Paper Title: **Estimations of the Price Transmission and Market Power in Canola Export Market: Implication to Canola Import of Japan**

Conference: 55th Annual AARES (Australian Agricultural and Resource Economics Sociey) National Conference

Date and Place: 8-11 February 2011, Melbourne, Crown Conference Centre

Author: Toru Nakajima
Ph.D. Student, Department of Agricultural and Resource Economics, Graduate School of Agricultural and Life Sciences, The University of Tokyo
Research Fellow of the Japan Society for the Promotion of Science (JSPS)
E-mail: n.through@gmail.com

Keywords: asymmetric price transmission, TAR, market power, dynamic programming, canola

Estimations of the Price Transmission and Market Power in Canola Export Market: Implication to Canola Import of Japan

Toru Nakajima*

Abstract

This paper analyzes the price transmission of canola in the international market, the market power of canola exporting countries over Japan, and the relationship between them. In the estimation of price transmission, asymmetric price transmission from futures prices in Winnipeg to export prices of Canadian canola importers was estimated using threshold autoregressive model with cointegration tests. Significant asymmetry was found in the Canadian canola export to Japan in such a way that Canada enjoyed long-lasting excess profits over Japan. Meanwhile, the results also showed that Mexico and the U.S. enjoyed the long-term excess profits over Canada. In the estimation of market power, considering the existence of adjustment process in Canada and Australia, linear-quadratic (LQ) dynamic duopoly model was employed. According to the results,

* Ph.D. student, Department of Agricultural and Resource Economics, Graduate School of Agricultural and Life Sciences, The University of Tokyo, and research fellow of the Japan Society for the Promotion of Science (JSPS). E-mail: n.through@gmail.com

Canada had more market power than does Australia, the latter of whose market power is close to competitive level. The implication for Japan's canola import is that Japan should diversify the origins of canola or import more from such countries that have less market power like Australia. This paper contributes in that it empirically showed the relationship between APT using TAR model and market power using LQ model.

Keywords: asymmetric price transmission, TAR, market power, linear-quadratic model, canola

1. Introduction

Canola oil consumption has been the largest among vegetable oils in Japan. Oil made of canola, the low ercic acid rapeseed, is considered to be a healthy oil and is most preferred of all vegetable oils in Japan. The annual supply of fats and oils in Japan is roughly 3 million tons every year and that of canola oil is 1 million tons. Almost all canola oil is produced in Japan, and almost all canola is imported. Japan has been the world largest importer of canola, whose imported quantity is more than 2 million tons a year. Japan imports canola mainly from Canada, whose share is nearly 90% on average from 1988 to 2009. Japan also imports canola from Australia, but the share is less than

10% on average.

What is the effect of the heavy dependence of Japan's canola import on Canada? And what strategies should Japan develop on canola import? The purpose of this study is to estimate the asymmetric price transmission (APT) and market power in the international canola export market, especially focusing on Japan as an importer. Threshold autoregressive (TAR) model is employed in estimating APT and linear-quadratic (LQ) model is used to estimate market power. Comparing the results of APT and market power, the relation between APT and market power is analyzed. Because the relation has not been shown with rigorous theoretical underpinnings (Meyer and von Cramon-Taubadel, 2004), this paper tries to offer some empirical evidence of it.

This paper is organized as follows. In section 2, the concept and the model of APT are explained, then the empirical analysis using TAR model is conducted. In section 3, market power of exporting or importing countries is estimated using LQ model. Finally, the relation between APT and market power is considered, then this study is closed with some concluding remarks.

2. Asymmetric price transmission

2.1 Overview

APT is a popular research topic, as mentioned in the survey paper by Meyer and von Cramon-Taubadel (2004). Price transmission is said to be asymmetric if the speed of adjustment of the output price is different after the input price increases or decreases. In particular, APT is positive if the output price adjusts more rapidly when the input price increases than when it decreases. A positive APT means that the squeezed margin restores more quickly than does the stretched margin. It also indicates that the price transmission has downward rigidity. In contrast, negative APT denotes that the output price adjusts more rapidly when the input price decreases than when it increases. Thus, the stretched margin is restored more quickly than the squeezed margin, and the price transmission has upward rigidity.

Following the method of Enders and Granger (1998), many empirical studies have been conducted using a TAR model to estimate APT with cointegration tests. The coverage of previous empirical studies of APT that use the TAR model for agricultural products includes the Ghanaian maize market in Abdulai (2000), the Swiss pork market in Abdulai (2002), wheat export prices in major wheat-producing countries in Ghoshray (2002), the French marine products in Gonzales *et al*. (2003), the French vegetable market in Hassan and Simioni (2001), the U.S. dairy market in Awokuse and Wang (2009), the Nepalese rice market in Sanogo and Amadou (2010), and Indonesian oil palm market in Nakajima *et al*. (2010).

2.2 TAR model

Below, the TAR model based on Enders and Siklos (2001) is explained. Denote p_{it} and p_{ot} as the input and output prices at time t. The long-run relationship between p_{it} and p_{ot} is represented using ordinary least squares (OLS) regression as follows:

$$p_{ot} = \alpha + \beta p_{it} + \mu_t \qquad (1)$$

where α and β are parameters, and μ_t is the disturbance term, which may be serially correlated. According to Engle and Granger (1987), if p_{it} and p_{ot} are part of a non-stationary process and Δp_{it} and Δp_{ot} are part of a stationary process (that is, if they are first-difference stationary (I(1)) variables), then Eq. (1) may indicate a spurious regression. If the residual series $\{\hat{\mu}_t\}$ is stationary, however, then p_{it} and p_{ot} are said to be cointegrated. Therefore, it is necessary to conduct unit root tests and cointegration tests on p_{it} and p_{ot} to avoid a spurious regression.

In a TAR model, a cointegration test is performed using $\{\hat{\mu}_t\}$ from Eq. (1) in the following equations (Enders and Siklos, 2001):

$$\Delta\mu_t = I_t \rho_1 \mu_{t-1} + (1 - I_t)\rho_2 \mu_{t-1} + \sum_{i=1}^{T} \gamma_i \Delta\mu_{t-i} + \varepsilon_t \qquad (2)$$

$$I_t = \begin{cases} 1 & \text{if} \quad \mu_{t-1} \geq \tau \\ 0 & \text{if} \quad \mu_{t-1} < \tau \end{cases} \tag{3}$$

where I_t is the Heaviside indicator function, and τ is the super-consistent estimator of threshold μ_{t-1} calculated following Chan (1993). ε_t is the white noise disturbance term and satisfies the following conditions:

$$\mathrm{E}(\varepsilon_t) = 0, \ \mathrm{E}(\varepsilon_t^2) = \sigma^2, \ \mathrm{E}(\varepsilon_t \varepsilon_j) = 0 \ \ (t \neq j). \tag{4}$$

The necessary and sufficient condition for $\{\hat{\mu}_t\}$ to be stationary is as follows (Petrucelli and Woolford, 1984):

$$\rho_1 < 0, \ \rho_2 < 0, \text{ and } (1+\rho_1)(1+\rho_2) < 1 \ \text{ for any } \tau. \tag{5}$$

T is the lag order that satisfies the conditions of Eq. (4) and (5) and minimizes the BIC (Bayesian information criteria).

A cointegration test is performed by testing $\rho_1 = \rho_2 = 0$; i.e., if the null hypothesis of $\rho_1 = \rho_2 = 0$ is rejected, then p_{it} and p_{ot} are said to be cointegrated. APT can be tested in the same model to compare the absolute values of ρ_1 and ρ_2. If $\rho_1 = \rho_2$ is rejected and $|\rho_1| < |\rho_2|$, then the negative discrepancies from the equilibrium error adjust more rapidly than the positive discrepancies, which indicates positive APT. On the other hand, if $\rho_1 = \rho_2$ is rejected and $|\rho_1| > |\rho_2|$, then the positive deviations adjust toward the equilibrium error more rapidly than do the negative deviations, which indicates negative APT.

There is another approach to represent the adjustment process, that is, the momentum TAR (M-TAR). The M-TAR model is the same as in Eq. (2) and (3) except that μ_{t-1} in Eq. (3) is replaced with $\Delta\mu_{t-1}$. The TAR model and M-TAR model correspond to the two asymmetric adjustment processes, Deepness and Steepness (Sichel, 1993). In both models, however, $|\rho_1| < |\rho_2|$ indicates positive APT and $|\rho_1| > |\rho_2|$ indicates negative APT. The model selection may be based on information criteria such as Bayesian information criteria (BIC).

2.3 Empirical results

2.3.1 Data

The input price was three month lags of canola futures prices for the nearest contract month in the Winnipeg market, which was obtained from "Cereals and Oilseeds Review" in Statistics Canada. Three month lags were taken because contracts between buyers and sellers are generally made in several months before the commodity clears through customs in the exporting country. In the empirical analysis below, two and four month lags were also employed to check the sensitivity of the lags. The output prices were Canada's canola export prices to Japan, the U.S. and the sum of countries without Japan (represented by the rest of the world, ROW). The data were obtained from

“Canadian International Merchandise Trade Database” in Statistics Canada. Both datasets included monthly data from January 1988 to December 2009. The total sample size was 264. The futures prices and export prices to Japan were shown in Fig. 1. It seems that futures prices of several month prior correspond to the actual export prices, which is consistent with the description above. The original data of both the input and output prices are in Canadian dollar per metric tons. In the TAR estimations, these series were transformed into natural logarithmic form as is always done in empirical analyses of TAR models (Ben-Kaabia and Gil, 2007).

2.3.2 Unit root tests

To test whether the price series are I(1) variables, augmented Dickey-Fuller (ADF) tests were conducted. The results are shown in Table 1. The null hypothesis that the series have a unit root is not rejected for the level series, but it is for the first-difference series. Therefore, the price series mentioned above can be said to be I(1) variables. The test statistics shown in Table 1 are those achieved by including intercepts (but not trends) in the test equations. Similar results were obtained by including intercepts and trends in the test equations, which are not shown here to save space.

2.3.3 TAR estimations

The results are shown in Table 2. The lag order for each model was determined by minimizing the BIC when the conditions of Eq. (4) and (5) are satisfied. Based on both the TAR model and the M-TAR model, I can conclude that the futures prices and export prices to each country are cointegrated because the Φ statistics in each model are much larger than those at the critical 1% significance level in Enders and Siklos (2001). According to that paper, the Φ statistics at a 1% significance level for 250 observations and four lagged changes are 10.18 for TAR and 8.47 for M-TAR. As shown in Enders and Siklos (2001), the Φ statistic tends to decrease as the number of observation increases, and it tends to increase as the number of lags increases. Therefore, it is reasonable to conclude that the null of no cointegration is rejected at the 1% level in each model. In fact, the Φ statistics obtained in this paper are far beyond the values shown above.

Regarding the results for Japan, although the null hypothesis that $\rho_1 = \rho_2$ is not rejected at the 10% level based on the TAR model, the null is rejected at the 1% level based on the M-TAR model, and $|\rho_1| < |\rho_2|$. It follows that price transmission from Canadian canola prices to export prices for Japan is symmetric in the TAR model and that there is positive APT in the M-TAR model. Based on the BICs, the value is lower in M-TAR than that in TAR model. Hence, the conclusion may be that Canada enjoys long-standing excess profits in terms of price transmission over Japan by exporting canola, that is, increased margin is restored more slowly than is decreased margin. It implies that Canada has more power to determine the export prices to Japan. However, it is not analyzed that Canada has market power over Japan using TAR model. Therefore, market power estimations are conducted in the next section.

Regarding the results for ROW, the null hypothesis that $\rho_1 = \rho_2$ is not rejected at the 10% level based on the TAR model, but it is rejected at te 5% level based on the M-TAR model, and $|\rho_1| > |\rho_2|$, which means negative APT. According to the BICs, M-TAR model is preferred and the conclusion may be that importing countries other than Japan enjoys long-lasting excess profits in terms of price transmission over Canada. The implication is that importing countries other than Japan has more power to determine canola prices than does Canada. The results for the U.S., which is the representative country in ROW, shows that the null is rejected at the 1% level based on both the TAR and M-TAR model. Negative APT $|\rho_1| > |\rho_2|$ was found significantly, and the results are consistent with that of ROW.

To check sensitivity of choosing lags in futures prices, TAR estimations using futures prices with two and four lags were also conducted. Although the parameter values changed slightly, the conclusion of the significance of APT was totally the same as those with three lags.

3. Market power

3.1 Motivation

As market power is defined by price-cost margin, the existence of APT do not necessarily mean the existence of market power, although the relation was referred in literature. Hence, this paper is motivated by investigating the relation.

Perloff *et al*. (2007) surveyed various methodology of estimating market power. There are two assumptions regarding the games that firms play, that is, static and dynamic. In a sequence of static games, each firm maximizes its current profit given its belief about rivals behavior and the assumption that actions in other periods do not affect behavior in this period. Meanwhile, in a dynamic game, each firm maximizes its expected present discounted value of the stream of its future profits. Considering the possibility of dynamic aspect of Canada and Australia in canola exports to Japan, this paper employed the dynamic model to estimate market powers of the exporters.

Previous studies of estimating market power with dynamic model focused on the use of LQ model because it offers closed-form solutions in a dynamic problem.

Such studies include Karp and Perloff (1989), Karp and Perloff (1993), and Deodhar and Sheldon (1996) for industry level approach, and Chalil (2009) for firm level approach. The models employed are the same, which is explained in the next subsection.

There are two types of dynamic strategies, that is, open-loop and Markov perfect (Perloff *et al*., 2007). With open-loop strategies, firms believe that their rivals' strategies do not depend on state variables, such as a level of capital or a stock of loyal customers, that affects rival's future actions. On the other hand, with Markov strategies, firms understand that their current actions affect the state variables. Firms take their rivals' strategies as given and understand that by altering the state variables they can affect rivals' future actions. The open-loop equilibrium (OLE) can be obtained by solving a one-agent optimal control problem, while the Markov perfect equilibrium (MPE) requires the solution to a game.

3.2 Linear-quadratic dynamic model

Assume that Japan imports canola from Canada and Australia, and Canadian canola and Australian canola are close substitutes. Japan's inverse linear demand function is written as:

$$p_{it} = a_i - \sum_{j=1}^{2} b_{ij} q_{jt} \ , \tag{6}$$

where p_{it} indicates real import price of Japan from country i ($i = 1, 2$, which indicate Canada and Australia, respectively) in period t, q_{jt} indicates import quantity of Japan from country j ($j = 1, 2$, which indicate Canada and Australia, respectively), and a_i and b_{ij} are parameters.

Each country has constant marginal costs c_{it} with respect to contemporaneous exports q_{it}. The change in output from one period to the next is defined as:

$$u_{it}\tau \equiv q_{it} - q_{it-\tau} \, , \tag{7}$$

where τ is the duration of a period, which is assumed to be 1 in this paper. Then the cost of changing output is quadratic in the rate of change:

$$(\theta_{0it} + \theta u_{it}/2) u_{it}\tau \, . \tag{8}$$

$\theta_{0it} = 0$ in this paper, which is generally assumed in literature. Adjustment costs are assumed to be positive whenever the change in the state variable is non-zero. For dynamic problems, it is necessary that $\theta > 0$, while $\theta = 0$ means the problem is static.

In period t, country i wants to maximize its expectation of the present discounted value of profits minus adjustment costs:

$$\mathrm{E}_{it} \sum_{t=1}^{\infty} \delta^{t-1} \left[(p_{it} - c_{it}) q_{it} - \left(\theta_{0it} + \frac{\theta u_{it}}{2} \right) u_{it}\tau \right], \tag{9}$$

where δ is a discount factor, which is assumed to be known. Hence, value function is written as:

$$V(q_{it}) = \max_{u_{it}} \sum_{t=1}^{\infty} \delta^{t-1} \left[(p_{it} - c_{it}) q_{it} - \left(\theta_{0it} + \frac{\theta u_{it}}{2} \right) u_{it} \tau \right], \quad \text{s.t.} \quad q_{i,t+1} = q_{it} + u_{i,t+1}. \tag{10}$$

Here q is a state variable and u is a control variable. Then, the Bellman equation is written as:

$$V(q_{it}) = (p_{it} - c_{it}) q_{it} - \left(\theta_{0it} + \frac{\theta u_{it}}{2} \right) u_{it} \tau + \delta V(\tilde{q}_{it}), \tag{11}$$

$$u_{it} = q_{it} - q_{i,t-1}. \tag{12}$$

where $\tilde{q}_{it} = q_{i,t+1}$. (11) is written in matrix notation as:

$$\mathrm{E}_i \sum_{t=1}^{\infty} \delta^{t-1} \left[\alpha_{it} \mathbf{e}_i' (\mathbf{q}_{t-\tau} + \mathbf{u}_t \tau) - \frac{1}{2} (\mathbf{q}_{t-\tau} + \mathbf{u}_t \tau)' \mathbf{K}_i (\mathbf{q}_{t-\tau} + \mathbf{u}_t \tau) - \frac{1}{2} \mathbf{u}_t' \mathbf{S}_i \mathbf{u}_t \right] \tau, \tag{13}$$

where $\mathbf{e}_i$ is a column vector of zeroes with a one in the ith position, $\mathbf{e}$ is an n-dimensional column vector consisting entirely of ones, $\mathbf{K}_i$ is an $n \times n$ matrix of zeroes with bs on the ith column and the ith row, except for the (i,i) element, which contains $2b$, and $\mathbf{S}_i$ is an $n \times n$ matrix consisting of zeroes except for the (i,i) element, which contains θ. α_{it} contains a_{it} and c_{it}, and $\alpha_{it} = \boldsymbol{\beta}_\mathbf{i}' \mathbf{x}_{it}$ and $\mathbf{x}_{i,t+1} = \boldsymbol{\Phi} \mathbf{x}_{it} + \mu_{it}$, where $\mathbf{x}_t$ are exogenous variables and μ_{it} is an i.i.d. random variable with zero mean. (12) is also written in matrix notation as:

$$\mathbf{q}_t = \mathbf{g}_t + \mathbf{G} \mathbf{q}_{t-1}, \tag{14}$$

for some $\mathbf{g}_t$ and $\mathbf{G}$.

3.3 Estimation method

In an empirical analysis, the demand equations (6) and the adjustment equations (14) are to be estimated. Then $\mathbf{G}$ and the demand slope parametes $\mathbf{b}$ that consist of $\mathbf{K}_i$ are derived. Given δ, and using $\mathbf{b}$ and $\mathbf{K}_i$, market power parameters and adjustment parameters can be calculated. The first-order condition for profit maximization is solved using Eq. (13) and (14). However, the solutions are different according to the strategies mentioned above. The solutions for OLE and MPE are shown as follows.

3.3.1 Solution for OLE

Given a value of δ, the first-order condition corresponding to (13) and (14) is:

$$\mathbf{K}_i \mathbf{v}_i = \left[\mathbf{G}^{-1}(\mathbf{I}-\mathbf{G})(\mathbf{I}-\delta\mathbf{G})\right]' \mathbf{e}_i \theta_i \equiv \mathbf{y}_i \theta_i, \tag{15}$$

where $\mathbf{v}_i$ is an n dimensional column vector with one in the ith position and v_{ij} elsewhere. $v_{ij} = \partial q_j / \partial q_i$ ($i, j = 1, 2, i \neq j$) indicates country i's conjectures for the outputs of the rival. Using estimated $\mathbf{G}$ and demand slope parametes $\mathbf{b}$ that consist of $\mathbf{K}_i$, each firm's conjectural variation is solved as follows:

$$v_{12} = y_{11}/y_{12} - 2b_{11}/b_{12},$$
$$v_{21} = y_{22}/y_{21} - 2b_{22}/b_{21}. \tag{16}$$

θ_i are also solved as follows:

$$\theta_1 = b_{12} / y_{12},$$
$$\theta_2 = b_{21} / y_{21}. \tag{17}$$

For the estimated dynamic system to make sense, it must have properties as follows. First, the dynamic system of control is asymptotically stable if the absolute eigenvalues of matrix $\mathbf{G}$ are less than one. Second, the adjustment parameter in each of the models is positive (dynamic property): $\theta_i > 0$.

3.3.2 Solution for MPE

To estimate $\mathbf{v}_i$ and θ_i in the MPE case, define the vectors

$$\mathbf{w}_i = \left[\mathbf{I} - \delta(\mathbf{G}' \otimes \mathbf{G}')\right]^{-1}\left[(\mathbf{G}' \otimes \mathbf{G}')(\text{vec}\mathbf{K}_i)\right], \tag{18}$$

$$\mathbf{z}_i = \left[\mathbf{I} - \delta(\mathbf{G}' \otimes \mathbf{G}')\right]^{-1}\left[(\mathbf{G}' \otimes \mathbf{G}') - (\mathbf{I} \otimes \mathbf{G}') - (\mathbf{G}' \otimes \mathbf{I}) + \mathbf{I}\right]\left[\text{vec}(\mathbf{e}_i\mathbf{e}_i')\right], \tag{19}$$

where $\otimes$ is Kronecker product and vec operator stacks the columns of the matrix. The inverse vec operation is then used to “rematricize” $\mathbf{w}_i$ and $\mathbf{z}_i$ to obtain the 2×2 matrices $\mathbf{W}_i$ and $\mathbf{Z}_i$. In MPE, the necessary condition corresponding to (13) and (14) is:

$$\left[\mathbf{K}_i + \delta\mathbf{W}_i + (\mathbf{e}_i\mathbf{e}_i' + \delta\mathbf{Z}_i)\theta_i\right]\mathbf{v}_i = \mathbf{G}'^{-1}\mathbf{e}_i\theta_i \equiv \mathbf{y}_i^*\theta_i, \tag{20}$$

3.4 Empirical results

3.4.1 Data

p_{it} and q_{it} are Japan's import unit prices and quantity of canola (low erucic acid rapeseed), respectively, from Canada and Australia. The data are obtained from Trade Statistics of Japan, Ministry of Finance. In the demand equations, the popuolation of Japan is included as an exogenous demand shifter. Time trend and a dummy variable are also indluded, the latter of which is one in the years 2007 and 2008 when the canola prices were much higher than other years. The price data were deflated using Japan's CPI (2005=100), which is obtained from IMF-IFS (International Financial Statistics). These data are annual series from 1992 to 2009. The starting year was selected as 1992 because canola imports from Australia to Japan was very few before 1992 (less than 100 tons) and the unit values were very expensive.

3.4.2 Results

First, the linear demand system of Eq. (6) with the exogenous variables were estimated using Zellner's seemingly uncorrelated regressions (SUR). The result is shown in Table 3. Next, the adjustment equations (Eq. (14)) with trend and the dummy variable were estimated using SUR. The result is shown in Table 4.

For the estimated dynamic system to make sense, it must have three properties:

(i) stable system property: $-2 < \mathbf{G}_{11} + \mathbf{G}_{22} < 2$ and $-1 < \mathbf{G}_{11}\mathbf{G}_{22} - \mathbf{G}_{12}\mathbf{G}_{21} < 1$,

(ii) market power index: $-1 \leq v_{ij} \leq 1$,

(iii) adjustment parameter: $\theta_i > 0$.

Chalil (2009) showed the stability condition (i) in the case of two firm model, which is the same as this study. (ii) indicates that the market structure lies between collusion and price taking. If $v_{ij} = -1$, firm i has no market power, which means that the firm is price taker. On the other hand, if $v_{ij} = 1$, firm i has a monopolistic power. And if $-1 < v_{ij} < 1$, the firm has an intermediate level of market power.

Imposing these properties using a classical approach is analyzed to be extremely difficult, if not possible (Karp and Perloff, 1993). Rather than estimating the unconstrained system and hoping that the point estimates lie in the desired range, previous studies employed Bayesian techniques to impose the restrictions. The methodology used here is the same as the previous studies, where Monte Carlo numerical integration with importance sampling is employed.

The result of the Bayesian estimations of the parameters using 100,000 random sample are shown in Table 5. The result indicates that v_{ij} for Canada is higher than that of Australia both in OLE and MPE, which implies that Canada has more market power than does Australia.

4. Conclusion

The empirical results of APT and market power lead us to the conclusion that Canada has market power over Japan in exporting canola, and that price transmission from Canadian canola domestic prices to export prices to Japan is asymmetric so that the excess margin of Canada is not restored to the equilibrium level more quickly than is its excess loss. It follows from this finding that possession of market powr is consistent with positive APT.

On the other hand, Australia, whose share in Japan's canola imports has been one nineth of Canada, does not have market power over Japan. The implication of this is that it is reasonable for Japan to import more canola from Australia, or to diversify the origins.

The contributions of this paper include that APT from Canadian canola domestic prices to export prices were estimated using TAR model, that market powers of Canada and Australia were estimated using LQ model, and that it gave an empirical evidence that positive APT is relevant to the existence of market power. A further direction of this study will be to construct such a way that price transmission and market power are jointly estimated. In addition, further research on theoretical connection of them will be needed.

References

Abdulai, A. (2000). Spatial Price Transmission and Asymmetry in the Ghanaian Maize Market, *Journal of Development Economics* 63, 327-349.

Abdulai, A. (2002). Using Threshold Cointegration to Estimate Asymmetric Price Transmission in the Swiss Pork Market, *Applied Economics* 34, 679-687.

Awokuse, T.O. and Wang, X. (2009). Threshold Effects and Asymmetric Price Adjustments in U.S. Dairy Markets, *Canadian Journal of Agricultural Economics* 57, 269-286.

Ben-Kaabia, M. and Gil, J.M. (2007). Asymmetric Price Transmission in the Spanish Lamb Sector, *European Review of Agricultural Economics* 34, 53-80.

Chalil, D. (2009). *Market Power: Empirical Analysis in the Indonesian Crude Palm Oil Industry*. VDM Verlag Dr. Muller Aktiengesellschaft & Co. KG.

Chan, K.S. (1993). Consistency and Limiting Distribution of the Least Squares Estimator of a Threshold Autoregressive Model, *Annals of Statistics* 21, 520-533.

Deodhar, S.Y. and Sheldon, I.M. (1996). Estimation of Imperfect Competition in Food Marketing: A Dynamic Analysis of the German Banana Market, *Journal of Food Distribution Research* 27, 1-10.

Enders, W. and Granger, C.W.J. (1998). Unit-Root Tests and Asymmetric Adjustment With an Example Using the Term Structure of Interest Rates, *Journal of Business & Economic Statistics* 16, 304-311.

Enders, W. and Siklos, P.L. (2001). Cointegration and Threshold Adjustment, *Journal of Business & Economic Statistics* 19, 166-176.

Engle, R.F. and Granger, C.W.J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing, *Econometrica* 55, 251-276.

Ghoshray, A. (2002). Asymmetric Price Adjustment and the World Wheat Market. *Journal of Agricultural Economics* 53, 299-317.

Gonzales, F., Guillotreau, P., Le Grel, L., and Simioni, M. (2003). Asymmetric Price Transmission with Consistent Threshold along the Fish Supply Chain, INRA Working Paper 2003-02.

Hassan, D. and Simioni, M. (2001). Price Linkage and Transmission between Shippers and Retailers In the French Fresh Vegetable Channel, INRA Working Paper 2001-06.

Karp, L.S. and Perloff, J.M. (1989). Dynamic Oligopoly in the Rice Export Market, *The Review of Economics and Statistics* 71, 462-470.

Karp, L.S. and Perloff, J.M. (1993). A Dynamic Model of Oligopoly in the Coffee Export Market, *American Journal of Agricultural Economics* 75, 448-457.

Meyer, J. and von Cramon-Taubadel, S. (2004). Asymmetric Price Transmission: A Survey, *Journal of Agricultural Economics* 55, 581-611.

Nakajima, T., Matsuda, H., and Rifin, A. (2010). The Structural Change in the Supply Chain of Oil Palm: A Case of North Sumatra Province, Indonesia, Proceedings of the 116th Seminar of European Association of Agricultural Economists, 27-30 Oct 2010, University of Parma, Italy.

Perloff, J.M., Karp, L.S., and Golan, A. (2007) *Estimating Market Power and Strategies*. Cambridge.

Petrucelli, J. and Woolford, S. (1984). A threshold AR(1) model, *Journal of Applied Probability* 21, 270-286.

Sanogo, I. and Amadou, M.M. (2010). Rice market integration and food security in Nepal: The role of cross-border trade with India, *Food Policy* 35, 312-322.

Sichel, D. (1993). Business Cycle Asymmetry: A Deeper Look, *Economic Inquiry* 31, 224-236.

Acknowledgements

I would like to thank Professor Masayoshi Honma, Dr. Katsuhiro Saito, Dr. Hirotaka Matsuda, and participants of seminar classes at the University of Tokyo for comments and suggestions. This research is a part of project “The Economic Research Regarding the Measures for Securing a Stable Food Import” of the Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Japan.

Tables

Table 1 Unit root test results

		ADF
Futures Price	level	-2.62 (1) *
	1st diff.	-12.06 (0) ***
Exports to Japan	level	-2.56 (1)
	1st diff.	-21.02 (0) ***
Exports to the U.S.	level	-2.48 (10)
	1st diff.	-10.05 (9) ***
Exports to ROW	level	-2.42 (10)
	1st diff.	-8.06 (7) ***

Note:

1. Values are statistics for ADF test.

2. Values in parentheses indicate lag order based on the Akaike Information Criteria (AIC).

3. In the equations for all tests, the intercept (no trend) is included.

4. ***, **, and * represent 1%, 5%, and 10% significance, respectively.

Table 2 TAR estimation results

Model	ρ_1	ρ_2	lags	Φ	Asym.	$Q(6)$	BIC	τ
Japan	-0.25***	-0.39***	1	17.22***	2.22	4.69	-2002.6	-0.09
TAR	(0.07)	(0.08)			[0.14]	[0.58]	2nd	
Japan	-0.24***	-0.56***	1	20.34***	7.75***	4.27	-2008.1	-0.07
M-TAR	(0.06)	(0.11)			[0.01]+	[0.64]	2nd	
ROW	-0.78***	-0.65***	2	32.44***	0.98	9.39	-1582.3	0.12
TAR	(0.12)	(0.10)			[0.32]	[0.15]	3rd	
ROW	-0.93***	-0.64***	2	34.63***	4.46**	9.82	-1585.8	0.13
M-TAR	(0.14)	(0.09)			[0.04]-	[0.13]	3rd	
U.S.	-0.76***	-0.39***	0	70.60***	8.73***	1.89	-1376.1	0.13
M-TAR	(0.07)	(0.11)			[0.00]-	[0.93]	1st	
U.S.	-0.78***	-0.43***	0	70.40***	8.46***	1.69	-1375.8	0.15
M-TAR	(0.07)	(0.10)			[0.00]-	[0.95]	1st	

Notes:

1. ρ_1 and ρ_2 are the adjustment coefficients in Eq. (2).

2. “lags” is the lag length in (2).

3. Φ is the F statistic for the test of the null hypothesis $\rho_1 = \rho_2 = 0$. The rejection

regions are based on Enders and Siklos (2001).

4. “Asym.” is the *F* statistic for the test $\rho_1 = \rho_2$. + and - indicate significant positive and negative APT, respectively.

5. *Q*(6) represents the *Q* statistics from the Portmanteau test for white noise, whose null hypothesis is that the error term is white noise up to 6 lags.

6. In BIC, “1st”, “2nd”, “3rd” indicate that the value are the 1st, 2nd, 3rd smallest, respectively.

7. τ is the threshold in (3).

8. For each result, the values in ( ) denote standard errors, and the values in [ ] denote *p* values.

9. ***, **, and * represent 1%, 5%, and 10% significance, respectively.

Table 3 Results of the demand equations

	Price of Canada		Price of Australia	
Imports from Canada	0.0038	(0.0099)	0.0057	(0.0108)
Imports from Australia	-0.0033	(0.0182)	0.0056	(0.0198)
Population of Japan	-2.8033	(6.4971)	-9.7573	(7.0638)
Time trend	885.08	(1079.28)	2211.5*	(1173.4)
2007 and 2008 dummy	19833.3***	(5278.0)	19812.1***	(5738.4)
Constant	376453.2	(810201)	1240558	880877.8
Nunber of observations	18		18	
R^2	0.75		0.77	
Durbin-Watson statistic	1.56		1.47	

Notes:

1. Values in parentheses denote standard errors.

2. ***, **, and * represent 1%, 5%, and 10% significance, respectively.

Table 4 Results of the adjustment equations

	Imports from Canada		Imports from Australia	
Imports from Canada (1 lag)	-0.0015	(0.2485)	-0.1395	(0.1981)
Imports from Australia (1 lag)	-0.1547	(0.2656)	0.5753**	(0.2118)
Time trend	22449.3*	(11909.5)	7606.0	(9496.7)
2007 and 2008 dummy	183971.5	(107825.9)	-173185.7*	(85981.1)
Constant	1579571***	(403203.2)	308930.2	321517.1
Nunber of observations	17		17	
R^2	0.60		0.67	
Durbin-Watson statistic	1.48		2.44	

Notes:

1. Values in parentheses denote standard errors.

2. ***, **, and * represent 1%, 5%, and 10% significance, respectively.

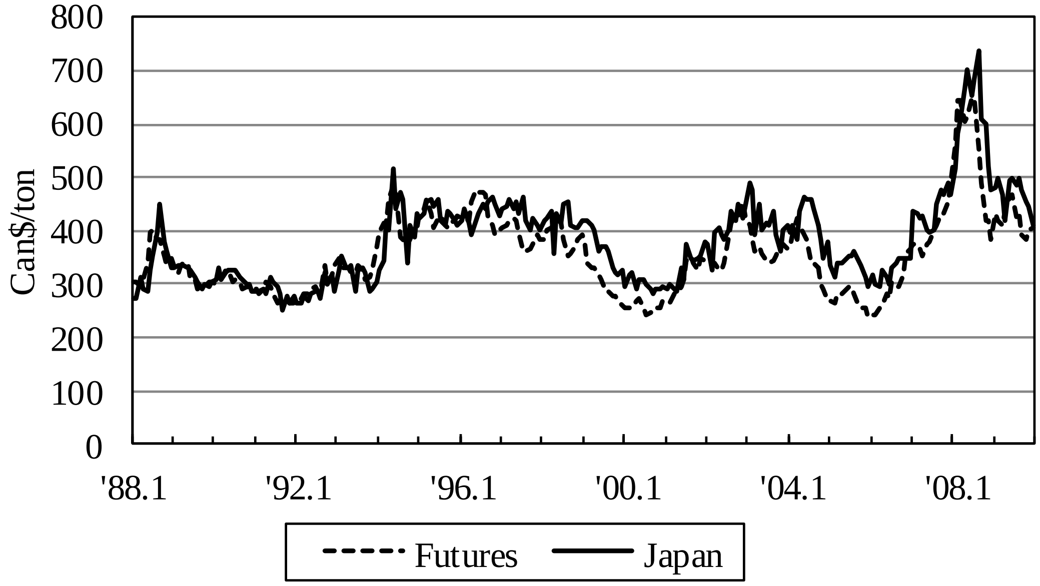
Table 5 Results of market power and adjustment parameters

Strategy	v_{12}	v_{21}	θ_1	θ_2
OLE	-0.4960	-0.7656	0.0039	0.0630
MPE	0.3832	-0.2145	27.4617	5.6325

Notes:

1. The parameters are calculated using the methodology mentioned above with 100,000 Monte Carlo replication.

Figure 1 Futures prices and export prices to Japan



Source: Cereals and Oilseeds Review and Canadian International Merchandise Trade Database (Statistics Canada).