$ or $\sigma^D=0$.

ii). Test for perfect monopsony solution:

H_o: $\sigma^F=1$ and $\sigma^D=0$,

versus H_a: $\sigma^F=1$ or $\sigma^D=0$.

Table 1. Estimates of Parameters

	Parameters	Estimates	t-values
Supply in Japan			
constant	a_0	1.4978	8.45
Ppw_J/C_J	a_1	.1873e-4	10.18
Ppr_J/C_J	a_2	-.1676e-4	13.84
$S_{J(-1)}$	a_3	.7125	6.03
Demand in Japan			
constant	b_0	62.3330	9.09
Prw_J	b_1	-.1777e-2	-7.76
Y_J	b_2	.2121e-4	8.31
Prr_J	b_3	-.4721e-3	-8.47
Prw_J*Prr_J	b_4	.1445e-7	7.77
Supply at ROW			
constant	d_0	99.5520	2.48
Pw_{ROW}/C_{ROW}	d_1	.3889	1.10
$S_{ROW(-1)}$	d_2	.7992	12.78
Pc_{ROW}/C_{ROW}	d_3	-.7457	1.43
Demand at ROW			
constant	e_0	475.1000	14.37
Pw_{ROW}	e_1	-3.8069	-9.07
Y_{ROW}	e_2	.8427e-4	18.82
Pr_{ROW}	e_3	-28.2180	-8.56
$Pw_{ROW}*Pr_{ROW}$	e_4	.2551	8.78
Stock at ROW			
constant	f_0	38.3750	1.76
Pw_{ROW}	f_1	-.2791	-1.80
$ST_{ROW(-1)}$	f_2	.8215	5.03
Market Power	σ_F	10.1920	5.10
	σ_D	.9923e-3	.27

iii). Test for perfect monopoly solution:

$$H_o: \sigma^F=0 \text{ and } \sigma^D=1,$$

$$\text{versus } H_a: \sigma^F=0 \text{ or } \sigma^D=1.$$

iv). Test for pure middleman solution:

$$H_o: \sigma^F=1 \text{ and } \sigma^D=1,$$

$$\text{versus } H_a: \sigma^F=1 \text{ or } \sigma^D=1.$$

Statistical inference for systems of simultaneous, nonlinear equations has been developed by Gallant and Jorgenson [1979]. They constructed a quasi-likelihood ratio (QLR) test statistic that can be used for hypothesis testing in a nonlinear model estimated using the NL3SLS estimator. Their QLR test statistic is:

$$T^o = n*(Q_o - Q_a),$$

where:

Q_o is the criterion level obtained from minimizing the system sum of squares under the null hypothesis,

Q_a is the criterion level obtained from minimizing the unrestricted system sum of squares,

and n is number of observations.

The QLR test statistic has a Chi-squared distribution with degrees of freedom equal to the number of restrictions under the null hypothesis.

To reject the null hypothesis, the value of T^o must be greater than the tabled Chi-squared value with 2 degrees of freedom, 9.91 at the 1 percent significance level. The QLR test statistic for the free trade hypothesis is T^o=63.87.

The value of T^o for the perfect monopsony hypothesis is 35.92, T^o for the perfect monopoly hypothesis is 5123.93 and T^o for the pure middleman hypothesis is 5091.46. Clearly all hypotheses are rejected at a high level significance. This means that the wheat market is not a free, pure middleman, perfect monopoly or perfect monopsony market.

Coefficient estimates from the unrestricted model indicate actual market structure. The parameter estimate for monopoly selling power of σ^D=.001 and its associated t-value of .27 indicate that little or no monopoly selling power is being imposed in the domestic market. On the other hand, the estimated parameter for monopsony market power of σ^F=10.192 and its associated t-value of 5.10 suggest that Japan is pursuing a more restrictive import policy than that would be indicated by an optimal tariff strategy (corresponding to the values of σ^D=0, σ^F=1).

Table 2 presents the elasticities of excess supply and demand calculated at mean values. The own-price elasticity of supply for Japan is estimated to be 2.45, which is close to the estimate from Roe, Shane and Vo [1986], of 2.72. Own-price elasticity of demand is -.26, also not far from the result of Roe, et.al's (-.18), Rojko's (-.33) and Coyle's (-.18). The estimated income elasticity of .26 is greater than Roe, et. al's (.006) and Rojko's (.10), but close to Greenshield's (.21).

Table 2. Price Elasticities at the Mean Values

JAPAN	
Supply	2.45
Demand	-.26
Excess Demand	
- Free-trade	-.30
- Observed trade	-.30
REST-OF-WORLD	
Supply	.07
Demand	-.29
Excess Supply	
- Free-trade	30.00
- Observed trade	2.68

The excess supply curve for the rest-of-world is very elastic (30.00) compared with the excess demand curve for Japan (-.30). These results imply that small changes in the quantity traded will cause small price changes in the rest-of-world market and large price changes in the Japanese domestic resale price. This result is consistent with the fact that Japan only imports seven percent of the total wheat traded in the world market, but wheat imports in Japan comprise almost 90 percent of total wheat consumed. Thus, a small reduction of wheat imports, in the presence of a trade restriction, will cause a big price increase in the domestic market and a small price decrease in the world market.

The magnitude of the market power coefficients are reflected in the elasticities. The parameter of domestic market power is almost zero (σ^D=.001) and therefore does not have much influence on the price elasticity of excess demand in Japan. By contrast, the elasticity of excess supply from the rest-of-world in the presence of market power exerted in the foreign market (σ^F=10.192) is ninety percent less than the elasticity of excess supply from rest-of-world in the absence of market power (which is 2.68 compared with 30.00).

A Welfare Analysis of Japanese Trade Restrictions

Price, quantity and welfare effects for five alternative policy scenarios are presented in Table 3.

Table 3. Model Solutions Under Alternative Policy Scenarios

	Free trade ($\sigma_F=\sigma_D=0$)	Perfect Monopsony ($\sigma_F=1, \sigma_D=0$)	Perfect Monopoly ($\sigma_F=0, \sigma_D=1$)	Pure Middleman ($\sigma_F=\sigma_D=1$)	Observed trade ($\sigma_F=10.192$, $\sigma_D=.001$)
M(m.mt)	5.60	5.56	2.50	2.50	5.24
Prw_J (US$/mt)	77.18	79.70	290.00	290.54	101.90
Pw_{ROW} (US$/mt)	66.85	66.83	65.43	65.42	66.70
<u>WELFARE EFFECTS</u>					
<u>JAPAN</u>					
TR (m.US$)	-	14.10	535.60	537.70	130.30
CS (m.US$)	1320.00	1304.00	330.00	328.00	1171.00
DW (m.US$)	0	1.90	454.40	455.00	18.70
DW/TR	-	.13	.85	.85	.14
<u>REST-OF-WORLD</u>					
CS (m.US$)	44332.70	44340.10	44858.35	44862.10	44388.10
PS (m.US$)	24528.20	24520.60	23990.10	23986.30	24471.30
DW (m.US$)	-	.20	12.45	12.50	1.50

Note : All prices and values are in 1967 US$ dollars. M = quantity traded, TR = tariff revenue, CS = consumers surplus, PS = producers surplus, DW = deadweight loss.

All calculations are based on the estimated parameters appearing in Table 1. The observed trade solution is obtained by replacing both σ^F and σ^D in the equilibrium condition (equations 4 and 5) with the estimated values of 10.192 and .001 respectively. The free trade, pure middleman, perfect monopsony and perfect monopoly scenarios are developed by setting σ^F and σ^D appropriately and keeping all other estimated parameters constant. Welfare results of the free trade, perfect monopsony, perfect monopoly and pure middleman simulations must be interpreted with some caution since estimated values of the other parameters in the model are assumed unchanged in spite of the structural changes implied by the alternative market structures resulting from changing assumptions concerning σ^F and σ^D. All dollar amounts are in 1967 U.S. dollars.

The observed trade scenario results in quantity traded of 5.24 million metric tons, resale price in Japan of US$ 101.90 per metric ton and rest-of-world price of US$ 66.70 per metric ton. Under the free trade scenario the quantity traded is 5.60 million metric tons, resale price in Japan is US$ 77.18 per metric ton and rest-of-world price is US$ 66.85 per metric ton. Compared with the free trade results, the quantity traded under the observed trade scenario is about six percent less. Price in rest-of-world under the observed trade scenario declines by 15 cents per metric ton compared with the free trade scenario and results in a gain in consumer surplus of US$ 55.40 million. Rest-of-world producers lose about US$ 56.90 million in surplus as a result of Japanese trade restrictions. In total, the deadweight loss to the rest-of-world is about US$ 1.50 million.

The observed trade scenario results in an increase in resale price in Japan of US$ 25.00 per metric ton when compared to the free trade scenario. As a result, JMAFF collects tariff revenue amounting to US$ 130.30 million. Japanese consumers lose US$ 149.00 million in consumer surplus while producers surplus remains unchanged. Producer price in Japan is maintained well above resale price (averaging US$ 216.80 per metric ton in 1967 dollars over the period of estimation versus an average US$ 101.90 per metric ton resale price over the same period). Thus, producer surplus is unaffected by changes in trade policy. Total deadweight loss to Japanese society from trade restrictions amounts to US$ 18.70 million.

Enke (1944) argued that the optimal tariff strategy may result in welfare gains for the country imposing the tariff. The optimal tariff strategy results in a quantity traded of 5.56 million tons. The Japanese resale price under the optimal tariff strategy is US$ 79.70 per metric ton and rest-of-world price is US$ 66.83 per metric ton. Compared with the free trade scenario, the optimal tariff strategy results in a decline in the quantity of wheat traded of about 40 thousand metric tons. Price in Japan rises by US$ 2.52 per metric ton and rest-of-world price declines by 2 cents per metric ton. The JMAFF collects tariff revenues amounting to US$ 14.10 million but Japanese consumers lose US$ 16.00 million. Total deadweight loss to Japanese society amounts to US$ 1.90 million.

The optimal tariff strategy in this analysis results in a deadweight loss to Japanese society because producer price in Japan remains fixed, leaving producer surplus constant across alternative market structures. This causes these results to deviate from Enke's conclusions because producer price responds to market structure in his analysis.

The preceding social welfare analysis suggests that tariff revenue may be the most important reason for market power imposition in Japan. Greenshield [1986] points out that self-sufficiency is a major objective of Japanese agriculture policies. Producer price could be set to maintain domestic wheat production.

During the period of estimation, the mean value of the government purchasing price for wheat from producers in Japan was US$ 216.80 per metric ton (1967 US$). At the fixed quantity of wheat produced, which has a mean value of 603 thousand tons over the period of estimation, the average domestic wheat subsidy is US$ 84.20 million per year. Under the free trade scenario, the government must finance the entire producer subsidy from general revenues. In the optimal tariff strategy, tariff revenue only amounts to US$ 14.10 million, so that the government has to finance most of the domestic wheat subsidy through general revenues. Thus, both of these scenarios may well be politically undesirable.

Other policy alternatives that can be pursued by JMAFF are perfect monopoly and pure middleman scenarios. Both policy scenarios produce much higher tariff revenue to the JMAFF, US$ 535.00 million, which is six times the total producer subsidy. However, under these scenarios, Japanese society would pay a very high cost because consumers lose US$ 990.00 million in consumer surplus. As a result, the deadweight loss to the Japanese society would be US$ 445.00 million, which means that the Japanese society would pay 85 cents in deadweight loss for every dollar in tariff revenue collected. These two policy scenarios are also politically undesirable alternatives.

Compared with other policy scenarios, the observed trade scenario is the most efficient choice because the collected tariff revenues of US$ 130.30 million per year are more than enough to cover the cost of domestic wheat subsidies and the associated deadweight loss of collecting this tariff revenue, US$ 18.70 million or 14 cents per dollar of tariff revenue collected, is relatively low and fairly close to the 12 cents loss resulting from the optimal tariff strategy. From a political perspective, the observed trade scenario is a favorable policy alternative for Japan.

In terms of model verification, the observed trade scenario gives a good approximation of the actual trade situation. For example, the observed trade scenario results in quantity of wheat traded of 5.24 million tons, resale price in Japan of US$ 101.90 and rest-of-world price of US$ 66.70 per metric ton. The corresponding values, based on the mean values during the period of estimation, are 5.14 million metric ton, US$ 105.90 and US$ 70.86 per metric ton.

Estimated market power coefficients resulting from separate hypothesis tests of monopsony and monopoly power are presented in Appendix A and B. These results support findings from the joint hypothesis tests already presented. The hypothesis test for the exertion of monopsony power yields an estimate of σ^F=8.71 and the monopoly test yields an estimates of σ^D=.001. These results are very similar to those from the joint hypothesis test presented in Table 1.

VII. CONCLUSION

Results of this study indicate that the Japanese government pursues a more restrictive wheat policy than would be indicated by an optimal tariff strategy. However, the Japanese government apparently does not pursue a restrictive policy for wheat resale in the domestic market. These results differ from those of Carter and Schmitz [1979] and Kolstad and Burris [1986], perhaps due to differences in the estimated price elasticity of excess supply. Small variations in this elasticity could result in fairly large variations in the coefficient of monopsony power (σ^F). On the other hand, the difference may stem from the failure of previous studies to incorporate statistical tests for market power. Indeed, the methodology in the present study allows one to incorporate parameters that can be used to directly identify market structure.

Analysis of the welfare results indicates that the Japanese government may be pursuing a trade strategy entirely different from that hypothesized in earlier works. Over the period of estimation, the average annual cost of subsidies to Japanese wheat producers amounted to about US$ 85 million (in 1967 U.S. dollars). Over the same period, tariff revenues amounted to about US$ 130 million per year. On average, enough tariff revenues were collected to offset the cost of running the domestic wheat program and provide some surplus funds to support Japan's very expensive rice program. The deadweight loss of collecting this tariff revenue was a relatively low 14 cents per dollar collected. Just how the producer subsidy is set remains a research issue.

While the deadweight loss to society in rest-of-world resulting from Japanese import tariffs is small, the redistributive effect is sizeable. Producers in rest-of-world lose US$ 57.00 million in producer surplus, while consumers achieve a similar gain in consumer surplus. Thus, a shift in Japanese trade policy to a free trade position would have significant economic impacts on market participants outside Japan.

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APPENDICES

APPENDIX A. Results of the Monopsony Power Test

	Parameters	Estimate	t-values
Supply in Japan			
constant	a_0	1.9733	7.08
Ppw_J/C_J	a_1	.5743e-5	1.66
Ppr_J/C_J	a_2	-.1087e-4	-4.76
$S_{J(-1)}$	a_3	.12742	.86
Demand in Japan			
constant	b_0	35.3260	7.24
Prw_J	b_1	-.9057e-3	-5.80
Y_J	b_2	.1506e-4	6.04
Prr_J	b_3	-.2517e-3	-6.39
Prw_J*Prr_J	b_4	.7401e-8	5.79
Supply at ROW			
constant	d_0	99.9760	2.90
Pw_{ROW}/C_{ROW}	d_1	.35815	1.17
$S_{ROW(-1)}$	d_2	.82707	15.20
PC_{ROW}/C_{ROW}	d_3	-.87855	-2.57
Demand at ROW			
constant	e_0	550.8100	14.19
Pw_{ROW}	e_1	-3.9024	-8.72
Y_{ROW}	e_2	.7764e-4	16.32
Pr_{ROW}	e_3	-40.6130	-9.77
$Pw_{ROW}*Pr_{ROW}$	e_4	.3391	9.45
Stock at ROW			
constant	f_0	25.5990	1.22
Pw_{ROW}	f_1	-.2066	-1.29
$ST_{ROW(-1)}$	f_2	.9077	6.08
Market Power	σ^F	8.7086	5.99

APPENDIX B. Results of the Monopoly Power Test

	Parameters	Estimate	t-values
Supply in Japan			
constant	a_0	1.9161	9.10
Ppw_J/C_J	a_1	.1382e-4	5.61
Ppr_J/C_J	a_2	-.1736e-4	-10.62
$S_{J(-1)}$	a_3	.8424	5.00
Demand in Japan			
constant	b_0	45.4240	7.52
Prw_J	b_1	-.1312e-2	-6.34
Y_J	b_2	.1240e-4	4.11
Prr_J	b_3	-.3300e-3	-6.81
Prw_J*Prr_J	b_4	.1067e-7	6.34
Supply at ROW			
constant	d_0	143.9900	3.69
Pw_{ROW}/C_{ROW}	d_1	.1483	.44
$S_{ROW(-1)}$	d_2	.7576	12.22
PC_{ROW}/C_{ROW}	d_3	-1.0305	-2.15
Demand at ROW			
constant	e_0	464.2500	13.71
Pw_{ROW}	e_1	-3.2068	-7.58
Y_{ROW}	e_2	.8325e-4	18.90
Pr_{ROW}	e_3	-30.4190	-7.13
$Pw_{ROW}*Pr_{ROW}$	e_4	.2494	8.08
Stock at ROW			
constant	f_0	44.9020	1.99
Pw_{ROW}	f_1	-.3463	-2.06
$ST_{ROW(-1)}$	f_2	.8829	5.51
Market Power	σ^D	.1569e-2	.37

APPENDIX C. Data

year	jpwpro	ppwheat	pprice	jppipf	CPI_J
1963	716	40600	85696	81.43	89.50
1964	1244	44200	95522	82.29	92.90
1965	1287	47200	107802	86.35	100.00
1966	1024	50400	117308	89.81	102.40
1967	997	52600	133068	93.95	104.30
1968	1012	55500	143618	96.80	114.70
1969	758	57300	148141	97.00	120.50
1970	474	60200	151502	100.00	130.30
1971	440	64600	156080	103.40	138.40
1972	284	67400	163992	108.10	142.20
1973	202	75200	188663	136.30	117.70
1974	232	98400	249359	171.30	146.40
1975	241	112000	285165	181.40	163.80
1976	222	121100	303516	104.00	179.00
1977	236	169833	315604	107.20	193.40
1978	367	174000	315953	103.50	199.80
1979	541	178333	316465	110.90	206.90
1980	583	178400	316465	123.22	223.40
1981	587	184167	295933	126.91	234.30
1982	742	184167	299183	126.91	240.90
1983	695	184867	304433	125.68	245.30
1984	741	184867	311133	126.91	250.90
1985	874	184867	311133	124.45	256.10

where:

jpwpro[1] = wheat production in Japan (1000 mt).
ppwheat[1&13] = government purchasing price for wheat (Yen per mt).
pprice[1&13] = government purchasing price for rice (Yen per mt).
jppipf[4] = price index paid by farmers for production requisites in Japan.
CPI_J[2&3] = consumer price index in Japan.

Variables used in the supply equation for Japan:

S_J = jpwpro/1000
Ppw_J = ppwheat/CPI_J
Ppr_J = pprice/CPI_J
C_J = jppipf/CPI_J

APPENDIX C. Data (continued)

year	jpst	yjp	resalew	ricesale	jptwhm	jpxrate
1963	235	20614	35200	88260	3898	362.00
1964	142	23375	35200	91484	3577	358.30
1965	100	26086	35200	104963	3591	360.90
1966	100	30443	34990	111850	4186	362.50
1967	42	36233	34710	119945	3938	361.90
1968	198	42870	34648	133168	4325	357.70
1969	31	52483	34508	137308	4472	357.80
1970	159	63443	34460	136300	4728	357.60
1971	95	68879	34513	135110	5049	314.80
1972	173	78928	33900	138864	5562	302.20
1973	35	97474	37707	142967	5266	280.00
1974	174	114656	45420	170933	5262	301.00
1975	334	127043	46533	203417	6011	305.20
1976	150	143232	58800	224183	5677	292.80
1977	133	158199	60600	246183	5690	240.00
1978	183	172859	60600	246183	5584	194.60
1979	61	188771	60600	256517	5804	239.70
1980	88	204574	69145	264850	5930	203.00
1981	46	216114	76097	273183	5637	219.90
1982	129	226246	81936	283883	5597	235.00
1983	180	234434	82335	283883	5901	232.20
1984	130	250024	82200	294550	5748	251.10
1985	33	265740	82551	305450	5565	238.50

where:

jpst[1] = stock of wheat in Japan (1000 mt).
yjp[8] = disposable income in Japan (1000 million Yen).
resalew[1&13] = government resale price of wheat (Yen per mt).
ricesale[1&13] = government resale price of rice (Yen per mt).
jptwhm[1] = total wheat import by Japan (1000 mt).
jpxrate[8&11] = Japan exchange rate (Yen/US$).

Variable used in the demand function:

D_J = $(jpwpro + jptwhm + jpst_{(-1)} - jpst)/1000$.
Prw_J = $resalew/CPI_J$.
Prr_J = $ricesale/CPI_J$.
Y_J = yjp/CPI_J.
M_J = $jptwhm/1000$.
β = $CPI_J/jpxrate/CPI_{US}$.

APPENDIX C. Data (continued)

year	worldprd	worldcon	worldst	yrwed	yrwing
1963	236.3	240.0	67.8	1202628	231235
1964	270.4	262.0	76.2	1239578	241035
1965	263.3	281.6	55.3	1300900	250015
1966	306.7	279.8	82.1	1489150	274815
1967	297.6	289.1	90.6	1683300	305700
1968	330.8	306.4	115.0	1832000	333800
1969	310.0	327.3	97.8	2016550	373350
1970	313.7	337.2	74.3	2226550	415700
1971	351.0	344.3	81.0	2508900	415700
1972	343.4	361.8	62.6	2968500	531900
1973	373.2	365.6	70.2	3427050	703650
1974	360.2	366.6	63.7	3855500	889500
1975	356.6	356.3	64.2	4253450	1003850
1976	421.4	385.9	99.8	4694350	1129350
1977	384.1	399.4	84.2	5493450	1311650
1978	446.8	430.2	100.9	6423350	1557400
1979	424.5	444.3	81.0	7255050	1956050
1980	440.0	445.8	78.2	7651200	2127950
1981	449.5	443.6	87.0	7649100	2136700
1982	477.5	462.2	102.3	7781400	2165700
1983	489.5	482.3	109.5	7910000	2111800
1984	511.5	494.9	126.1	8072450	2140500
1985	498.8	487.6	137.3	8234900	2169200

where:

worldprd[6] = world wheat production (million mt).
worldcon[6] = world wheat consumption (million mt).
worldst[6] = world wheat stock (million mt).
yrwed[12] = Gross Domestic Product in the developed countries (million US$).
yrwing[12] = Gross Domestic Product in the developing countries (million US$).

Variable used in the ROW function:

S_{ROW} = worldprd - Sj.
Y_{ROW} = (yrwed + yrwing)/CPI_{US}.
D_{ROW} = worldcon - Dj.
St_{ROW} = worldst - (jpst/1000).

APPENDIX C. Data (continued)

year	usxpw	caxpw	auxpw	cawx	uswx	auwx
1963	66.14	70.70	62.35	16182.6	23299	6896
1964	63.93	69.09	58.32	10876.3	19732	7268
1965	59.52	69.90	58.69	15920.1	23607	4755
1966	67.24	73.46	63.02	14025.8	20256	8527
1967	62.46	67.82	58.23	9145.6	20713	5658
1968	63.20	62.27	57.98	8324.4	14810	6694
1969	57.32	62.93	53.93	9431.3	16491	8190
1970	62.83	65.09	57.63	11846.9	20085	9049
1971	61.73	65.46	57.74	13711.6	17200	7760
1972	91.00	99.00	91.00	15693.9	32223	4137
1973	177.00	207.00	195.00	11415.0	31271	7418
1974	164.00	206.00	167.00	10740.2	28277	8550
1975	152.00	192.00	147.00	12285.8	31924	8233
1976	113.00	142.00	113.00	13447.2	25855	9763
1977	116.00	137.00	119.00	16040.5	30590	8098
1978	141.00	164.00	142.00	13084.9	32495	11693
1979	174.00	202.00	169.00	15888.4	37421	13197
1980	182.00	201.00	181.00	16262.2	41204	9614
1981	171.00	190.00	165.00	18446.8	48199	11014
1982	159.00	190.00	164.00	21367.6	41068	7280
1983	154.00	193.00	154.00	21764.8	38891	14159
1984	148.00	188.00	150.00	17543.4	38782	14675
1985	131.00	181.00	135.00	17683.4	24766	15000

where:

usxpw[5] = wheat export prices from the U.S (US$ per mt Hard Winter Ord., fob Gulf).
caxpw[5] = wheat export prices from Canada (US$ per mt Canada Western Red Spring, fob Pacific Port).
auxpw[5] = wheat export prices from Australia (US$ per mt Australian Standard Wheat, Australian Wheat Board selling price (fob)).
cawx[5] = total wheat export from Canada (thousand mt).
uswx[5] = total wheat export from the U.S (thousand mt).
auwx[5] = total wheat export from Australia (thousand mt).

Variable used in the ROW function:

Pw_{ROW} = z1*(usxpw/cpius) + z2*(auxpw/cpius) + z3*(caxpw/cpius).
z1 = uswprd/(uswpro+auwpro+cawpro).
z2 = auwpro/(uswpro+auwpro+cawpro).
z3 = cawpro/(uswpro+auwpro+cawpro).
uswprd = uswpro/36.74.

APPENDIX C. Data (continued)

year	uswpro	auwpro	cawpro	CPI_{US}
1963	1146821	11714	19134	91.70
1964	1283371	12980	15732	92.90
1965	1315603	9626	17202	94.50
1966	1304889	16779	22519	97.20
1967	1507598	9817	16139	100.00
1968	1556635	19037	17690	104.20
1969	1442679	14229	18269	109.80
1970	1351558	12907	9025	116.30
1971	1617789	14744	14413	121.30
1972	1544936	10585	14515	125.30
1973	1711400	12000	16163	133.10
1974	1781918	11357	13296	147.60
1975	2126927	11982	17078	161.20
1976	2148780	11713	23587	170.50
1977	2045527	9350	19862	181.50
1978	1775524	18086	21145	195.40
1979	2134060	15697	17185	217.40
1980	2380934	10800	19158	246.80
1981	2785357	16360	24519	272.40
1982	2764967	8879	26790	289.10
1983	2419824	21780	26914	298.10
1984	2594777	18666	21199	311.10
1985	2424765	16127	24252	322.20

where:

uswpro[9] = U.S total wheat production (thousand bus).
auwpro[4] = Australia total wheat production (thousand mt).
cawpro[10] = Canada total wheat production (thousand mt).
CPI_{US}[11] = Consumer Price Index in the U.S.

APPENDIX C. Data (continued)

year	uscrprd	aucrprd	cacrprd	usxpcr	auxpcr	caxpcr
1963	103900	921	145	54.80	64.50	177.80
1964	90327	1348	174	54.24	87.50	117.13
1965	109963	1514	125	55.64	100.00	129.63
1966	104448	1688	204	55.39	82.50	203.06
1967	120199	1886	316	51.76	69.42	399.26
1968	111357	2055	202	50.56	83.88	268.36
1969	116525	1869	188	54.62	88.76	250.20
1970	104611	2569	203	57.57	71.89	267.76
1971	141022	2952	213	56.69	64.94	133.12
1972	141053	2687	188	70.45	74.65	127.30
1973	143435	2803	139	105.88	102.76	291.45
1974	118144	2589	106	129.53	146.28	634.47
1975	148062	3645	133	125.34	141.75	496.15
1976	159173	3771	131	110.09	107.31	141.89
1977	163213	4196	144	104.01	130.11	127.68
1978	180008	3251	145	112.15	125.86	121.71
1979	201655	4983	169	127.13	107.55	139.95
1980	168787	5753	151	138.92	130.56	148.91
1981	208330	6673	173	129.17	141.35	139.18
1982	209180	6513	212	126.12	136.20	135.96
1983	106041	5933	139	140.11	128.29	144.98
1984	194475	7024	238	132.50	134.71	148.00
1985	225180	7393	311	110.55	125.81	142.46

where:

uscrprd[7] = total corn produced in the U.S. (1000 mt).
aucrprd[7] = total corn produced in Australia (1000 mt).
cacrprd[7] = total corn produced in Canada (1000 mt).
usxpcr[7] = export price of corn from the U.S. (US$ per mt).
auxpcr[7] = export price of corn from Australia (US$ per mt).
caxpcr[7] = export price of corn from Canada (US$ per mt).

Variable used in the ROW function:

Pc_{ROW} = u1*(usxpcr/cpius) + u2*(auxpcr/cpius) + u3*(caxpcr/cpius).
u1 = uscrprd/(uscrprd + aucrprd + cacrprd).
u2 = aucrprd/(uscrprd + aucrprd + cacrprd).
u3 = cacrprd/(uscrprd + aucrprd + cacrprd).

APPENDIX C. Data (continued)

year	uspipf	capipf	aupipf	usfr	cafr	aufr	ricep
1963	47.07	24.56	21.50	11.28	7.22	7.50	8.75
1964	46.55	25.39	22.35	11.64	7.67	7.92	8.30
1965	47.59	26.47	23.21	11.65	7.97	8.17	8.10
1966	49.14	28.23	24.27	10.83	7.55	6.52	8.15
1967	49.48	30.05	25.12	10.80	8.65	8.76	8.35
1968	50.34	31.86	25.55	9.60	7.84	7.51	8.45
1969	52.07	32.93	25.76	12.68	10.04	9.50	8.55
1970	53.97	33.44	26.83	10.04	10.64	10.67	8.70
1971	56.55	34.67	28.32	6.52	6.63	7.04	8.90
1972	60.52	36.30	30.45	13.90	11.90	11.71	12.70
1973	73.10	43.49	35.13	30.79	26.17	26.69	26.40
1974	83.10	49.66	45.77	24.50	21.87	22.58	20.05
1975	89.00	55.82	53.65	15.64	14.33	14.62	15.85
1976	95.00	59.25	59.00	15.34	14.90	14.90	13.30
1977	100.00	61.64	66.00	15.73	14.06	13.92	19.10
1978	108.00	68.84	73.00	23.00	17.79	18.05	15.40
1979	125.00	80.48	78.00	36.17	30.25	32.63	21.40
1980	138.00	88.36	87.00	38.42	30.68	31.46	25.95
1981	148.00	100.00	100.00	27.38	26.85	24.67	20.20
1982	153.00	103.00	111.00	23.41	17.69	16.98	18.00
1983	152.00	104.00	123.00	24.42	18.27	18.21	19.38
1984	155.00	107.00	133.00	26.08	19.41	19.14	17.98
1985	151.00	108.00	141.00	28.67	17.83	17.83	16.11

where:

uspipf[4] = price index paid by farmers for production requisites in the U.S.
capipf[4] = price index paid by farmers for production requisites in Canada.
aupipf[4] = price index paid by farmers for production requisites in Australia.
usfr[5] = freight rate from the U.S to Japan (US$ per mt).
aufr[5] = freight rate from Australia to Japan (US$ per mt).
cafr[5] = freight rate from Canada to Japan (US$ per mt).
ricep[6] = world price of rice (US$ per cwt).

Variable used in the ROW function:

C_{ROW} = z1*(uspipf/cpius) + z2*(aupipf/cpius) + z3*(capipf/cpius).
Pr_{ROW} = ricep/cpius
t = x1*(usfr/cpius) + x2*(aufr/cpius) + x3*(cafr/cpius).
x1 = usxw/(usxw+auxw+caxw).
x2 = auxw/(usxw+auxw+caxw).
x3 = caxw/(usxw+auxw+caxw).

APPENDIX D. Sources of Data

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