

How Competitive is the World Wheat Market?

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Abstract — Japan is one of the largest importers of wheat, with imports originating from three countries, Australia, Canada, and the United States. Australia, Canada and Japan all use a government single-desk agency to control wheat trade. Many previous studies on competition in the world grain trade have argued the market is imperfectly competitive, and they often point to the Japanese market. We study the Japanese wheat import market for this reason, but find no compelling evidence of imperfect competition on the exporters' side.

I. INTRODUCTION

The global grain trade has always been of interest to economists because grain represents the single most important component of world food consumption. It is one of the world's key staple products, with about 12 percent of production traded on world markets each year. The majority of previous studies on competition in the world grain trade have argued the market is imperfectly competitive. For some markets (wheat, rice) the exporters have been found to hold market power (Kolstad and Burris [1986], Karp and Perloff [1989]), while others suggest the importers have the power to influence price (Love and Murniningtyas [1992], Sampson and Snape [1980]). In some ways, these results are surprising. How is it that price can be set different from marginal cost for a commodity produced around the world with ease of entry unless there are increasing returns to scale?

This paper revisits the question of whether there is any evidence of imperfect competition in the grain trade, with a focus on wheat in Japan. We allow for various possible forms of imperfect competition. This question is currently important for at least two reasons. Firstly, the new trade theory suggests there are possible strategic reasons for government intervention in international markets based on imperfect competition (Corden [1991]). Secondly, the market impacts of state trading agencies in grains are a priority item in the next round of World Trade Organization (WTO) negotiations, and perhaps the biggest issue facing agricultural trade may be the

competitive impacts of state trading enterprises in grains such as the Australian Wheat Board (AWB), the Canadian Wheat Board (CWB), and the Japanese Food Agency (JFA) (Dixit and Josling [1997]). Australia, Canada and Japan all use a government single-desk agency to control wheat trade. Furthermore, Japan has consistently imported around 6.5 percent in value of the total wheat traded in international markets, procured totally by the United States, Canada, and Australia.

In most previous studies on the grain trade, the Cournot non-cooperative oligopoly model with homogeneous products has typically been employed. Presumably, the quantity-setting assumption is more convenient than the alternative of price setting because imperfect competition in prices implies differentiated products, if the Bertrand paradox is to be avoided. Assuming for the moment that there exist oligopolistic international markets for some commodities, it is difficult to know, a priori, whether these markets are characterized by firms adopting a price- or a quantity-setting strategy. Theoretically, there are reasons to expect either type of behavior, depending on market and cost conditions. For example, in some markets, such as the Japanese market, commodity imports may not necessarily be procured from the lowest cost supplier. Wolak and Kolstad [1991] examined Japanese imports of coal and argued that Japan imports from a variety of countries in order to diversify risk, and does not necessarily minimize the cost of imports. If the Japanese "manage" imports and pre-determine quantities to be imported from each source, then exporting firms would

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find it optimal to set prices rather than quantities (i.e., price is the strategic variable). Alternatively, the use of price rather than quantity as the strategic variable might be determined by the nature of the commodity in question rather than the destination market. *Ceteris paribus*, it might be expected that there would be price competition for commodities that can be stored at relatively low cost (e.g., rice, wheat and coal) because there is no reason that current production need be sold during the current period.

In this paper we begin with the view that the wheat market may or may not be competitive. If it is imperfectly competitive, we believe it may be characterized by either price or quantity competition. We present a set of alternative theoretical models of the Japanese market for wheat imports in which account is taken of various forms of strategic interaction among Australian, Canadian and United States exporters. We test for the type of strategic interaction that is most consistent with the data.

Our analysis is conducted in two steps. We first calculate the elasticity of the residual demand for Japanese wheat imports for each of three exporters, to determine whether there is any evidence of markup over marginal cost. This allows us to narrow down the number of possible models. Then, on the basis of a statistical test developed by Vuong [1989], we estimate which of the (remaining) competing models best fits the data.

II. ELASTICITY OF THE RESIDUAL DEMAND CURVE

The degree of competition in a market is often expressed as the relative mark-up of price (p) over marginal cost (MC), i.e., as the Lerner Index $(p - MC)/p$. In practice, it is usually nearly impossible to obtain data at the firm level on marginal costs or even prices in order to calculate the index. In the present context, we would need to obtain price and marginal cost data for the two state trading enterprises (the AWB and the CWB) and for US firms which export to Japan. Hence, the direct measurement of market power is not practicable.

Following Bresnahan [1989], and Goldberg and Knetter [1999], we make use of the relationship between the Lerner Index and the elasticity of the residual inverse demand function faced by each exporting country. At one extreme, this elasticity is zero when there is perfect competition and there is no mark-up over marginal cost; at the other, it coincides with the market demand elasticity of a monopolist and the mark-up is that of the monopolist. In between these extreme cases, the residual inverse demand elasticity reflects that of an oligopoly. In the latter case, the perceived residual inverse demand elasticity will depend upon the importing country's inverse demand elasticity and the strategic interaction

between exporting countries. Hence, the elasticity of the residual inverse demand function is a practical way of measuring a country's market power in a particular import market.

For example, if the exporting country has no market power, then changes in its level of exports will not alter its export price and its residual inverse demand function will be horizontal. Thus, if it is indicated by the data that this country's price is determined by shifts in its competitors' costs and not by its own quantity exported, then it has no market power. Alternatively, if there is a negative relationship between quantity exported and price received, then there is market power. However, the uniqueness of the relationship between the Lerner Index and the elasticity of the residual inverse demand function depends upon whether the actual and perceived functions coincide. Baker and Bresnahan [1988] show that there is coincidence for the Stackelberg and dominant firm models. In both models, the dominant firm takes account of the followers' supply and, therefore, correctly perceives its residual inverse demand function. Thus there is a direct relationship between the relative mark-up, the elasticity and market power. There is also a direct relationship when there is perfect competition and when there is substantial product differentiation (Goldberg and Knetter [1999, p. 39]). In other forms of market structure, there is not a specific relationship between the relative mark-up and the residual inverse demand elasticity.

Our approach to estimating the parameters of the residual demand function follows Goldberg and Knetter [1999]. Using this method, an inverse demand function for each exporting country is defined as a function of the total quantity of own exports, prices of each competing exporting country, as well as a vector of demand shifters in the destination market. Using its inverse demand function, each exporting country simultaneously solves its profit maximization problem to generate an expression for its price defined as a function of its own exports, a vector of cost shifters in each of the competing exporting countries, and a vector of demand shifters in the destination market. The simultaneous solution of the maximization problem enables the elimination of the prices of the competing products from each implicit price expression.¹

¹ This approach assumes that each country is a firm. For the United States, where there is more than one firm exporting to Japan, we interpret the parameters as share-weighted industry averages for all firms. This enables us to transform the first-order conditions so as to be estimated with market level data without using implausible aggregation assumptions.

Goldberg and Knetter are able to define a reduced form equation from which market power can be inferred without being able to identify separately the parameters of the inverse residual demand function and the first-order conditions. The form of the equation for the United States is as follows:

(1)

$$\ln p_t^u = \alpha + \eta^u \ln Q_t^u + \beta^c \ln W_t^c + \beta^a \ln W_t^a + \gamma \ln Z_t + \varepsilon_t$$

where p_t^u is the price (unit value) of US wheat exported to Japan in Yen, Q_t^u is the quantity of US wheat exported to Japan, W_t^i is the vector of cost shifting variables for export competitor i ($i = a, c$), Z_t is a vector of demand shift variables in Japan, η^u is the elasticity of the residual inverse demand function, β is the coefficient vector for the cost shift variables for the main competitors, Canada and Australia, and γ is the coefficient vector of demand shifters for the destination market, Japan. The equations for Canada and Australia are similar. The subscript t stands for time, and ε is the error term. The cost shifters include measures of input prices as well as exchange rates. The demand shifters consist of real income in the destination market. Given the double logarithmic functional form, it is possible to separate the shift variables into two components, namely, their values in domestic currency and the exchange rate between each country's currency and the Yen (see Goldberg and Knetter [1999, p. 41]). This procedure allows the exchange rates to act as cost shifters which display considerable variation over the sample period. The export volume of each exporting country to Japan is an endogenous variable. The instrument proposed by Goldberg and Knetter [1999, p. 41] is the exchange rate between the exporting country's currency and the importing country's currency.

The data used in this study cover 88 quarterly observations over the 1970-1991 time period. The US unit values and export quantities are based on the monthly *Department of Commerce, Bureau of the Census* data. Canadian data were obtained from *Statistics Canada, International Trade Division* and from the *Winnipeg Commodity Exchange*. The Australian data came from the *Australian Bureau of Statistics and Wool International*. Real GDP data were obtained from the *International Financial Statistics (IFS)* of the *International Monetary Fund*. The exchange rates were

obtained from the *USDA* data base to be found at http://usda.mannlib.cornell.edu/mor_start.html.²

The method of two-stage least squares was used to estimate equation (1). The residual inverse demand elasticity for the United States is reported as the coefficient of the right-hand side variable, *LOGUSQ* (Table 1). The absolute value of the coefficient, which is significantly different from zero and with the expected sign, approximates the mark-up over marginal cost. It implies a residual demand elasticity of 1.08 (= 1/0.93), in absolute value. Thus, the conjecture that the US has a horizontal residual inverse demand function is rejected and with it, the conjecture of competitive behavior by that exporting country.

The results for Canadian wheat exports to Japan are presented in Table 2. The dependent variable is the log-price of Canadian wheat to Japan (in Yen). The set of cost and demand shifters include the same variables as for the US equation but replacing the variables for the United States with those from Canada. The set of instruments was selected in a similar way. The results of this estimation imply that there is no significant mark-up over marginal cost for Canadian wheat, although the coefficient has the correct expected sign. All of the other right-hand side variables were statistically significant, except for the Australian exchange rate against the Japanese Yen. In other words, Japanese expenditure on wheat and the US exchange rate against Japanese Yen, as well as the production cost indices for the United States and Australia have explanatory power regarding the price of Canadian wheat exported to Japan. This result is consistent with Canada being a price taker because changes in the Canadian export price do not vary with export volume but with changes in the costs of competitors and shifts in Japanese import demand.

The results of the residual demand elasticity estimation for Australian wheat are presented in Table 3. The set of cost and demand shifters is formed as before and the set of instruments is also similar, except that the equation includes the first lags of the log-price and log-quantity of the Australian wheat exports to Japan because of serial correlation in the originally specified equation. The coefficient of primary interest, *LOGAQ*, has the correct sign but it is not significantly different from zero. This can be interpreted as no evidence of mark-up over marginal cost for Australian wheat exported to Japan.

² The model was also estimated using various other specifications that included labor cost indices, producer price indices and wholesale price indices, in addition to the above variables. The parameters for these variables were statistically insignificant, and they were dropped from the final specification.

Japanese expenditure on wheat has the expected sign and is significantly different from zero. The production cost index for the United States is the other significant explanatory variables. The US and Canadian exchange rates against the Japanese Yen do not have any explanatory power. Hence, there is weak evidence that Australia is a price taker in the Japanese market.

It was argued above that the residual demand elasticity can be viewed as a measure of the degree of competition and, under certain forms of imperfect competition, can be related directly to the Lerner Index. One of these forms is price leadership. Our results indicate that the United States is possibly a price leader in the Japanese market for imported wheat whereas Australia and Canada form a competitive fringe. This finding allows us to eliminate the alternatives of Cournot or Bertrand competition because there is only one country with any evidence of market power. But there is another possibility, namely, that there is monopsony power, where Japan exerts some market power in the international wheat markets (Love and Murniningtyas [1992]). Therefore, in the second stage of our analysis, we focus on three alternative market structures, namely, competitive pricing, monopsony, and US price leadership with a competitive fringe.

III. LIKELIHOOD RATIO TESTS FOR MODEL SELECTION

Now that the number of relevant models has been narrowed down, the approach taken in this section is to derive and estimate a structural econometric model associated with each of these three market structures for the six endogenous variables, which are quantities and prices for the three competing exporting countries. Each market structure investigated is nested in a general linear model through the use of cross-equation restrictions.³

III(i). *The Competitive Model*

Let the inverse demand function facing the i^{th} exporting country be

$$p_i = \gamma_{i0} - \delta_{ii}q_i + \sum_j \delta_{ij}p_j + \gamma_{i1}y, \quad i = u, c, a, \quad i \neq j \quad (2)$$

where p_i is the price of country i 's exports in the importing country's currency, q_i is the quantity exported by country i , y is the total expenditure on imported wheat by Japan. The supply functions are defined as

$$p_i = \theta_{i0} + \theta_{i1}q_i + \theta_{i2}PP_i \quad (3)$$

where PP_i is a proxy for input prices in Japanese Yen in exporting country i , measured in terms of the opportunity cost of growing alternative crops. This proxy is the price of corn in the US case, that of canola for Canada, and that of wool for Australia.

For each country, it is assumed that the exporting firm (wheat boards for the Canadian and Australian cases) maximizes profits from export sales only, i.e., the domestic market is ignored. Letting, $\Pi_i = TR_i - TC_i$, the associated first-order condition is

$$p_i = \theta_{i0} + (\delta_{ii} + \theta_{i1})q_i + \theta_{i2}PP_i \quad (4)$$

Equations (2) and (4) for each of the exporting countries forms a system of six simultaneous equations in six endogenous variables, namely, prices and quantities.

III(ii). *The Monopsony Model*

Assume now that the Japanese Food Agency acts as a monopsonist and that the exporting countries are price takers. Let the Food Agency's marginal revenue function for imports from exporting country i be

(5)

$$MR_i = \gamma_{i0} - 2\delta_{ii}q_i + \sum_j \delta_{ij}p_j + \gamma_{i1}y, \quad i = u, c, a, \quad i \neq j$$

where the notation is as before.

The average outlay function for wheat from each of the exporting countries is the same as in Equation (3). Defining the maximization problem as, $\max \Pi_i = TR_i - TO_i$, the associated first-order condition is

(6)

$$p_i = \gamma_{i0} - (2\delta_{ii} + \theta_{i1})q_i + \sum_j \delta_{ij}p_j + \gamma_{i1}y, \quad i = u, c, a,$$

The average outlay function (Equation (3)) and the first-order condition (Equation (6)) now define the model for estimation.

III(iii). *The US Price Leadership Model*

Let the inverse demand function facing the i^{th} exporter be the same as in Equation (2). With unit costs, $c_i = \theta_i PP_i$, firms maximize $\Pi_i = TR_i - TC_i$ under US price leadership, where $TC_i = \theta_i PP_i q_i$. The associated first-order condition for the United States will be

(7)

$$p_u = \delta_{uu}(1 + \delta_{uc}\delta_{cu} + \delta_{ua}\delta_{au})q_u - \theta_u PP_u$$

and that for Canada and for Australia will be

$$p_j = \theta_j PP_j, \quad j = c, a. \quad (8)$$

³ See Carter and MacLaren [1997] for more detail.

Equations (2), (7) and (8) form a system of six simultaneous equations in six endogenous variables, namely, prices and quantities.

III(iv). Methodology for Empirical Analysis

Since the models derived above are non-nested with respect to each other, the statistical testing of each type of market structure requires the use of a test for non-nested models. Such a test, to provide pair-wise comparisons among different non-nested alternatives, has been constructed by Vuong [1989]. It should be emphasized that the validity of the test is not dependent upon one of the models in the pair being the correct model. The procedure begins with the estimation of the demand equations (supply equations for the monopsony case) and the first-order conditions jointly by the full information maximum likelihood (FIML) method. The FIML parameter estimates are not presented here, since the magnitude and the signs of the parameters do not contribute to our analysis. Nevertheless, most of the parameters have the expected signs even without any sign restrictions on the models.

The second step in the procedure is to calculate the likelihood ratio, as $(L_f - L_g)$, for each of the three pairs of comparisons, (M_f, M_g) , and then to normalize this difference by

$$(9) \quad n^{\frac{1}{2}} \hat{w}_n = \frac{1}{2} \left[\sum_{t=1}^n \left(\hat{u}'_{ft} \hat{\Sigma}_f^{-1} \hat{u}_{ft} - \hat{u}'_{gt} \hat{\Sigma}_g^{-1} \hat{u}_{gt} \right)^2 \right]^{\frac{1}{2}}$$

where L_s is the log likelihood, and \hat{u}_s and $\hat{\Sigma}_s$ are the estimated residuals and covariance matrix for model M_s , $s = f, g$. Under the null hypothesis that each model fits the data equally well, the normalized LR is asymptotically distributed as a standard normal variable. The decision rules for the test are: first, if the absolute value of the normalized LR statistic is less than the appropriate critical standard normal value, at some level of significance, then it is not possible to discriminate between the two models; and second, if the test statistic is less (greater) than the appropriate negative (positive) critical value, then it is concluded that model M_g (M_f) is significantly better. The results of this approach are reported in Table 4. The LR statistic for the comparison between the competitive model and the US price leadership model is 37.55, which is significant at the 1 percent level. Since it is positive, it can be concluded that the competitive model is significantly better than the US price leadership model. The pair-wise comparison between the monopsony model and the US price leadership model provides a standardized LR statistic of 27.60, which is also significant at the 1 percent level. Hence, the monopsony model is closer to the true data

generating process than the US price leadership model. The LR statistic for the comparison between the competitive model and the monopsony model is 1.16. Since this value is not statistically significant, it means that we cannot discriminate between the competitive and monopsony models.

IV. CONCLUSION

The competitive structure of the international wheat market has been a much investigated issue. Yet despite the substantial amount of research, the definitive answer remains elusive. Some results have supported imperfect competition amongst the exporting countries with price-taking behavior amongst the importing countries; other results have supported monopsonistic behavior by individual importing countries and price-taking behavior amongst exporting countries. Clearly, both cannot be correct. The issue remains: given that there are exporting countries without capacity constraints on supply and relative freedom of entry to and exit from the market, then prices should be close to marginal cost in the absence of market power, i.e., there should be very little relative mark-up.

In this paper, we have employed two approaches. The first approach is based on estimating the residual inverse demand function facing each of the three exporting countries (Australia, Canada and the US) that ship wheat to Japan, which is treated as a segment of the international wheat market. This approach permits an estimate of the relative mark-up. The second approach is based on a series of non-nested tests derived from the estimation of a linear model within which each market structure is nested. The three alternative market structures investigated were competitive pricing, monopsony and price leadership by the US.

The results generated from the first approach support the proposition that the import market for wheat in Japan is imperfectly competitive on the export side. In particular, the results indicate that there is price leadership by the US and that Australia and Canada form a competitive, or price-taking, fringe. The results generated in the second approach suggest that price leadership by the US is inconsistent with the data when alternative market structures are evaluated. Overall, our findings suggest that we cannot rule out the competitive model.

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TABLE 1 — Residual Demand Elasticity Calculation for the US Wheat

Dependent Variable : *LOGUSPJ*
 Method : Two-Stage Least Squares
 Number of Observations : 86
 Instrument List : *LOGJEJ, LOGNXAJ, LOGNXCJ, LOGAPP, LOGCPP, LOGNXJ, LOGUSPP*

Variable	Coefficient	t-statistic
<i>C</i>	11.55	3.08
<i>LOGUSQ</i>	-0.93	-3.03
<i>LOGJEJ</i>	1.04	6.53
<i>LOGNXAJ</i>	-0.20	-1.34
<i>LOGNXCJ</i>	0.23	0.90
<i>LOGAPP</i>	-0.00	-0.02
<i>LOGCPP</i>	0.07	0.71

R-squared = 0.88
 Adjusted R-squared = 0.87
 F-statistic = 101.28
 Durbin-Watson statistic = 1.97

TABLE 2 — Residual Demand Elasticity Calculation for the Canadian Wheat

Dependent Variable : *LOGCPJ*
 Method : Two-Stage Least Squares
 Number of Observations : 88
 Instrument List : *LOGJEJ, LOGNXAJ, LOGNXJ, LOGAPP, LOGCPP, LOGNXCJ, LOGCPP*

Variable	Coefficient	t-statistic
<i>C</i>	5.87	1.28
<i>LOGCQ</i>	-0.49	-1.29
<i>LOGJEJ</i>	0.49	3.61
<i>LOGNXAJ</i>	-0.02	-0.21
<i>LOGNXJ</i>	0.47	2.10
<i>LOGAPP</i>	0.12	2.16
<i>LOGUSPP</i>	0.43	3.29

R-squared = 0.85
 Adjusted R-squared = 0.84
 F-statistic = 80.32
 Durbin-Watson statistic = 1.90

TABLE 3 — Residual Demand Elasticity Calculation for the Australian Wheat

Dependent Variable : *LOGAPJ*
 Method : Two-Stage Least Squares
 Number of Observations : 85 (after adjusting endpoints)
 Instrument List : *LOGJ EJ, LOGNXCJ, LOGNXJ, LOGCPP, LOGUSPP, LOGNXAJ, LOGAPP, LOGAPJ(-1), LOGAQ(-1)*

Variable	Coefficient	t-statistic
<i>C</i>	3.83	2.75
<i>LOGAQ</i>	-0.08	-0.87
<i>LOGJ EJ</i>	0.30	3.91
<i>LOGNXCJ</i>	-0.22	-0.62
<i>LOGNXJ</i>	0.12	0.30
<i>LOGCPP</i>	0.10	0.58
<i>LOGUSPP</i>	0.43	2.45
<i>AR(1)</i>	0.33	2.88

R-squared = 0.83

Adjusted R-squared = 0.82

F-statistic = 54.31

Durbin-Watson statistic = 2.16

TABLE 4 — Adjusted LR Statistics for Model Selection

	M_1	M_2	M_3
M_1		1.16	37.55 ⁺
M_2	-1.16		27.60 ⁺
M_3	-37.55 ⁺	-27.60 ⁺	

Notes: M_1 : Competitive model, M_2 : Monopsony model; M_3 : US price leadership model

⁺ Significant at the 1 percent level in both a one-sided and a two-sided test.