Market Power in the World Market for Soymeal Exports

Satish Y. Deodhar and Ian M. Sheldon

In this article, the degree of imperfect competition in the world market for soymeal exports is estimated using a structural econometric model. The procedure consists of estimating a demand function and the industry first-order profit-maximization condition, from which an estimate of the degree of market power can be retrieved. Using a nonlinear three-stage least squares procedure, the estimate of market power shows that the world market for soymeal exports is perfectly competitive. The empirical results also indicate that this market was competitive even prior to entry by Argentinean firms in the mid-1970s.

Key words: econometric estimation, imperfect competition, industrial organization, international trade, soymeal exports

Introduction

Over the past fifteen years, industrial economics has seen a renewed interest in empirical analysis, which is now commonly referred to as the "new empirical industrial organization" (NEIO). This new empirical research has developed largely due to dissatisfaction with the older structure-conduct-performance (SCP) methods that dominated empirical work in industrial organization during the 1960s and 1970s (Bresnahan and Schmalensee; Bresnahan 1989). Typically studies in the NEIO use time-series data from a single industry to estimate structural econometric models based on firm-level optimization. The approach evaluates the presence of market power in a specific industry based on demand and cost functions and hypotheses concerning the strategic interaction of firms: things which studies based on the SCP approach generally failed to specify.

Of the various applications of this new method to the food and agricultural sector, only a few relate to export markets. Some examples are Buschena and Perloff, coconut oil export market; Karp and Perloff (1989, 1993), rice and coffee export markets; Love and Murniningtyas, wheat export market; and Lopez and You, Haitian coffee exporting. Estimating the degree of imperfect competition in international markets is a logical extension of NEIO. Recent developments in international trade theory emphasize imperfect competition's effect on trade and trade policies (Helpman and Krugman 1985, 1989).

The objective of this article is to estimate the degree of imperfect competition in the world market for soymeal exports using a structural econometric model. The procedure adopted draws on a method of identifying market power that has been discussed in papers

by Bresnahan (1982, 1989) and Lau and applied to international agricultural markets by Buschena and Perloff and Love and Murniningtyas.

An earlier study by Yamazaki, Paarlberg, and Thursby did evaluate competition in the world soybean processing industry using a model that allowed retrieving a parameter measuring firm behavior for the industry, which suggested that the export market is perfectly competitive. Yamazaki, Paarlberg, and Thursby, however, used a simple, non-stochastic, partial equilibrium model which does not allow for calculating standard errors of the estimated degree of market power. In addition, the previous study did not separate the markets for processed soybean products, soymeal, and soyoil. Although these are obtained simultaneously in the processing operation, soymeal and soyoil are sold in virtually independent markets, with each having a single identifiable world market (Uri, Chomo, and Hoskin). Hence, the present study focuses on the degree of competition in the soymeal export market.[1]

The Structure of the World Market for Soymeal Exports

The world soymeal export market is a major agricultural export market. World demand for soymeal derives mostly from the demand to feed livestock and manufacture food products. The world market for soymeal exports has increased rapidly from less than three million tonnes in 1966 to approximately 29 million tonnes in 1994, an increase of more than 800% (American Soya Association). Eighty percent of the value of soybeans is derived from the soymeal market (Larson and Rask). In addition, soymeal dominates the protein meal market, accounting for more than 60% of the world market in 1994, there being no major competing substitutes (American Soya Association).

In terms of the geographic structure of soymeal exports, Larson and Rask report that more than 95% of world exports are accounted for by four countries/country blocs: Argentina (20%), the European Union (EU-12) (20%), the U.S. (20%), and Brazil (35%). Argentina is a relative newcomer, whose firms began exporting during the mid-1970s, growing from a 2 to a 20% share of the world market over 1980 to 1990, largely at the expense of the market shares of U.S. and Brazilian firms. Larson and Rask suggest that Argentinean and Brazilian firms have a relative competitive advantage partly due to lower soybean production costs but also due to the use of government policies designed to promote the export of processed soybeans.

On the face of it, the extent of country participation in the global trade of soymeal suggests that the world market for soymeal exports might be oligopolistic.[2] Closer analysis of the market structure of soybean processing, however, gives no clear empirical indication as to whether or not firms in this market behave competitively. In the case of the U.S., soybean processing is relatively concentrated. Marion and Kim report that between 1977 and 1988, the largest four firms' share of soybean crushing capacity rose from 46 to 76%, with the largest two firms, Archer Daniels Midland (ADM) and Cargill, taking just over 50%. Similarly in the EU, soybean crushing is highly concentrated.

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[1] An initial attempt was made to conduct a similar study on soyoil; it was dropped, however, due to insufficient variability in soyoil exports to allow estimation of a demand function and data on prices of rapeseed oil, a substitute for soyoil, were not available for the entire period used in the study.

[2] The agricultural trade literature has tended to focus on the competition between countries that dominate the export of certain agricultural commodities (e.g., McCalla; Alaouze, Watson, and Sturgess; Karp and McCalla; Kolstad and Burris).

Scoppola reports that, in 1988, the four-firm concentration ratio for the EU as a whole was 85%, all of which was accounted for by multinational corporations.[3] For example, Cargill, which accounts for approximately 20% of EU processing capacity, operates plants in France, the Netherlands, Spain, and the U.K.; while ADM has plants in the Netherlands and Germany (American Soya Association).

In contrast, while there is also multinational involvement in Brazil and Argentina, Cargill accounting for 6% of Brazilian and 17% of Argentinean capacity, their soybean processing industries are considerably less concentrated, with the largest four firms accounting for 27 and 39% of crushing capacity respectively in 1994 (American Soya Association). In addition, processing capacity has expanded in both countries since the 1970s (Larson).

Hence, while soybean processing is heavily concentrated by country, and there is evidence of multinational firm involvement, the structure of the industry worldwide cannot be unambiguously described as oligopolistic. In addition, while studies have shown the industry has scale economies due to large fixed costs in processing (U.S. International Trade Commission), there also seems to be chronic excess capacity in the industry which would tend to undermine firms' ability to extract monopoly rents. For example, a 1988 U.S. Department of Agriculture study shows that capacity use in Brazil during the mid-1980s was only 55% (USDA).

Methodology of Estimating Market Power

Suppose an industry consisting of a number of identical firms faces world market demand given by the following:

$$(1) \qquad\qquad Q_t = Q(P_t, Z_t),$$

where Q_t is the total quantity demanded, P_t is the world market price, Z_t is a vector of exogenous variables such as the prices of substitutes and income, and t is a time subscript. Since Q_t and P_t are determined simultaneously, the demand function can also be written in inverse form, $P_t = P(Q_t, Z_t)$. Suppose also that the aggregate marginal cost facing the industry is given by

$$(2) \qquad\qquad MC_t = MC(Q_t, W_t),$$

where W_t is a vector of exogenous variables such as input costs.

Assuming that the industry is perfectly competitive, equilibrium price and quantity will be determined by

$$(3) \qquad\qquad P_t = P(Q_t, Z_t) = MC_t = MC(Q_t, W_t).$$

More generally, if the industry is imperfectly competitive, equilibrium is where perceived industry marginal revenue equals industry marginal cost. If industry revenue is defined as $R_t = P_t Q_t = P(Q_t, Z_t)Q_t$, the equilibrium condition can be rewritten as:

$$(4) \qquad MR_t(\lambda) = \left[P(Q_t, Z_t) + \lambda \frac{dP}{dQ_t}(Q_t, Z_t)Q_t \right] = MC(Q_t, W_t).$$

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[3] Multinationals are commonly associated with markets exhibiting economies of scale and imperfect competition (Ethier; Markusen).

λ can be interpreted as an index of market power being exerted in an industry, that is, the wedge, in equilibrium, between industry price and industry marginal cost (Bresnahan 1982). The value of λ falls in the range $0 \leq \lambda \leq 1$; if the industry is perfectly competitive, the parameter $\lambda = 0$, and (4) becomes the usual condition that price equals marginal cost. If the industry is either a monopoly or firms demonstrate perfectly collusive behavior, $\lambda = 1$, and (4) becomes the normal expression for a monopoly markup. Intermediate values of λ reflect oligopolistic outcomes where the markup over marginal cost is less than the monopoly mark-up; for example, λ will take the value $1/n$ if the n firms in the market behave in Cournot-Nash fashion. The reason for the Cournot-Nash value of $\lambda = 1/n$ becomes apparent once a connection is made between the market power parameter λ and the concept of conjectural variations.

This connection is illustrated briefly here using a simple duopoly model. Let firm 1 expect firm 2 to produce q_2^e units of output. If firm 1 produces q_1 units of output, the total output it expects to be sold in the market is $Q = q_1 + q_2^e$. The profit maximizing problem for firm 1 is then:

$$(5) \qquad \qquad \max\ q_1\{P(Q)q_1 - c_1(q_1)\},$$

where $P(Q)$ is the inverse demand function, and $c_1(q_1)$ is firm 1's total cost function. Differentiating (5) with respect to q_1 and after some manipulation, the first-order condition is

$$(6) \qquad \qquad P(Q) + \frac{dP}{dQ}\left[1 + \frac{dq_2}{dq_1}\right]q_1 + MC_1(q_1),$$

where $MC_1(\cdot)$ is firm 1's marginal cost, q_2 is the equilibrium value of q_2^e, and dq_2/dq_1 is the conjectural variations term. It summarizes how firm 1 conjectures firm 2 will vary its output when firm 1 makes a small change in output. Denote this term as v. If the firms are symmetric, that is, they have identical costs and, therefore, produce the same level of output, then equation (6) can be generalized to n firms as:[4]

$$(7) \qquad \qquad P(Q) + \frac{dP}{dQ}\left[\frac{1 + (n - 1)v}{n}\right]Q = MC.$$

Recall equation (4) and compare with (7). These two are identical equations, where the index of market power is defined as $\lambda = [1 + (n - 1)v] / n$. It is obvious that if firms behave in Cournot-Nash fashion, that is, $v = 0$, then the corresponding value of λ is $1/n$. Hence, λ is interpreted as an index of the degree of market power, in which is nested a conjectural variations parameter.

In order to identify λ in an econometric model, the method outlined in Bresnahan (1982) is followed. The world export demand function in (1) is specified in the following form:

$$(8) \qquad Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Z_{1t} + \alpha_3 Z_{2t} + \alpha_4 Z_{3t} + \alpha_5 P_t Z_{3t} + \epsilon_t,$$

where Q_t is the quantity of soymeal sold in the export market, P_t is the real soymeal price, Z_{nt} ($n = 1, \ldots, 3$) are exogenous variables (defined explicitly in the next section),

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[4] This is clearly a restrictive assumption, but one that is invariably made in the literature. The usual justification being that an uneven distribution of firm sizes can be translated into a distribution of symmetric-sized firms through using the numbers equivalent of the Herfindahl index.

and ϵ_t is the error term. This form of demand function, used in earlier studies by Buschena and Perloff and Love and Murniningtyas, is linear in coefficients but contains the interactive term $P_t Z_{3t}$.

Following Bresnahan (1989) and Buschena and Perloff, suppose that the aggregate marginal cost of production takes the following functional form:

$$(9) \qquad\qquad MC_t = \gamma_1 Q_t + \gamma_2 W_{1t} + \gamma_3 W_{2t}.$$

Marginal cost is assumed to vary with respect to output Q_t, and W_{nt} ($n=1, \ldots, 2$) are proxies for the real input costs of producing soymeal.

Equation (9) can now be substituted into the profit-maximizing condition (4). Rearranging terms, the following equation is derived:

$$(10) \qquad\qquad P_t = \gamma_1 Q_t + \gamma_2 W_{1t} + \gamma_3 W_{2t} + \delta \left[\frac{Q_t}{\alpha_1 + \alpha_5 Z_{3t}} \right] + \epsilon_t,$$

where the variables are defined as above, and ϵ_t is the error term. The market power parameter in this equation is the coefficient δ with a negative sign, that is, $\lambda = -\delta$.

As shown by Bresnahan (1982) and Lau, the interactive term adds some nonlinearity to the demand function so that λ can be identified.[5] If Z_3 changes, the demand curve will rotate around the equilibrium point and trace out the supply relation, which allows calculating the degree of market power. If no cross-product variable is included in the demand function, the coefficient of Q_t in equation (10) reduces to $(\gamma_1 + \delta/\alpha_1)$, and hence, an identification problem occurs for δ as γ_1 and δ cannot be estimated separately.

Data and Regression Analysis

In order to evaluate the degree of market power, equations (8) and (10) are estimated. In its complete form, (8) is specified as:

$$(11) \quad Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Z_{1t} + \alpha_3 Z_{2t} + \alpha_4 Z_{3t} + \alpha_5 P_t Z_{3t} + \alpha_6 D_{1t} + \alpha_7 T_t + \epsilon_t,$$

where Q_t and P_t are as already defined; Z_{1t} is the real price of a key substitute product, fishmeal. Fishmeal was chosen over other protein meal substitutes due to fishmeal having been the second-largest traded protein meal in the world, and data were available for the time-period of this study. Z_{2t} is the rest of the world (ROW) population that excludes the population of Argentina, Brazil, and the U.S. Although firms in the EU are major exporters of soymeal, its population is included because there is some intra-EU trade in soymeal (Crowder and Davison). Similarly, Z_{3t} is an index of the gross domestic product of the ROW. T_t represents a trend variable and D_{1t} is a dummy variable that takes into account the exogenous price increases that occurred in 1973 due to the oil shock. It takes a value of one for 1973 and zero otherwise.

Similarly, equation (10) in its complete form is specified as follows:

$$(12) \qquad P_t = \gamma_1 Q_t + \gamma_2 W_{1t} + \gamma_3 W_{2t} + \delta \left[\frac{Q_t}{\alpha_1 + \alpha_5 Z_{3t}} \right] + \gamma_4 D_{1t} + \gamma_5 T_t + \epsilon_t.$$

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[5] It should be noted that Bresnahan (1982) outlined the basic principle of identifying λ; while Lau provided proof of the conditions under which identification will occur.

Table 1. Description of Variables

Variable	Description
P_t	Real price of soymeal at the port of Rotterdam: $/tonne cif
Q_t	Total world soymeal exports: thousand tonnes/annum
Z_{1t}	Real price of fishmeal at the port of Hamburg: $/tonne fob
Z_{2t}	World population except that of Argentina, Brazil, and U.S.
Z_{3t}	Index of world gross domestic product except Argentina, Brazil, and U.S.
W_{1t}	Real price of soybeans at the port of Rotterdam: $/tonne cif
W_{2t}	Real ocean freight rate, average of Argentina-Rotterdam and U.S.–Rotterdam rates: $/tonne
D_{1t}	Oil shock dummy: 1 for 1973, 0 otherwise
D_{2t}	Dummy for Argentina's entry: 0 until 1974, 1 since 1975
T_t	Time trend
t	1966–93

Note: All variables except dummies are expressed in logarithmic form.

The additional variables W_{1t} and W_{2t} are the real soybean price, and the real average ocean freight rate respectively. Until 1974, the world export market for soymeal was dominated by firms from Brazil, the EU-12, and the U.S. Since 1975 firms from Argentina have increased their market share which, by 1990, had reached more than 20%. In order to see if there is any structural change in the degree of market power after Argentinean firms entered the world export market, the coefficient δ is expressed as a linear function of a structural dummy $\delta = \delta_0 + \delta_1 D_{2t}$. D_{2t} is the structural dummy which takes a value of zero prior to 1975 and one since 1975, indicating Argentinean firms' entry to the export market. This implies that prior to such entry, $\delta = \delta_0$; therefore, the market power parameter $\lambda = -\delta_0$. After the entry of Argentinean firms, $\delta = \delta_0 + \delta_1$; therefore, $\lambda = -(\delta_0 + \delta_1)$.

The variables used in the estimation procedure are summarized and described in table 1. Annual data on aggregate quantities of world soymeal exports (Q_t) were collected for the period 1966 to 1993 from a U.S. Department of Agriculture staff report (Crowder and Davison). Prices of soymeal (P_t), fishmeal (Z_{1t}) and soybeans (W_{1t}) were collected for the same period from various issues of the U.S. Department of Agriculture publications: *Oilseeds and Products, World Oilseed Situation and Outlook,* and *Oilseeds: World Markets & Trade*; and from various issues of the Food and Agriculture Organization publication: *Production Yearbook.* Data on ocean freight rates (W_{2t}) were collected from various issues of the Food and Agriculture Organization publication: *Trade Yearbook.* Population figures (Z_{2t}) were constructed from a U.S. Department of Agriculture staff report (Urban and Nightingale). Similarly, indices for gross domestic product were constructed from the United Nations publication: *Trends in International Distribution of Gross World Product.* The U.S. consumer price index was used to deflate the nominal

Table 2. N3SLS Estimation of the World Soymeal Export Model, 1966–93

	Coefficient	t-Ratio
Soymeal export demand:		
Intercept	84.41*	2.36
Real soymeal price: P_t	−10.13*	−2.29
Real fishmeal price: Z_{1t}	0.59*	2.27
ROW population: Z_{2t}	−4.63	−1.27
ROW income: Z_{3t}	−8.38‡	−1.57
Price times income: $P_t Z_{3t}$	2.17*	2.29
Oil shock dummy: D_{1t}	0.33‡	1.60
Trend: T_t	0.26‡	1.52
R-square between observed and predicted	0.98	
Durbin-Watson statistic	2.09	
First-order condition:		
Soymeal exports: Q_t	−0.22	−1.20
Real soybean price: W_{1t}	1.20*	6.37
Real ocean freight: W_{2t}	−0.06	−0.45
δ_0	−0.04‡	−1.42
δ_1	0.04‡	1.40
Oil shock dummy: D_{1t}	−0.30†	−1.29
Trend: T_t	0.32*	1.46
R-square between observed and predicted	0.76	
Durbin-Watson statistic	2.15	

Note: * Indicates significance at the 0.05 level using a two-tail test. †
Indicates significance at the 0.05 level using a one-tail test. ‡ Indi-
cates significance at the 0.10 level using a one-tail test.

variables and was collected from the International Monetary Fund publication: *International Financial Statistics* (1992, 1994).

Since equations (11) and (12) represent a nonlinear simultaneous equations system, they were estimated using nonlinear three-stage least squares (N3SLS). All the exogenous variables in the system were used as instruments. The results of estimating these equations are shown in table 2. In the demand regression, soymeal and fishmeal prices have their expected signs and are statistically significant at the 5% level. While the positive coefficient of the variable $P_t Z_{3t}$ dampens the strong negative magnitude of the soymeal price coefficient, it also offsets the negative coefficient of the income variable. Further, the population variable has a statistically insignificant impact on demand. In the first-order condition regression, soymeal exports have a negative coefficient implying that marginal cost is decreasing in output; however, the coefficient on this variable is statistically insignificant. The positive and significant coefficient of soybean price is consistent with its expected effect on marginal cost; while ocean freight rates has a nonsignificant negative coefficient. The relevant coefficients for calculating market power are $\delta_0 = -0.04$ and $\delta_1 = 0.04$. Both the coefficients are statistically different from zero at the 10% level using a one-tail test. They are so close to zero, however, that testing this at any stricter significance level is inconsequential. The results show that, even before the entry

of Argentinean firms, the world export market was extremely competitive; the index of market power being $\lambda=0.04$. The effect of entry by firms from Argentina does result in λ falling to zero. Although the change in λ is very small, it certainly reinforces that soymeal exporting is perfectly competitive.

Summary

The aim of this article has been to determine the magnitude of market imperfection in the world market for soymeal exports, an industry where firms based in developed countries are competing with those from developing countries. An earlier study by Yamazaki, Paarlberg, and Thursby found the soybean processing industry to be perfectly competitive; however, their study used a calibration method to measure the degree of competitiveness such that no statistical confidence can be attached to their results. In contrast, the present study has used a structural econometric model to estimate the degree of market power in the soymeal export market. The results presented in this article show that the world market for soymeal exports is perfectly competitive, which does confirm the earlier result of Yamazaki, Paarlberg, and Thursby.

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