Journal of Agribusiness 20,1 (Spring 2002):67–83

Meat Trade Liberalization and Soybean-Rapeseed Competition in the Japanese Market

Suresh Chand Persaud and Wen S. Chern

This study identifies variables which increase Japan's imports of canola (soybeans) at the expense of soybeans (canola), and quantifies their impacts by estimating an import demand model. A key finding is that lower Japanese meat production tends to increase rapeseed imports while lowering soybean imports. Thus, Canada benefited from U.S. and Australian efforts to open Japan's market for imported beef, since the vast majority of Japan's canola imports are from Canada.

Key Words: canola, meat trade liberalization, rapeseed, soybeans

Japan is the single largest importer of soybeans and rapeseed, accounting for approximately 19% of world soybean imports between 1972 and 1994 (78% of which was supplied by the United States) and 40% of world rapeseed imports (almost all of which was supplied by Canada). Soybeans and rapeseed dominate oilseed crush in Japan, accounting for just over 90% of all oilseed imports from 1979 onward. However, the improved rapeseed varieties (known as canola) have emerged as a strong competitor against soybeans, as Japan's soybean imports have stagnated in recent years while rapeseed imports have continued to grow (figure 1) [Japan Oil and Fat Importers and Exporters Association (JOFIEA), 1964–1996].

The objective of this study is to identify variables that increase Japan's imports of rapeseed (soybeans) at the expense of soybeans (rapeseed), and to quantify their impacts by estimating an import demand model. In the import demand equations for rapeseed and soybeans, an explanatory variable which is positively associated with rapeseed imports while at the same time negatively related to soybean imports may induce oilseed processors to displace soybean imports with rapeseed. A key finding of this analysis is that Japan's liberalization of its meat imports, and the consequent reduction in domestic meat production, favors rapeseed imports over soybeans.

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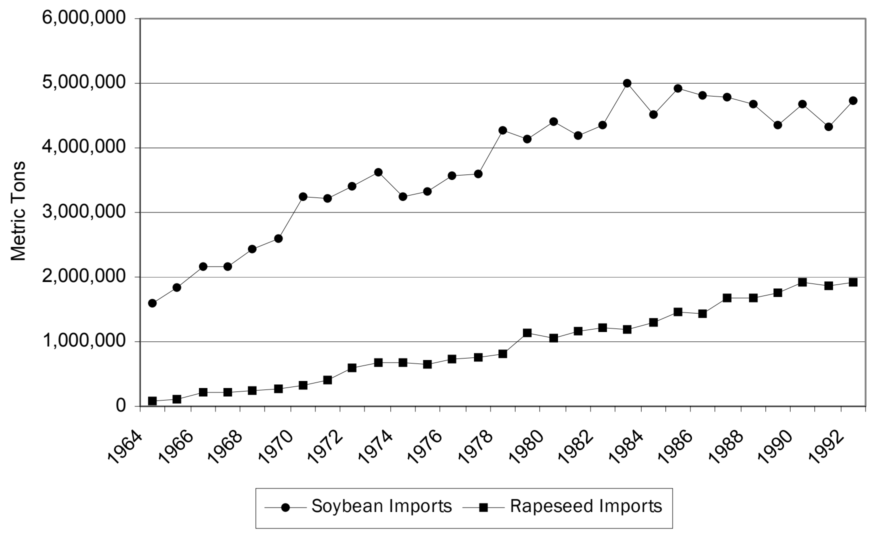

Source: Statistics of Oilseeds, Oils, and Oilcakes, various annual issues (JOFIEA).

Figure 1. Japan's imports of soybeans and rapeseed (metric tons), 1964–1992

The role of meat trade liberalization is explained by treating these two oilseeds as inputs in the production of meal and oil, and by taking into account the intrinsic attributes of these two inputs, as discussed in the following two sections. The econometric model and the implications of the study are presented in the remaining sections.

Theoretical Framework

The theoretical framework for this study treats the import demands for rapeseed and soybeans as derived demands for factors of production by Japanese oilseed processors. A constrained optimization problem is developed for an oilseed processor who crushes both imported rapeseed and imported soybeans to produce soybean meal, soybean oil, rapeseed meal, and rapeseed oil, under the assumptions that imports of the final products are negligible and that domestic production of the oilseeds is zero. In addition, it is assumed an individual oilseed processor operates in a perfectly competitive environment for each of these four products, and that Japan is a small country whose rapeseed and soybean imports do not affect world prices.

The small-country assumption is made for simplicity. The extent of its accuracy is an empirical issue we address later by estimating the econometric model with and without simultaneous equation techniques. The final results are given by the latter, because we find no evidence to suggest changes in Japan's rapeseed demand impact the import prices paid.

Although the assumption of perfect competition simplifies the model, it could be argued it is not realistic—in Japan, the five largest rapeseed/soybean crushing firms controlled about 75% of the market in the late 1980s (Carter and Mooney, 1987). However, the Japanese oilseed complex is integrated with world markets. The credible threat of a sharp increase in oil and meal imports can discipline crushers toward conduct which is closer to marginal cost pricing. Indeed, Japan does in fact import rapeseed oil, rapeseed meal, soybean oil, and soybean meal. Thus far, however, domestic oilseed crush supplies the vast majority of Japan's consumption of oil and meal.

Soybeans are imported in response to demand factors in three markets: oil, food, and meal. The first two are for human consumption, and the latter is for livestock production. Japan's production of rapeseed is negligible, and its soybean production is for food purposes. Imported soybeans are mostly crushed to obtain oil and meal. On average, from 1960 to 1982, 81% of Japan's imported soybeans were crushed (Salunkhe and Chavan, 1992). At the time Salunkhe and Chavan published their book on world oilseeds, the use of rapeseed meal for human consumption was still at the experimental stage. Thus, Japan's domestic demands for oil and meal are the primary factors driving its import demand for soybeans and rapeseed, and this will be the focus of the theoretical framework.

The demand equations for soybeans and rapeseed are developed by extending Beattie and Taylor's (1985) treatment of two joint products with one allocable input and one nonallocable input. The oilseed crusher's manufacturing process is described by four hypothetical production functions:

(1) $$Q_{so} = SO(Q_{sb}, K),$$

(2) $$Q_{sm} = SM(Q_{sb}, K),$$

(3) $$Q_{ro} = RO(Q_{rs}, K),$$

and

(4) $$Q_{rm} = RM(Q_{rs}, K),$$

where

Q_{so} = quantity of soybean oil produced,
Q_{sm} = quantity of soybean meal produced,
Q_{ro} = quantity of rapeseed oil produced,
Q_{rm} = quantity of rapeseed meal produced,
Q_{sb} = quantity of soybeans imported and crushed,
Q_{rs} = quantity of rapeseed imported and crushed, and
K = units of oilseed crushing machinery.

For simplicity, these production functions do not include other factors of production such as labor, energy, etc. However, the production functions do reflect the joint product relationship between soybean oil and meal, since the functions contain nonallocable inputs—specifically, Q_{sb} and K. Since the firm uses nonallocable inputs, it is not possible to treat the profits associated with soybean meal production separately from profits obtained from soybean oil production. This is also true for rapeseed oil and rapeseed meal. Soybean meal and oil are joint products in a strict sense, because they are produced in fixed proportions, apart from any exogenous changes in extraction rates. The same is true for rapeseed meal/oil (Gardner, 1987).

Note that all four production functions contain the common input, K. Japan's soybean processors are capable of switching between rapeseed and soybean crush, implying the crushing machinery, K, can be used for both oilseeds (Carter and Mooney, 1987).

Total costs (TC), total revenues (TR), and profits (PR) in yen are specified, respectively, as:

$$TC = P_{sb}*Q_{sb} + P_{rs}*Q_{rs} + C*K, \tag{5}$$

$$TR = P_{so}*Q_{so} + P_{sm}*Q_{sm} + P_{ro}*Q_{ro} + P_{rm}*Q_{rm}, \tag{6}$$

and

$$PR = P_{so}*Q_{so} + P_{sm}*Q_{sm} + P_{ro}*Q_{ro} + P_{rm}*Q_{rm} - P_{sb}*Q_{sb} - P_{rs}*Q_{rs} - C*K, \tag{7}$$

where

C = unit price of oilseed crushing machinery in yen,
P_{sb} = import price of soybeans in yen per metric ton (MT),
P_{rs} = import price of rapeseed in yen per MT,
P_{sm} = domestic price of soybean meal in yen per MT,
P_{so} = domestic price of soybean oil in yen per MT,
P_{ro} = domestic price of rapeseed oil in yen per MT, and
P_{rm} = domestic price of rapeseed meal in yen per MT.

The production functions are substituted into the equation for profits to obtain an unconstrained profit-maximization problem:

$$PR = P_{so}*SO(Q_{sb}, K) + P_{sm}*SM(Q_{sb}, K) + P_{rm}*RM(Q_{rs}, K) + P_{ro}*RO(Q_{rs}, K) - P_{sb}*Q_{sb} - P_{rs}*Q_{rs} - C*K. \tag{8}$$

The import prices of rapeseed and soybeans are taken as given due to the small country assumption. First-order conditions (FOCs) for maximizing profits are obtained by differentiating equation (8) with respect to the inputs, as written below:

$$\partial PR/\partial Q_{rs} = P_{ro}*(\partial RO/\partial Q_{rs}) + P_{rm}*(\partial RM/\partial Q_{rs}) - P_{rs} = 0, \tag{9}$$

$$\partial PR/\partial Q_{sb} = P_{so}*(\partial SO/\partial Q_{sb}) + P_{sm}*(\partial SM/\partial Q_{sb}) - P_{sb} = 0, \tag{10}$$

and

$$\partial PR/\partial K = P_{ro} * (\partial RO/\partial K) + P_{rm} * (\partial RM/\partial K) + P_{so} * (\partial SO/\partial K) + P_{sm} * (\partial SM/\partial K) - C = 0. \tag{11}$$

Second-order conditions are given by the bordered Hessian determinant.

Simultaneous solutions of the FOCs provide the demand equations for the factors of production:

$$^{D}Q_{rs} = {}^{D}Q_{rs}(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C), \tag{12}$$

$$^{D}Q_{sb} = {}^{D}Q_{sb}(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C), \tag{13}$$

and

$$^{D}K = {}^{D}K(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C). \tag{14}$$

Equations (12) and (13) are the general forms of a single firm's demand for rapeseed and soybeans, respectively, and under the given assumptions they represent the firm's import demand. The demand for oilseed crushing machinery shown in (14) is not investigated in this study. If Japan's soybean and rapeseed processing industry is comprised of N identical firms, then the summation of equation (12) over N, and equation (13) over N, would represent Japan's import demand for rapeseed and soybeans, respectively, when there are no direct imports of the oilseed derivatives and no domestic production of the oilseeds.

Note that the import demands for soybeans and rapeseed are functions of all the factor prices. This is a consequence of jointness of production between soybean meal and oil, jointness of production between rapeseed meal and oil, and capacity constraints in the oilseed processing sector. Although Carter and Mooney (1987) maintain there is excess capacity of 20–25% in Japan's oilseed processing sector, capacity constraints may be more of a factor than this figure implies. Based on a personal communication with Kent Nelson of the American Soybean Association in Japan, operating an oilseed processing plant above 80% capacity utilization is not recommended. This is likely because maintenance costs and risks become prohibitively high. [By way of comparison, capacity utilization for the United States and Canada are both 75%, and for Germany 81% (World Bank, 1997).] In practical terms, capacity constraints may be binding in the Japanese case, implying the import demands for soybeans and rapeseed are not separable.

Therefore, variables that shift the import demand for one oilseed, such as meat production and meat imports, may also have impacts on the imports of the other oilseed, although previous studies did not capture these effects. For example, Anderson and Garcia (1989) used quarterly data from 1974–1985 to examine the impact of exchange rate variability on imports of American soybeans by Japan, Spain, and France. Their findings revealed Japan's soybean imports were least sensitive to exchange rate variability relative to Spain and France. The authors also found the coefficient for the price of rapeseed meal was statistically significant ($\alpha = 0.05$) and positive, suggesting rapeseed meal is a substitute for raw soybean imports.

Japan's demand for rapeseed meal, however, is met mostly through imports and crush of rapeseed, implying the import price of rapeseed may be the more important price to include, rather than the import price of rapeseed meal. Japan's meat production was also omitted by Anderson and Garcia, despite the importance of this variable in accounting for the demand for livestock meal, and hence the import demand for soybeans.

Thraen, Hwang, and Larson (1992) examined the impact of U.S. monetary policy on the U.S. market share of aggregate soybean exports to the Japan/EC-12 countries, through its impact on exchange rates. Their study found that a weak dollar increased imports of U.S. soybeans and soybean meal significantly, although expansionary monetary policy did not significantly raise U.S. market share. In the import demand equation for soybeans by the Japan/EC-12 countries, the price of rapeseed had a positive coefficient, as hypothesized. Thus, Thraen, Hwang, and Larson's model did, in fact, account for the substitution relationship between soybean imports and rapeseed. However, their soybean equation omitted domestic meat production in the Japan/EC-12 countries, most likely leading to biased parameter estimates.

Many earlier studies were reviewed prior to undertaking the current research. We found that even when the import price of rapeseed was included in the soybean import demand models, the models excluded Japanese livestock production. An important hypothesis we test here is the dual impact of lower meat production—which is to lower (raise) soybean (rapeseed) imports—as suggested by statements of experts within the Japanese Soybean Supply Stabilization Association (SSSA).[1] This hypothesis is tested by including meat production in the import demand equations for both oilseeds.

The key to explaining the increased competitiveness of rapeseed against soybeans as a result of Japan's liberalization of its meat imports involves an understanding of the intrinsic attributes of these two oilseeds. Toward this end, the next two sections provide a discussion of oilseed characteristics and an overview of the impacts of meat trade liberalization.

Oilseed Characteristics

In addition to economic factors such as movements in relative prices and exchange rates, the increased competitiveness of rapeseed is also due to quality improvements. Before 1970, rapeseed oil contained high levels of erucic acid and glucosinolates, and more than twice as much fiber as soybean meal (13% compared to 6%). The effects of the erucic acid found in rapeseed oil include slower animal growth and lesions of the heart muscle (Rocquelin and Sergiel, 1971). Although the impacts of erucic acid on humans were not well defined prior to 1970 (Salunkhe and Chavan, 1992), problems in the production of margarine and shortening required improvements in the quality of rapeseed (Craig, 1971). Glucosinolates are known to cause

[1] This information was obtained during a personal conversation with Mr. Yasuhira Suzuki and Mr. Yoshikazu Kasai, both members of the Soybean Supply Stabilization Association, during a visit by the senior author to Japan in 1996.

liver necrosis and thyroid enlargement in livestock (Salunkhe and Chavan, 1992). Further, livestock, particularly pigs and chickens, cannot tolerate high levels of fiber (Bickerton and Glauber, 1990), also prompting the need for improved rapeseed varieties.

In 1974, rapeseed varieties such as *Tower B. napus* and *Altex*, which are low in both erucic acid and glucosinolates, were developed and introduced. The oil from *Tower B. napus* contains less than 0.3% erucic acid and is essentially equal in nutritional quality to soybean and peanut oils. By 1976, this double-low or double-zero variety accounted for one-fourth of the area sown to rapeseed, and by 1981, Canada's production of high-glucosinolate rapeseed was virtually zero[2] (Shahidi, 1990). Consequently, the period after 1981 represents an important structural break, and the rapeseed model given by equation (12) is modified to include a dummy variable for Canada (*DUMCAN*), defined accordingly:

$$(15) \qquad {}^{D}Q_{rs} = {}^{D}Q_{rs}(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C, DUMCAN).$$

There are major differences between soybeans and canola and their derivatives. Soybeans have a much higher meal/oil ratio than canola. The average meal content for soybeans and canola is 79% and 57%, respectively, and the corresponding oil content is in the range of 18% and 38%. Canola meal has a lower protein content, lower levels of metabolizable energy, and more than twice as much crude fiber as soybean meal (13% fiber for canola meal versus 6% for soybean meal).

In summary, canola tends to compete more in the market for vegetable oil than livestock meal (quality improvements notwithstanding) because it contains twice as much oil as soybeans. Livestock production and the demand for livestock meal tend to drive Japan's import demand for soybeans, because soybeans contain more meal per unit than rapeseed. Thus, changes in Japan's market conditions caused by the liberalization of its meat imports favor rapeseed over soybeans, as discussed in the following section.

Impacts of Meat Trade Liberalization

When Japanese oilseed processors decide the relative quantities of rapeseed and soybeans to import, their decision is based on the domestic demand for meal relative to the demand for oil. In June of 1988, Japan signed the Beef Market Access Agreement (BMAA). Under this agreement, quotas were raised by 60,000 MT each year from April 1988 to April 1991, when an import tariff replaced the quota restriction (Mori and Lin, 1994). Consequently, Japan's meat production began first to stagnate

[2] In 1979, Canada adopted the name "canola" for all of its double-low rapeseed varieties. Canola is defined as rapeseed varieties containing less than 2% erucic acid in the oil and less than 30 umol/g of one or any combination of the four known glucosinolates in the meal. In 1985, the U.S. Food and Drug Administration granted canola "generally recognized as safe" (GRAS) status (Shahidi, 1990). With the 1991 harvest, the European Economic Community (EEC) would only pay support prices for seed that was of canola quality (Downey and Bell, 1990).

and then actually to fall, while meat imports rapidly increased. The result was declining demand for livestock meal combined with continuing growth in demand for vegetable oil.

These impacts are shown graphically in figure 2, where panels A and B represent the domestic soybean meal and oil markets, and C and D depict the rapeseed meal and oil markets. Japan's liberalization of its meat imports would tend to lower domestic demand for soybean meal more so than rapeseed meal. As shown in panels A and C, demands for soybean meal and rapeseed meal shift inward from *Dsm* to *Dsm′* and from *Drm* to *Drm′*, respectively. Soybean imports and crush decline (panel E), and due to the joint product relationship, the supply of soybean oil shifts back from *Sso* to *Sso′*, while the price of this commodity rises (panel B). Because soybean oil and rapeseed oil are substitutes, a higher domestic price of the former shifts domestic demand for rapeseed oil outward from *Dro* to *Dro′*, as shown in panel D. Although Japan's domestic demand for rapeseed meal falls with lower meat production, it is assumed the impact of meat trade liberalization is concentrated on soybean meal, since a relatively low quantity of rapeseed meal is used in the production of livestock.

Under this assumption, the outward shift in demand for rapeseed oil dominates the relatively small inward shift in demand for rapeseed meal, implying rapeseed imports and crush rise (panel F of figure 2). It could be argued that the outward shift in rapeseed oil demand results in greater vegetable oil imports as well. Although we are not ruling out higher vegetable oil imports, there is likely to be a positive impact on rapeseed imports as well, given that the oilseed processing capacity is already in place. We hypothesize there is a positive (negative) relationship between meat production and soybean (rapeseed) imports, implying the import demand equations for rapeseed (15) and soybeans (13) must be modified to include Japan's meat production:

$$(16)\qquad {}^{D}Q_{rs} = {}^{D}Q_{rs}(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C, DUMCAN, Meat\ Production),$$

$$(17)\qquad {}^{D}Q_{sb} = {}^{D}Q_{sb}(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C, Meat\ Production).$$

Because rapeseed imports are driven primarily by the demand for oil, equation (16) is expanded to include Japan's per capita income (GDP):

$$(18)\qquad {}^{D}Q_{rs} = {}^{D}Q_{rs}(P_{ro}, P_{rm}, P_{so}, P_{sm}, P_{rs}, P_{sb}, C, DUMCAN, Meat\ Production, GDP).$$

However, soybean imports (17) are more likely to be driven by meat production, as opposed to factors such as income which shift the demand for vegetable oil. Thus, per capita income is not included in the import demand equation for soybeans, and equation (17) is not further modified.

One factor which increases the substitution between soybean and rapeseed imports is that soybean oil and rapeseed oil are blended. The blending of the two oils

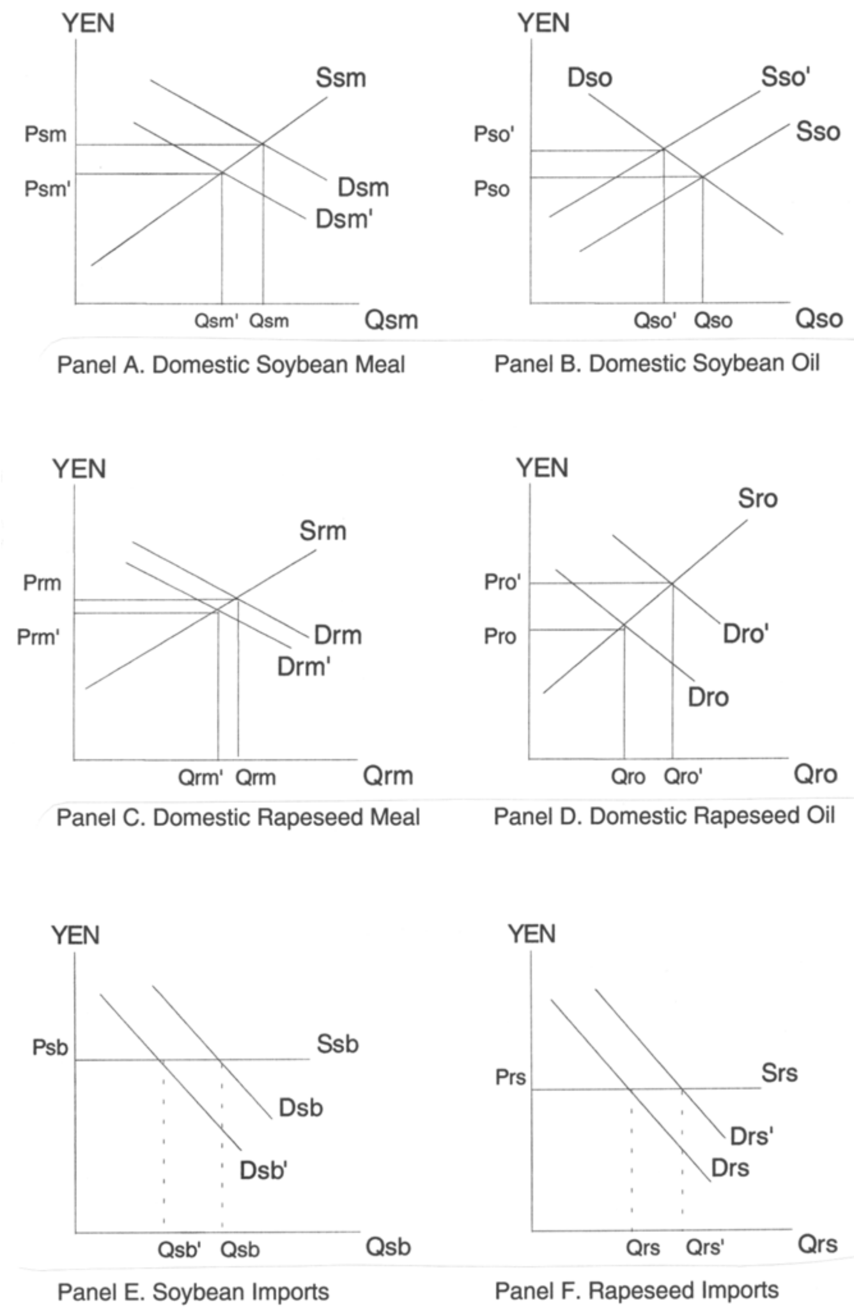

Figure 2. Impacts of Japan's meat trade liberalization on its domestic oil/meal markets and on its oilseed imports

has the effect of insulating oilseed processors from shifts in consumer demand for soybean oil or rapeseed oil as separate commodities, particularly since the vegetable oil sold to consumers is not labeled and the market for pure rapeseed oil or soybean oil is negligible. The flexibility in the ratio of blending permits substitution in accordance with movements in relative prices of the oilseeds, as well as fluctuations in Japan's demand for livestock meal.

In summary, the Japanese oil and fat industry has positioned itself to enhance the substitutability between rapeseed and soybeans by (*a*) using oilseed processing machinery with the ability to switch between rapeseed and soybean crush, and (*b*) blending soybean oil with rapeseed oil and not labeling the blend to identify the ratio of these two oils. The development of improved rapeseed varieties low in fiber, glucosinolates, and erucic acid has also contributed to rapeseed's competitiveness against soybeans. The substitutability between rapeseed and soybeans, and the role of fluctuations in Japan's meat production in influencing its import demands for these two oilseeds, are quantified in the econometric model.

Data Sources and Imputation

The annual price and quantity data for the period 1972–1996 for Japan's imports of the various oilseeds, oils, and meals were obtained from selected volumes of *Statistics of Oilseeds, Oils, and Oilcakes*, published by the Japan Oil and Fat Importers and Exporters Association. Japan's annual production statistics for total meat, beef, pork, poultry, soybeans, and rapeseed were obtained from selected annual issues of the *FAO Production Yearbook* (FAO). Data for Canada's production and stocks of rapeseed were taken from various issues of *Oils and Fats* (Statistics Canada). Finally, Japan's wholesale price index, exchange rate data, population, GDP, and GDP deflator were obtained from various issues of *International Financial Statistics* (International Monetary Fund). The sample means of key variables are shown in table 1.

Econometric Model

Estimation Techniques

Results of the final estimated import demand equations reported in tables 2 and 3 for rapeseed and soybeans, respectively, are based on ordinary least squares (OLS). The *p*-values are provided in the tables, allowing readers to form their own judgments regarding statistical significance. The rapeseed import demand was corrected for autocorrelation using the Cochrane-Orcutt approach. This correction method converged in six iterations to a ρ value of 0.24377 (convergence criterion = 0.00100).

A possible problem associated with OLS estimation is its failure to capture simultaneity (Greene, 1993). Analysis of the impact multipliers of the tariffs undertaken by Jones (1988) produced results consistent with the assumption that Japan acts as a small country, exerting only minute influences on world prices, *with the exception*

Table 1. Sample Means of Key Variables, 1972–1996 (25 observations)

Variable	Unit	Mean
Quantity of Rapeseed Imports	MT	1.33E+06
Quantity of Soybean Imports	MT	4.33E+06
Import Price of Soybeans	Yen/MT	63,461
Import Price of Rapeseed	Yen/MT	66,638
Import Price of Soy Meal	Yen/MT	55,566
Total Meat Production	MT (000s)	3,008.9
GDP per Capita	Yen (000s)	2,541.3

Table 2. Import Demand for Rapeseed: OLS Results (Dependent Variable = Quantity of Rapeseed)

Variable	Estimated Coefficient	Standard Error	*t*-Ratio (18 DF)	*p*-Value	Elasticity at Means
Log of Real Import Price of Soybeans	1.27E+06	5.39E+05	2.352	0.030	0.9539
Log of Real Import Price of Rapeseed	−8.28E+05	2.86E+05	−2.893	0.010	−0.6235
Log of Real Import Price of Soymeal	−6.77E+05	2.61E+05	−2.597	0.018	−0.5093
Log of Total Meat Production	−6.46E+05	2.79E+05	−2.314	0.033	−0.4862
Log of Real GDP per Capita	2.31E+06	3.91E+05	5.926	0.000	1.7423
DUMCAN	1.66E+05	8.46E+04	1.963	0.065	—
CONSTANT	1.13E+06	2.35E+06	0.4818	0.636	—

$R^2 = 0.9757$
Durbin-Watson Statistic = 2.0040

Table 3. Import Demand for Soybeans: OLS Results (Dependent Variable = Log of Soybean Quantity)

Variable	Estimated Coefficient	Standard Error	*t*-Ratio (18 DF)	*p*-Value	Elasticity at Means
Real Import Price of Soybeans	−9.92E-06	3.34E-06	−2.975	0.007	−0.6298
Log of Real Import Price of Rapeseed	0.2486	0.1269	1.96	0.064	0.2486
Log of Real Import Price of Soymeal	3.87E-06	1.76E-06	2.194	0.040	0.2149
Total Meat Production	1.16E-04	4.09E-05	2.846	0.010	0.3502
CONSTANT	12.598	1.239	10.17	0.000	—

$R^2 = 0.8747$
Durbin-Watson Statistic = 1.7239

of rapeseed. To examine the issue of simultaneity, a three-stage least squares (3SLS) model was developed, incorporating an inverse supply equation for rapeseed. The specification of the inverse rapeseed supply equation is based on Sarwar and Anderson (1990), where the price-dependent export supply function was expressed as a function of the quantity of exports supplied, domestic production, commodity stocks, and a lagged dependent variable.

Under 3SLS (results are not shown to conserve space), the coefficients of the rapeseed import demand equation are virtually unchanged. However, the supply equation performed rather poorly, as the coefficients had implausible signs. There was no evidence to suggest changes in Japan's rapeseed demand impact the import prices paid, and so the final results for this study are based on the OLS estimation procedure (tables 2 and 3).

Specification Issues

Although the theoretical framework is indispensable for development of econometric models, it does not identify the precise functional relationship between the dependent variable and the right-hand side variables. For example, theory does not generally indicate when the use of lagged dependent and independent variables, log transformations, scaled variables, dummy variables, etc. is warranted (Thursby and Thursby, 1984). Thus, the specification choice is not completely based on economic theory.

In theory, the import demand equations should contain as explanatory variables the prices of rapeseed, soybeans, and their respective meals and oils. However, it is not possible to include all six prices. The price of the oilseed and the value of the processed products (the meal and the oil) are closely linked. For example, in the case of soybeans, the linkage between the prices of the seed, meal, and oil is expressed by the following equation:

$$P_{sb} = [(1/A) * P_{sm}] + [(1/B) * P_{so}] - P_p,$$

where

- P_{sb} = price per ton of soybeans,
- A = quantity of soybeans needed to produce one ton of meal,
- P_{sm} = price per ton of soybean meal,
- B = quantity of soybeans needed to produce one ton of oil,
- P_{so} = price per ton of soybean oil, and
- P_p = cost of crushing one ton of soybeans.

The same type of linkage exists between the price of rapeseed and the value of the processed products (Bickerton and Glauber, 1990), thus precluding the use of all the prices in (17) and (18).

Variables were eliminated from the model if the signs of their coefficients contradicted a priori expectations, or if they entered with extremely low *t*-ratios while substantially lowering the statistical significance of the other variables. (In the cases

Table 4. Elasticities at Sample Means for Rapeseed and Soybean Demand

Variable	Rapeseed Demand	Soybean Demand
Real Import Price of Soybeans	0.9539	−0.6298
Real Import Price of Rapeseed	−0.6235	0.2486
Real Import Price of Soymeal	−0.5093	0.2149
Total Meat Production	−0.4862	0.3502
Real GDP per Capita	1.7423	—

where variables entered with unexpected signs, multicollinearity is likely the cause.) Thus, none of the variables included in the model have unexpected signs.

As shown in table 2, the rapeseed import demand is estimated in semi-log form, while the soybean equation (table 3) is a mixed specification. When the rapeseed equation is specified completely in logs (except for the dummy variable), the statistical significance falls for all variables, apart from the dummy variable and the constant term. Under a completely linear specification, the significance of all variables deteriorates, with the exception of income. Hence, for rapeseed, the log-log and the linear functional forms were both rejected in favor of the semi-log specification shown in table 2. When the soybean equation is estimated completely in logs, or completely in linear form, all variables are insignificant ($\alpha = 0.10$), with the exception of Japan's meat production. Therefore, the log-log and linear forms were both rejected in favor of the mixed specification shown in table 3 for soybeans.

Although it is not always accurate to assume the true functional form is best approximated with equations that are completely linear or logarithmic, the use of a mixed specification (as in this study) gives rise to issues of interpreting and comparing the coefficients. Accordingly, the coefficients are converted to elasticities at the sample means (table 4), with the exception of the coefficient of the price of rapeseed in the soybean equation, where the coefficient itself is a (constant) elasticity.

Results

As shown in table 4, the regression results produced by this study indicate that a number of variables affect the competitiveness of rapeseed against soybeans. The models for soybeans and rapeseed both contain the following variables: the import prices of soybeans, rapeseed, soybean meal, and Japan's total meat production. These four variables take on opposite signs in the rapeseed and soybean equations (as hypothesized), implying they change the composition of Japan's oilseed crush.

It is apparent from table 4 that soybean imports are more responsive to the import price of soybeans than to the import price of rapeseed. A 10% increase in the former tends to lower soybean imports by about 6.3%, while a 10% increase in the latter raises soybean imports by 2.5%. Thus, if these two import prices rise together by the same number of percentage points, the net impact is to lower soybean imports.

Rapeseed imports are more elastic with respect to changes in the import price of soybeans than with respect to changes in the import price of rapeseed. As observed in table 4, a 10% increase in the latter leads to a 6.2% reduction in rapeseed imports, while a 10% increase in the former raises rapeseed imports by 9.5 percentage points. Consequently, if these two import prices rise together by the same number of percentage points, the net impact is to raise rapeseed imports.

The ability to import soybean meal at relatively low prices favors rapeseed imports at the expense of soybeans, as shown in the econometric results. A 10% reduction in the import price of soybean meal tends to increase rapeseed imports by 5.1 percentage points, while lowering soybean imports by 2.1 percentage points (table 4). Between 1985 and 1991, there was a dramatic increase in Japan's imports of Chinese soybean meal. Japan's large imports of low-priced Chinese soybean meal have induced oilseed processors to reduce soybean crushing, thereby increasing Japan's demand for alternative sources of vegetable oil. This has encouraged rapeseed imports because rapeseed has a higher oil content (Bickerton and Glauber, 1990).

It could be argued that vegetable oil imports will also rise. Although we are not ruling out higher vegetable oil imports in response to lower soybean meal prices, there is a positive impact on rapeseed imports as well, because, as noted earlier, the oilseed processing capacity is already in place. Thus, Japan may prefer to import an alternative oilseed (e.g., rapeseed), rather than vegetable oil itself.

Rapeseed imports respond more than proportionately to per capita income growth. A 10% increase in income is associated with a 17 percentage point increase in rapeseed imports. Finally, as shown in table 4, a key finding of this study is that lower Japanese meat production tends to increase rapeseed imports at the expense of soybeans. A 10% decline in Japan's total meat production lowers soybean imports by 3.5% and raises rapeseed imports by 4.9%.

In summary, table 4 reveals that a market environment favoring imports of soybeans over rapeseed is characterized by falling import prices of soybeans, higher meat production, and increasing import prices of soybean meal and rapeseed. Despite the contributions of this study, there remain a number of unanswered questions. As discussed in the final section, this study sets the stage for a great deal of future research which would allow greater policy implications.

Conclusions

Based on the results of this study, lower meat production in Japan tends to increase its rapeseed imports while lowering its soybean imports. Although previous analyses have estimated the impacts of meat production on Japan's soybean imports, these investigations did not include in their models both the import price of rapeseed and meat production. In addition, previous research did not quantify the impacts on rapeseed imports of fluctuations in the import price of soybean meal, and meat production. The current analysis fills these gaps in the literature.

It is well to note that the Beef Market Access Agreement (BMAA) resulted from negotiations occurring (sporadically) over a 20-year period. Further, this bilateral trade agreement cannot be viewed in isolation from a multilateral process. Indeed, the credible threat of GATT actions against Japan was instrumental in successfully concluding the BMAA. Thus, regional trade agreements need not compete with multilateral processes (Dyck, 1998).

The current study demonstrates that Canada benefited from Japan's liberalization of its meat imports, due to the increased rapeseed imports (almost all of which is Canadian canola). Switching away from soybeans in favor of rapeseed may be a rational response for other countries who are lowering their restrictions on imports of U.S. meat. This finding may have value in trade negotiations, because it provides a basis for the United States to enlist the support of Canada when negotiating with other countries to allow greater imports of meat, and when negotiating with Japan for further reductions in its meat trade restrictions.

One interesting question raised by this study is the extent to which the United States benefits from more open Japanese markets for meat. Although soybean exports to Japan fall as a consequence, the increased import demand for meat raises production in the United States, to the benefit of American soybean and livestock producers. Japan's consumption of beef and other meats would be greater under more open markets, implying net gains for U.S. producers.

Indeed, Japan's imports of chilled U.S. beef exhibited strong growth in the period following the BMAA, as chilled beef could compete more effectively with Japanese-raised beef. Additionally, U.S. firms achieved substantial cost reductions by developing methods of transporting chilled beef to Japan by ship, rather than by air. The technology and expanded marketing channels created for exporting chilled beef were also applied to chilled pork. Thus, an important commodity spillover from the BMAA was the strong growth in chilled U.S. pork exports to Japan in the post-1988 period (Dyck, 1998).

The U.S. market share of soybeans in the Japanese market was already eroding due to competition from other oilseeds and the soybean exports of Argentina and Brazil. Although these two countries are competitive in soybean exports, they are not as capable at competing with the United States in livestock exports. Japan's health and sanitary regulations have excluded beef from South America and the European Community, due to the possible presence of foot-and-mouth disease [Australian Bureau of Agricultural and Resource Economics (ABARE), 1988]. Consequently, the liberalization of Japan's beef trade may effectively reduce the competitive threat of Brazilian and Argentinean soybeans.

For the most part, the countries seeking to pressure Japan into liberalizing its beef imports were the United States and Australia, the major suppliers of Japan's beef and veal imports. Although the United States will have to share the growing Japanese market for imported beef with Australia and other countries, the U.S. position has been strengthening. The U.S. share of beef and veal imports grew from 6% in 1970 to 43% in 1986, in value terms. Australia's share declined from 81% to 51% over this same time period (ABARE, 1988).

Although this study establishes an empirical link between Japan's meat production and Japan's imports of soybeans and rapeseed, the parameter estimates are not invariant to Japanese efforts to rationalize in response to lower trade barriers. The scope for improving the efficiency of both livestock meal production and livestock production itself is rather large. Thus, our results should be interpreted with caution, since improved Japanese competitiveness in livestock production and/or emergence of strong tastes and preferences for domestically produced beef would restrain the expansion of Japan's rapeseed imports.

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