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Apple Export Competition between the United States and China in the Association of Southeast Asian Nations

Jeff Luckstead, Stephen Devadoss, and Ron C. Mittelhammer

We developed a trade model under imperfect competition to analyze the market power of U.S. and Chinese apple producers in the Association of Southeast Asian Nations (ASEAN) market and their domestic markets and the elimination of ASEAN tariffs on U.S. and Chinese apples. We also formulated welfare functions for the United States, China, and ASEAN. Comparative static results are derived to analyze the effect of tariff changes on exports, domestic sales, and welfare. Based on the theoretical model, we derived an econometric specification and used the new empirical industrial organization literature to estimate the market power of U.S. and Chinese apple producers. The econometric model is simulated to quantify the effect of tariff removal on exports and domestic sales.

Key Words: apples, ASEAN, imperfect competition, market power, trade policy

JEL Classifications: F12, F13, L13

U.S. apple production has been stagnant since the late 1980s. The average production was approximately 4.5 million tonnes, peaked briefly to 5.28 million tonnes in 1998, and declined to 4.21 million tonnes by 2010 (Food and Agricultural Organization—FAOSTAT, 2012). U.S. per-capita apple consumption has decreased steadily from its peak at 43.47 pounds in 1987 to 25.74 pounds in 2010 (Food and Agricultural Organization—FAOSTAT, 2012; The World Bank—World Development Indicators Database, 2011). Consequently, expansion to export markets such as the Association of Southeast Asian Nations (ASEAN)[1] is vital for the survival of the apple industry. ASEAN is an important market for U.S. apple exports because recent economic growth, resulting from economic reform, has augmented average per-capita real income from $566 in 1980 to $1665 in 2010 (The World Bank—World Development Indicators Database, 2011). This income growth boosted average per-capita apple consumption from 0.45 pounds in 1980 to 2.52 pounds in 2010 (Food and Agricultural Organization—FAOSTAT, 2012). Because ASEAN countries do not produce apples as a result of the tropical climate, all consumption is met from imports.

The Chinese government implemented substantial reforms to its apple production in 1984 by turning state-owned apple orchards to

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[1] The ten ASEAN countries are Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.

private farms and providing a two million Yuan subsidy to stimulate production (Zhang, Qiu, and Huang, 2009). After these extensive agricultural reforms, Chinese apple production increased dramatically (630%) from 4.56 million tonnes in 1991 to 33 million tonnes in 2010 as a result of low-input costs, particularly labor costs. This dramatic growth in production led to a rise in exports by 581% from 0.17 million tonnes in 1996 to 1.12 million tonnes in 2010. Chinese exports to ASEAN have grown significantly as a result of the close proximity to ASEAN countries, whereas U.S. exports to ASEAN remained stagnant (see Figure 1). Thus, in recent years, ASEAN import demand is largely met by Chinese exports rather than U.S. exports. Consequently, the U.S. market share has been trending downward, whereas the Chinese market share has been trending upward significantly (Luckstead, 2013).

The ASEAN countries imposed tariffs ranging from 5% to 30% on apple imports until 2010 (World Trade Organization—Tariff Analysis Online, 2011). However, on January 1, 2010, the ASEAN China free trade area went into effect, and all tariffs on Chinese imports were eliminated. As a result, Chinese apples continue to displace U.S. apples as a result of the relative price advantage arising from the ASEAN–China trade agreement. Currently, the TransPacific Partnership is under negotiation. If implemented, this regional trade agreement will enhance the access of U.S. apples to the ASEAN market through tariff reductions.

U.S. and Chinese apple exporters together have controlled approximately 77% of the ASEAN apple market (Food and Agricultural Organization—FAOSTAT, 2012). In China, although there are numerous apple growers, they sell their apples to intermediary traders or specialized supply firms who, in turn, sell the apples to packing houses, supermarkets, and processors. Thus, by the time Chinese apples are sold in the domestic market or exported, marketing channels are consolidated (Gale, Huang, and Gu, 2011; U.S. International Trade Commission, 2011). Also, export firms generally incur additional fixed costs, leading to further consolidation, i.e., only large firms with high market shares can operate in the export market (Aw, Chung, and Roberts, 2000). Similarly, in the United States, considerable consolidation occurs in the apple export market. For instance, according to a survey of apple producers in Washington State (the largest apple-producing and -exporting state in the United States), 78% of producers operate under cooperatives and 88% use an intermediary firm when exporting apples to reduce high fixed costs and financial risk (McCracken et al., 1991). Because of concentration, a limited number of U.S. and Chinese firms export apples to ASEAN and control approximately 80% of the market; thus, firms can potentially exert market power. Therefore, it is important to analyze the market power in U.S., Chinese, and ASEAN apple markets and the impacts of ASEAN free trade agreements.

The objectives of this study are to 1) develop a theoretical trade model under imperfect competition to analyze the effects of ASEAN tariff elimination; 2) derive an econometric model from the theoretical analysis and estimate the

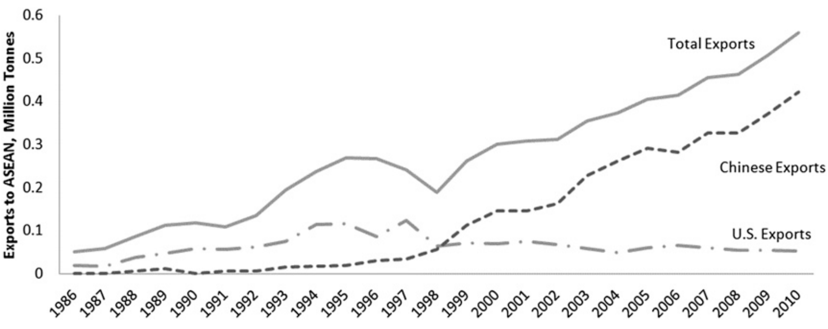

Figure 1. ASEAN Apple Imports

market power parameters; and 3) quantify the impacts of ASEAN tariff elimination on U.S., Chinese, and ASEAN apple markets.

Theoretical Analysis

Following the new trade theory literature,[2] we developed a model to capture the imperfect market structure in the U.S. and Chinese apple industry.[3] U.S. and Chinese producers sell apples in their respective domestic markets, and their exports to ASEAN are subject to tariffs t^i (hereafter, $i = U$ refers to the United States and $i = C$ refers to China). The profit (π^i) functions for the U.S. and Chinese apple industries are

$$\text{(1)} \quad \begin{aligned} \pi^i(y, x^i; t^i) &= \frac{p^A(y)}{(1+t^i)} y^i + p^i(x^i)x^i \\ &\quad - c^i(x^i + y^i) - F^i, \\ i &= U(U.S.), C(China) \end{aligned}$$

where p^A is the price of apples in the ASEAN market, $p^A(y)$ is the ASEAN inverse demand function for apples, $y = y^U + y^C$ is total exports to ASEAN, p^i is the domestic price of apples, $p^i(\bullet)$ is the domestic demand function for apples, x^i is domestic apple sales, $c^i(\bullet)$ is the variable cost function, and F^i is the fixed cost of production.

The first-order conditions (or reaction functions) with respect to y^i and x^i are

$$\text{(2)} \quad \pi^i_{y^i} = \frac{y^i p^A_{y^i}(y) + p^A(y)}{(1+t^i)} - c^i_{y^i}(\bullet) = 0$$

$$\text{(3)} \quad \pi^i_{x^i} = x^i p^i_{x^i} + p^i - c^i_{x^i}(\bullet) = 0.$$

Note that the subscript refers to the derivative of the function. The reaction functions imply a unique solution if they are downward-sloping and satisfy the second-order conditions for a maximum (Brander and Spencer, 1985).

Analytical Results of Trade Liberalization

Next, we analyze the effect of the ASEAN–China free trade area and the TransPacific Partnership negotiation on exports to ASEAN and domestic sales by totally differentiating the first-order conditions (equations [2] and [3]) and expressing them as a linear system $Dq = b$:

$$\text{(4)} \quad \begin{bmatrix} \pi^i_{y^i y^i} & \pi^i_{y^i x^i} & \pi^i_{y^i y^j} & 0 \\ \pi^i_{x^i y^i} & \pi^i_{x^i x^i} & 0 & 0 \\ \pi^j_{y^j y^i} & 0 & \pi^j_{y^j y^j} & \pi^j_{y^j x^j} \\ 0 & 0 & \pi^j_{x^j y^j} & \pi^j_{x^j x^j} \end{bmatrix} \begin{bmatrix} dy^i \\ dx^i \\ dy^j \\ dx^j \end{bmatrix} = - \begin{bmatrix} \pi^i_{y^i t^i} dt^i \\ 0 \\ \pi^j_{y^j t^j} dt^j \\ 0 \end{bmatrix}.$$

We solve this system to analyze the effects of the reduction in the ASEAN tariff on country i's apples on y^i, y^j, x^i, x^j ($i,j = U,C$)[4]:

$$\text{(5)} \quad \frac{dy^i}{dt^i} = -\frac{1}{|D|} \pi^i_{y^i t^i} \pi^i_{x^i x^i} (\pi^j_{y^j y^j} \pi^j_{x^j x^j} - \pi^j_{x^j y^j} \pi^j_{y^j x^j}) < 0$$

$$\text{(6)} \quad \frac{dx^i}{dt^i} = \frac{1}{|D|} \pi^i_{y^i t^i} \pi^i_{x^i y^i} (\pi^j_{y^j y^j} \pi^j_{x^j x^j} - \pi^j_{x^j y^j} \pi^j_{y^j x^j}) > 0$$

$$\text{(7)} \quad \frac{dy^j}{dt^i} = \frac{1}{|D|} \pi^i_{y^i t^i} \pi^j_{x^j x^j} \pi^j_{y^j y^i} \pi^i_{x^i x^i} > 0$$

$$\text{(8)} \quad \frac{dx^j}{dt^i} = -\frac{1}{|D|} \pi^i_{y^i t^i} \pi^i_{x^i x^i} \pi^j_{x^j y^j} \pi^j_{y^j y^i} < 0.$$

A decrease in the tariff on country i's imports will reduce the price of i's apples relative to the price of country j's apples in ASEAN, which leads to higher exports from country i (equation [5]). As exports from country i to ASEAN expand, there are fewer apples available for the domestic market and domestic sales contract (equation [6]). Furthermore, higher apple imports from country i by ASEAN displaces apples imports from country j (equation [7]). As apples are diverted from ASEAN to the domestic market in country j, domestic sales in j increase (equation [8]).

Welfare Analysis of Tariff Reduction

We analyze the effect of a reduction in ASEAN tariffs on U.S., Chinese, and ASEAN welfare.

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[2] See Krugman (1979) and Lancaster (1980) for seminal work in the new trade theory and Brander (1981), Brander and Krugman (1983), and Brander and Spencer (1985) for seminal work in the strategic trade theory.

[3] See Kim, Schaible, and Daberkow (2010) for the impact of market power on trade in the biofuels sector.

[4] $|D| = (\pi^i_{y^i y^i} \pi^i_{x^i x^i} - \pi^i_{y^i x^i} \pi^i_{x^i y^i})(\pi^j_{y^j y^j} \pi^j_{x^j x^j} - \pi^j_{y^j x^j} \pi^j_{x^j y^j}) - \pi^j_{x^j x^j} \pi^i_{y^i y^j} \pi^j_{y^j y^i} \pi^i_{x^i x^i} > 0$ for plausible supply and demand functions.

In the United States and China, profits are earned from exports and domestic sales and apples are consumed domestically. Thus, the welfare function for these countries comprises profits plus consumer surplus:

$$W^i(y,x^i;t^i,t^j) = \pi^i(x^i,y) + \left\{ \int_0^{x^i} p^i(q^i)dq^i - p^i(x^i)x^i \right\}. \tag{9}$$

Because ASEAN does not produce apples, all consumption is from imports and the government imposes tariffs. Hence, the welfare function consists of consumer surplus and tariff revenues:

$$W^A(y,t^i,t^j) = \left\{ \int_0^{y} p^A(q)dq - p^A(y)y \right\} + p^A t^i y^i + p^A t^j y^j. \tag{10}$$

To analyze the effect of a reduction in t^i on welfare in country i, we totally differentiate equation (9) to yield

$$\frac{dW^i(\bullet)}{dt^i} = \overbrace{-\frac{p^A(y)y^i}{(1+t^i)^2} + \frac{y^i p_y^A(y)}{(1+t^i)^2}\frac{\partial y^j}{\partial t^i}}^{PS(<0)} \overbrace{-p_{x^i}^i(x^i)x^i\frac{\partial x^i}{\partial t^i}}^{CS(>0)}. \tag{11}$$

The first term on the right-hand side of equation (11) represents revenues from exports to ASEAN, whereas the second term characterizes the strategic effect of displacing Chinese exports.[5] The combined effect results in a producer surplus (*PS*) gain, i.e., the decline in ASEAN tariff increases country i's profits. The reduction in domestic sales (equation [6]) and a higher domestic price results in a reduction in the consumer surplus (*CS*) as shown by the third term in equation (11). The net effect on welfare is ambiguous; however, because country i is an exporter, the *PS* gain will likely outweigh the *CS* loss, leading to a net gain for country i.

To consider the effect of a decrease in t^i on welfare in country j, we totally differentiate equation (9) to get

$$\frac{dW^j(\bullet)}{dt^i} = \overbrace{\frac{y^j p_y^A(y)}{1+t^j}\frac{\partial y^i}{\partial t^i}}^{PS(>0)} \overbrace{-p_{x^j}^j(x^j)x^j\frac{\partial x^j}{\partial t^i}}^{CS(<0)}. \tag{12}$$

As country j's exports to ASEAN decline (refer to equation [7]), the *PS* declines. This reduction in exports leads to higher sales in j (refer to equation [8]) and a lower price in country j, which augments the *CS*. The net effect on welfare is indeterminate; however, the *PS* loss will most likely outweigh the *CS* gain because of the export market loss.

To examine the effect of a decline in t^i on ASEAN welfare, we totally differentiate equation (10) to obtain

$$\frac{dW^A(\bullet)}{dt^i} = \overbrace{-yp_y^A(y)\frac{\partial y^i}{\partial t^i}}^{CS^i(<0)} \overbrace{-yp_y^A(y)\frac{\partial y^j}{\partial t^i}}^{CS^j(>0)} + \overbrace{t^i y^i \frac{\partial p^A(y)}{\partial y}\frac{\partial y^i}{\partial t^i} + p_y^A(y)t^i\frac{\partial y^i}{\partial t^i} + p^A(y)y^i}^{TR^i(?)} + \overbrace{t^j y^j \frac{\partial p^A(y)}{\partial y}\frac{\partial y^j}{\partial t^i} + p^A(y)t^j\frac{\partial y^j}{\partial t^i}}^{TR^j(?)}. \tag{13}$$

A reduction in t^i results in higher imports and a lower price of country i's apples in ASEAN, which leads to a gain in consumer surplus, CS^i. However, reduced imports from country j leads to a consumer surplus loss, CS^j. This tariff reduction has an ambiguous effect on tariff revenues from country i (TR^i) because the tariff falls but imports rise; the sign depends on where the initial tariff is on the Laffer curve. Tariff revenues from imports of country j's apples is

[5] Because $\frac{\partial y^i}{\partial t^i} > 0$ and $\frac{\partial y^j}{\partial t^i} < 0$, the combined effect $\frac{\partial y}{\partial t^i}$ is ambiguous. However, the direct effect $\frac{\partial y^i}{\partial t^i}$ outweighs the indirect effect $\frac{\partial y^j}{\partial t^i}$, leading to $\frac{\partial y}{\partial t^i} > 0$, which will reduce the ASEAN price $p_y^A(y) < 0$.

also indeterminant because price declines and imports rise. The net effect on welfare is indeterminate; however, ASEAN will likely gain because the consumer surplus gain from increase in imports from country i will dominate the import loss from country j.

Econometric Model Specification

The conceptual econometric model is derived from the theoretical analysis. We follow the new empirical industrial organization literature (see Devadoss, Luckstead, and Mittelhammer [2013], for a detailed discussion) to address issues of identification of the market power parameters (defined subsequently), which are key to the empirical estimation.[6] For econometric analysis, we include, in addition to ASEAN imports from the United States and China, ASEAN imports from the Southern Hemisphere (Australia, Chile, and New Zealand). We consider imports from the Southern Hemisphere exogenous in the estimation because these imports are less than 10% of the total market share in ASEAN.

Rewriting the first-order conditions (equations [2] and [3]), the export and domestic industry supply relations, respectively, are

$$p^A = (1+t^i)mc^i + p^A \eta_{p^A,y} \phi^i_{y,y^i} \tag{14}$$

$$p^i = mc^i + p^i \eta_{p^i,x^i} \phi^i_x \quad i = U, C, \tag{15}$$

where $mc^i = c^i_{y^i}(\bullet) = c^i_{x^i}(\bullet)$ is the marginal cost function for country i, $\eta_{p^A,y} = -\frac{\partial p^A}{\partial y}\frac{y}{p^A}$ is the demand flexibility in ASEAN, $\phi_{y,y^i} = \frac{\partial y}{\partial y^i}\frac{y^i}{y}$ is the market power parameter for country i in ASEAN, $\eta_{p^i,x^i} = -\frac{\partial p^i}{\partial x^i}\frac{x^i}{p^i}$ is the domestic demand flexibility in country i, and $\phi^i_x = \frac{\partial x^i}{\partial x^i}\frac{x^i}{x^i}$ is the industry-level market power parameter in country i, defined as the weighted average of each firm's market power parameter and not necessarily equal to one.[7] As shown by the second term on the right-hand-side of equations (14) and (15), the industry's ability to mark price above marginal cost depends on both demand ($\eta_{p^A,y}$ and η_{p^i,x^i}) and supply (ϕ^i_{y,y^i} and ϕ^i_x) conditions. Higher demand flexibilities (inelastic demand) lead to larger markups because price is more responsive to small changes in quantity. The effect of the market power parameter on markup depends on the concentration and the level of collusion in an industry. Under monopoly (or perfect collusion), the conjectural variation $\left(\frac{\partial y}{\partial y^i}\right)$ and market share $\left(\frac{y^i}{y}\right)$, and thus the market power parameters, are equal to one, and the industry markup is dictated by only the demand flexibility. Under the Cournot assumption, the conjectural variations are equal to one and markups depend on demand flexibilities and market shares. Without the Cournot assumption, markups depend on the interaction of market power parameters and demand flexibilities. Under perfect competition, no firm in the industry is large enough to

[6] See MacDonald and Key (2012) for estimation of market power in the broiler processing sector.

[7] To see this more clearly, start from the firm-level profit for the domestic apple market, $\pi^i_j = p^i(x^i)x^i_j - c^i_j(x^i_j)$, $i = u,c$ and $j = 1, ..., m$ represents individual firms, x^i is total quantity demanded in country i, x^i_j is total quantity supplied by firm j, and $c^i_j(x^i_j)$ is cost of apple production of firm j. The first-order conditions for firm j can be written as $p^i = \frac{\partial c^i_j(\bullet)}{\partial x^i_j} + p^i \eta_{p^i,x^i}\phi^i_{j,x}$ where $\phi^i_{j,x} = \frac{\partial x^i}{\partial x^i_j}\frac{x^i}{x^i_j}$ is the firm-level market power parameter (note that if we started from the industry level profit function, then $\phi^i_x = \frac{\partial x^i}{\partial x^i}\frac{x^i}{x^i}$) and $\eta_{p^i,x^i} = -p^i_{x^i}\frac{x^i}{p^i}$ is the price flexibility. Because firm-level data are generally not available, most studies use industry-level supply relations, which can be derived by aggregating firm-level decisions. Multiplying the first-order condition by firm i's market share $\frac{x^i_j}{x^i}$ and aggregating we obtain $p^i = mc^i(x^i) + \eta_{p^i,x^i}\phi^i_x p^i$ where $mc^i(x^i) = \sum_j \frac{x^i_j}{x^i}\frac{\partial c^i_j(\bullet)}{\partial x^i_j}$ and $\phi^i_x = \sum_i \frac{x^i_j}{x^i}\phi^i_{j,x}$ are, respectively, industry-level marginal cost and market power parameter. When starting from the industry-level profit function, this weighted average is not readily apparent (see Devadoss, Luckstead, and Mittelhammer [2013] for additions analysis).

influence the price, and the conjectural variation, market share, and thus the market power parameter are all equal to zero.

Next, we consider the following demand functions for ASEAN, the United States, and China:

$$(16) \quad p^A = \alpha_0 + \alpha_1 y + \boldsymbol{\alpha_2 z^A}$$

$$(17) \quad p^i = \beta_0^i + \beta_1^i x^i + \boldsymbol{\beta_2^i v^i}$$

and marginal cost functions

$$(18) \quad mc^i = \gamma_0^i + \gamma_1^i w^i + \gamma_2^i (x^i + y^i)$$

where α_k and β_k^i $(k = 0,1,2)$ are ASEAN and domestic demand parameters, $y = y^U + y^C + y^S$ (y^S is total ASEAN imports from the Southern Hemisphere), $\boldsymbol{z^A}$ and $\boldsymbol{v^i}$ are vectors of ASEAN and domestic exogenous demand variables, γ_k^i are marginal cost parameters, and w^i are input prices. The estimable supply relations are derived by substituting the demand flexibilities calculated from equations (16) and (17), and marginal costs (equation [18]) into the supply relations (equations [14] and [15]):

$$(19) \quad \begin{aligned} p^A = {} & \left(1 + t^i\right)\left(\gamma_0^i + \gamma_1^i w^i + \gamma_2^i (x^i + y^i)\right) \\ & - \phi_{y,y^i}^i \alpha_1 y \end{aligned}$$

$$(20) \quad p^i = \gamma_0^i + \gamma_1^i w^i + \gamma_2^i (x^i + y^i) - \phi_x^i \beta_1^i x^i.$$

Because y and $(x^i + y^i)$ are unique variables in equation (19) and α_1 is estimated in the demand function (equation [16]), the marginal cost parameter γ_2^i and market power parameter ϕ_{y,y^i}^i are uniquely identified. Similarly, x^i and $(x^i + y^i)$ are observationally different in equation (20) and β_1^i is estimated in the demand function (equation [17]); thus, the marginal cost parameter γ_2^i and market power parameter ϕ_x^i are also identified. It is also worth pointing out that the specification of equations (19) and (20) allow for market structures to range from perfect competition to oligopoly to monopoly. The market power parameters ϕ_{y,y^i}^i and ϕ_x^i are zero for perfect competition, between zero and one for oligopoly, and equal to one for monopoly.

The market structure in the ASEAN apple market likely changed over the sample period because of increased exports from China starting in the late 1990s (see Figure 1). To account for this structural change, we decompose the market power parameters in the export market as $\phi_{y,y^i}^i = \phi_{y,y^i}^{ia} + \phi_{y,y^i}^{ib}\Gamma(t)$ where

$$(21) \quad \Gamma(t) = \frac{t - t_0}{t_f - t_0} I_{(t_0,t_f]}(t) + I_{(t_f,t_N]}(t),$$

is a piecewise linear drift variable, t is time, t_0 is the start and t_f is the end of the structural change, t_N is the end of the sample period, and I is an indicator function ($I_{(t_0,t_f]} = I_{(t_f,t_N]} = 1$ for the periods $t \in (t_0,t_f]$ and $t \in (t_f,t_N]$, respectively, and zero otherwise). Thus, the market power parameters are defined as $\phi_{y,y^i}^i = \phi_{y,y^i}^{ia}$ for $t < t_0$, $\phi_{y,y^i}^i = \phi_{y,y^i}^{ia} + \phi_{y,y^i}^{ib} \dfrac{t - t_0}{t_f - t_0}$ for $t_0 < t \leq t_f$, and $\phi_{y,y^i}^i = \phi_{y,y^i}^{ia} + \phi_{y,y^i}^{ib}$ for the period $t_f < t \leq t_N$. We select $t_0 = 1996$ and $t_f = 2004$ based on ASEAN market shares (Luckstead, 2013).

Data

The data consist of 23 annual observations covering the period 1986–2008. The price and quantities of U.S., Chinese, and Southern Hemisphere apples sold in ASEAN of U.S. and Chinese apples sold in their domestic markets are obtained from the Food and Agricultural Organization—FAOSTAT (2012). Shipping costs are collected from the U.S. Census Bureau—Foreign Trade Statistics (2011). Input prices (agricultural wage rate, fuel price index, and fertilizer price index) for the U.S. marginal cost are compiled from the U.S. Department of Agriculture—Quick Stats (2011). Input prices (agricultural wage and fuel price index) for the Chinese marginal costs are collected from the National Bureau of Statistics of China—Statistical Data (2011). Exogenous demand variables (gross domestic product, population, and an orange cross-price) are obtained from Food and Agricultural Organization—FAOSTAT (2012), International Labor Organization—LABORSTA (2011), and The World Bank—World Development Indicators Database (2011). The Gross Domestic Product (GDP) deflators for ASEAN, China, and the United States are obtained from the International Monetary Fund—World Economic and Financial Surveys, World Economic Outlook Database (2011). The applied tariff rate on apples entering each ASEAN country is collected from the World Trade

Organization—Tariff Analysis Online (2011). We calculate the tariff rate as a weighted average based on quantity of imports, which ranges from 5% to 11% over the sample period.

Empirical Results

This section presents the empirical counterpart to the conceptual econometric model of the third section and also provides estimation results, describes the Lerner indices, and discusses the simulation results for the elimination of the ASEAN tariffs on apple imports from the United States and China.

Estimation

We estimate the system of seven equations (16) and (17) and (19) and (20) (recall $i = U,C$) in seven endogenous prices and quantities $p^U, p^C, p^A, x^U, x^C, y^U$, and y^C. Given the nonlinearity of the system, we use nonlinear three-stage least squares to account for the endogeneity and cross-equation correlation. The homogeneity condition for the demand functions are achieved by deflating prices and income with the GDP deflators. To reduce the dimensionality of the estimation with minimal information loss, we use principal components to generate inputs indices (w^U and w^C) to estimate the marginal cost functions and exogenous demand variable indices ($\mathbf{z^A}, \mathbf{v^U}$, and $\mathbf{v^C}$) to estimate the demand functions. Because the theory purports that the market power parameters (ϕ^U_{y,y^U} and ϕ^C_{y,y^C}) are between zero and one, we impose these bounds in estimation.

Table 1 defines variables used in the estimation. Table 2 presents the estimated results of the ASEAN apple market.[8] The hypothesis tests are based on the more stringent *t*-distribution than the asymptotic *z*-distribution; the sample size is accounted for in the hypothesis testing. For U.S. apple exports, the parameter estimates for the input price index, trend, and the weight for the drift variable, $\hat{\phi}^{Ub}_{y,y^U}$, are significant at the 10% level or better. The parameter estimates for the input price index and output are positive, implying increases in these variables will result in higher marginal costs. The negative estimate for the trend variable indicates that marginal costs have declined over time, reflecting technological advances. The estimate for the intercept of the U.S. market power parameter, $\hat{\phi}^{Ua}_{y,y^U}$, is small (0.054) and insignificant. This indicates that before $t_0 = 1996$, U.S. apple exporters exerted minimal market power in ASEAN. However, the estimate for the weight on the drift variable, $\hat{\phi}^{Ub}_{y,y^U}$, is 0.160 and significant. This result shows that U.S. exporters' market power in ASEAN increased after 1996.

Table 1. Variable Definition

Variable	Description
y^U	ASEAN imports of U.S. apples (1000 tonnes)
y^C	ASEAN imports of Chinese apples (1000 tonnes)
y^S	ASEAN imports of Southern Hemisphere apples (1000 tonnes)
x^U	Apple sales in the U.S. domestic market (1000 tonnes)
x^C	Apple Sales in the Chinese domestic market (1000 tonnes)
w^U	Index of U.S. input prices: wage, fuel, and fertilizer
w^C	Index Chinese input prices: wage and fuel
z^A	Index of exogenous ASEAN demand variables: GDP, population, and orange price
u^U	Index of exogenous U.S. demand variables: GDP, population, and orange price
u^C	Index of exogenous Chinese demand variables: GDP, population, and orange price
T^i	Tariff rate: $1 + t^i$

ASEAN, Association of Southeast Asian Nations; GDP, Gross Domestic Product.

[8] Given the sample size, we performed a "delete-1 observation" jackknife simulation as a robustness check on the parameter estimates and the results derived from them. The results show that 21 of the 24 parameter estimates were within the 90% jackknife confidence interval. Moreover, for the three parameters lying outside of the confidence intervals, all were in a small neighborhood of a bound of the confidence interval, and moreover, the signs of all 24 parameter estimates were consistent with and supported by the jackknifed confidence intervals.

Table 2. ASEAN Apple Market

Variable/Coefficients	United States (U)	China (C)
	Export Supply Relations	
intercept	−0.989 (0.154)	0.294 (0.000)
$T^i \times w^i$	0.166 (0.003)	0.012 (0.000)
$T^i \times (y^i + x^i)$	0.314e-3 (0.260)	0.110e-4 (0.001)
trend	−0.046 (0.052)	—
$\hat{\phi}^{ia}_{y^i,y^i}$	0.054 (0.759)	0.000 (.)
$\hat{\phi}^{ib}_{y^i,y^i}$	0.160 (0.035)	0.327 (0.000)
	ASEAN Export Demand Function	
intercept	2.098 (0.000)	
$y^u + y^c + y^s$	−0.005 (0.000)	
z^A	0.003 (0.019)	

Note: p values based on the t-distribution are in parentheses. The (.) indicates a restricted parameter estimate reached its lower bound of zero.
ASEAN, Association of Southeast Asian Nations.

All of the parameter estimates in the Chinese export supply relation are highly significant. The estimates for the input price index and output are positive, indicating an increase in input prices and output results in higher marginal costs. The intercept for the Chinese market power parameter, $\hat{\phi}^{Ca}_{y,y^C}$, is at its lower bound of zero, implying that Chinese apple exporters followed marginal cost pricing before 1996. This is because China was in the early stages of expanding its production and exports, and during this period, Chinese exporters had low market shares in ASEAN and could not exert market power. The estimate for the weight on the drift variable, $\hat{\phi}^{Cb}_{y,y^C}$, is 0.327 and highly significant, which suggests that Chinese exporters were able to exert market power after 1996. All the estimated parameters in the ASEAN export demand function are significant at the 5% level. The flexibility of demand $\eta_{p^A,y} = -\frac{\partial p^A}{\partial y}\frac{y}{p^A}$, computed from the coefficient estimate, is –1.16, which is equivalent to an elasticity of 0.86. This estimation indicates that both U.S. and Chinese apple exporters exerted minimal market power in the ASEAN apple market before 1996. After $t_f = 2004$, the Chinese market power parameter was greater than that of the United States.

Table 3 reports the estimation of U.S. and Chinese domestic apple supply relations and

Table 3. Domestic Apple Markets

Variable/Coefficient	United States (U)	China (C)
	Domestic Supply Relations	
intercept	−0.989 (0.154)	0.294 (0.000)
w^i	0.166 (0.003)	0.012 (0.000)
$(y^i + x^i)$	0.314e-3 (0.260)	0.110e-4 (0.001)
trend	−0.024 (0.136)	—
$\hat{\phi}^i_x$	0.024 (0.571)	0.634 (0.000)
	Domestic Demand Functions	
Intercept	1.963 (0.012)	1.164 (0.000)
x^i	−0.001 (0.028)	−0.004e-2 (0.000)
v^i	0.137e-2 (0.002)	0.002 (0.000)
$trend^2$	—	0.003 (0.000)

Note: p values based on the t-distribution are in parentheses. The (.) indicates a restricted parameter estimate reached its lower bound of zero.
ASEAN, Association of Southeast Asian Nations.

demand. Because production costs are the same for apples sold in the domestic and export market, the parameter estimates for both the U.S. and Chinese domestic marginal costs are the same as those presented in Table 2 for the export market (see equations [19] and [20]). The estimate for the U.S. domestic market power parameter, $\hat{\phi}_x^U$, is low at 0.024 and is insignificant. Thus, marginal cost pricing likely prevails in the U.S. domestic market because of numerous highly competitive producers. However, the estimate for the Chinese market power parameter, $\hat{\phi}_x^C$, is 0.634 and is highly significant, indicating that apple sellers in the Chinese domestic market exert market power. The rationale for this results is because of increased concentration and consolidation of apple sales in China (U.S. International Trade Commission, 2011).

All of the parameter estimates in both the U.S. and Chinese domestic demand functions are significant at the 5% level or better. The demand flexibilities computed from the coefficient estimates for the U.S. and Chinese domestic markets are 2.308 (an elasticity of 0.433) and 1.187 (an elasticity of 0.842), respectively. Therefore, price is more responsive to changes in quantity in the U.S. apple market than in the Chinese apple market.

Lerner Indices

The Lerner index measures an industry's ability to exert market power and is computed as the percentage of price markup over marginal cost. The Lerner index is calculated for the ASEAN and U.S. and Chinese apple markets by rewriting the supply relations (equations [14] and [15]), which are given by

$$\text{(22)} \qquad \frac{(p^A - (1+t^i)mc^i)}{p^A} = \eta_{p^A,y}\phi^i_{y,y^i}$$

$$\text{(23)} \qquad \frac{(p^i - mc^i)}{p^i} = \eta_{p^i,x^i}\phi^i_x.$$

As shown on the right-hand side of equations (22) and (23), an industry's ability to mark price above its marginal cost is given by the interaction of the demand flexibility and market power parameter.

Because the volume of Chinese exports expanded dramatically starting in the late 1990s, as shown by Figure 1, the market structure changed over the sample period. To highlight this structural change, we compute the Lerner index (equation [22]) by multiplying the ASEAN flexibilities and market power parameters for each year in the sample. Table 4 reports the point demand flexibilities for the ASEAN market, the U.S. and Chinese market power parameters (calculated using $\phi^i_{y,y^i} = \phi^{ia}_{y,y^i} + \phi^{ib}_{y,y^i}\Gamma(t)$), and the U.S. and Chinese Lerner indices for the ASEAN market.

The point flexibilities in the ASEAN market increase from 0.052 in 1986 to 2.641 in 2008 suggesting the demand conditions varied significantly over the sample period. This is a result

Table 4. Market Power in the ASEAN Export Market

	ASEAN	U.S.		China	
Year	$\hat{\eta}_{p^A,y}$	$\hat{\phi}^U_{y,y^U}$	Lerner	$\hat{\phi}^C_{y,y^C}$	Lerner
1986	0.052	0.054	0.003	0.000	0.000
. . .					
1995	0.573	0.054	0.031	0.000	0.000
t_0 = 1996	0.615	0.054	0.033	0.000	0.000
1997	0.873	0.074	0.065	0.041	0.036
. . .					
2003	2.393	0.194	0.463	0.286	0.685
t_f = 2004	2.408	0.214	0.514	0.327	0.788
2005	2.717	0.214	0.580	0.327	0.889
. . .					
t_N = 2008	2.641	0.214	0.564	0.327	0.864

ASEAN, Association of Southeast Asian Nations.

of improved economic conditions in ASEAN leading to higher income and the expansion of Chinese exports to ASEAN starting in the mid-1990s, which led to a decline in the real ASEAN apple price.

The industry-level market power parameter (ϕ) indirectly measures the number of firms operating in the industry under Cournot competition, as shown in the seminal work by Bresnahan (1982, p. 88), and can be written as $\phi^i_{y,y^i} = \frac{1}{n^i}$. Therefore, although data for the number of firms exporting to ASEAN countries are not available, our results indicate that over the sample, the number of firms operating in ASEAN decrease for both the United States ($\hat{\phi}^U_{y,y^U}$ increased from 0.054 in 1986 to 0.214 in 2008) and China ($\hat{\phi}^C_{y,y^C}$ increased from 0.000 in 1986 to 0.864 in 2008). Therefore, although the volume of trade expanded because of the increased demand by ASEAN and greater supply by China and the United States, the number of U.S. and Chinese exporting firms declined, and consequently each firm controlled a larger market share in ASEAN.

Early in the sample (before 1996), both U.S. and Chinese apples were priced at marginal cost as indicated by very low values of the Lerner indices. By 1996, U.S. apples were marketed at 3.3% above U.S. exporters marginal cost. However, in the following decade, both the U.S. and Chinese Lerner indices steadily rose, and the Chinese Lerner index surpassed that of the United States starting in 2000. By 2008, Chinese exporters marked prices 86.4% over marginal cost, whereas U.S. exporters marked prices only 51.4% over marginal cost. This increase in Lerner indices for both the United States and China is a result of the reduction in firms (increase in ϕ) with greater market shares and demand conditions (increase in η). In China, dramatic increases in supply and exports, along with greater consolidation (fewer firms exporting more), lead to more market power. For the U.S. firms to compete effectively with Chinese firms, they have to be more efficient, which can occur through consolidation, higher market share, and greater market power. Thus, U.S. market power in ASEAN also increases, albeit by a smaller magnitude than that of Chinese market power.

Table 5 reports the flexibilities, market power parameters, and Lerner indices for the U.S. and Chinese domestic markets. As discussed in the domestic demand estimation results, the demand flexibility estimates show that the U.S. apple price is more responsive to quantity changes than the Chinese apple price. However, the Chinese domestic market power parameter suggests a higher level of concentration in the Chinese market than in the U.S. market. The Lerner index suggests that the U.S. producers' markup is low at 5.6% over market cost. In the Chinese market, apples are marked 75.3% above marginal costs.

These findings are consistent with the industry evidence that export firms are more concentrated than domestic market, particularly for U.S. firms (see McCracken et al. [1991] for industry evidence pertaining to the United States, and Gale, Huang, and Gu [2011] and U.S. International Trade Commission [2011] for industry evidence pertaining to China).

Simulation Results

The ASEAN–China free trade area went into effect on January 1, 2010, eliminating ASEAN tariffs on apple imports from China. Also, the TransPacific Partnership, if implemented, will eliminate some ASEAN tariffs on U.S. apples. Therefore, in this section, we quantify the effects of tariff removal on U.S. and Chinese apples by simulating the econometric model. For this simulation analysis, we run the baseline scenario and three alternate scenarios. In

Table 5. Market Power in the U.S. and Chinese Markets

	United States			China		
Year	$\hat{\eta}_{p^U,x^U}$	$\hat{\phi}^U_x$	Lerner	$\hat{\eta}_{p^C,x^C}$	$\hat{\phi}^C_x$	Lerner
Average 1986–2008	2.308	0.024	0.056	1.187	0.634	0.753

Table 6. Simulation: Elimination of Tariffs

	Chinese Tariff		U.S. Tariff		Both Tariffs	
Export Market	Difference	Percent	Difference	Percent	Difference	Percent
y^{US}	−185.255	−256.7	269.246	369.8	73.721	98.8
y^{CH}	203.657	73.8	−268.552	−98.1	−54.689	−20.6
p^{A}	−0.101	−12.0	−0.003	−0.5	−0.104	−12.5
Domestic Market						
x^{US}	70.083	3.0	−102.251	−4.5	−28.290	−1.2
p^{US}	−0.059	−6.9	0.085	10.1	0.023	2.9
x^{CH}	−70.868	−0.4	94.186	0.6	19.792	0.1
p^{CH}	0.004	0.7	−0.005	−1.0	−0.001	−0.2

Difference is the difference in the alternate and baseline scenarios (quantities are in 1000 tonnes and prices are mean in U.S. dollars) and percent is the percentage difference between the alternate and baseline scenarios.

the baseline scenario, we solve the parameterized econometric model of seven equations ([16] and [17] and [19] and [20]) for the seven endogenous variables ($p^U, p^C, p^A, x^U, x^C, y^U$, and y^C). The three alternate scenarios are elimination of 1) the Chinese tariff; 2) the U.S. tariff; and 3) both tariffs.[9] The alternate scenarios are compared with the baseline to quantify the magnitude of trade liberalization effects. We average the results over the last seven years because the end of the sample period more accurately represents the current market conditions.

Table 6 presents the results of all three simulations. The directional effect for all the simulation results are consistent with the predictions of the theoretical analysis. The removal of the tariff on Chinese apples expands Chinese apple exports to ASEAN by 73.8% (203,657 tonnes). The increase in Chinese exports displaces U.S. exports, which decline by 256.7% (185,255 tonnes). Because U.S. and Chinese apples are modeled as homogeneous goods, the increase in Chinese apple exports leads to a reduction in U.S. apple exports by nearly the same amount. As discussed in the theoretical section, the direct effect of the higher Chinese apples exports dominates the indirect effect of the reduction in U.S. apple exports. As a result, net exports to ASEAN expand by 18,402 tonnes, resulting in an ASEAN price decline of 12%. The higher Chinese exports to ASEAN cause domestic sales in China to decline by 0.4% (70,868 tonnes) and the Chinese domestic price to rise by 0.7%. Similarly, fewer U.S. exports to ASEAN causes domestic sales to expand by 3.0% (70,083 tonnes) and the U.S. domestic price to drop by 6.9%.

The removal of the tariff on U.S. apples results in a rise of U.S. exports by 370% (269,246 tonnes), which causes Chinese exports to decline by 98.1% (268,552 tonnes). The substitutability of U.S. apples for Chinese apples in the ASEAN market causes the Chinese exports to decline by roughly the same amount as the increase in U.S. exports. However, the direct effect of higher U.S. apple exports dominates the indirect effect of the reduction in Chinese apple exports, and net exports to ASEAN rise by 694 tonnes causing the ASEAN price to fall by 0.5%. The higher U.S. exports to ASEAN cause U.S. domestic sales to decline by 4.5% (102,251 tonnes) and the U.S. prices to increase by 10.1%. Similarly, fewer Chinese exports to ASEAN causes Chinese domestic sales to rise by 0.6% (94,186 tonnes) and Chinese price to fall by 1%.

Next, we analyze the impact of simultaneously eliminating both the U.S. and Chinese tariffs. Because the own- and cross-effects, equations (5) and (7), respectively, of tariff elimination have conflicting signs, ex ante we do not know which countries' exports will increase or decrease after the tariff reform. This will mainly be determined by the U.S. and Chinese export

[9] To improve the accuracy of the simulation, we use add factors following Intriligator (1983) to calibrate the model to the observed historical outcomes.

supply conditions because the ASEAN demand conditions are the same for both countries' exporters. Simultaneous elimination of both tariffs results in U.S. exports increasing by 98.8% (73,721 tonnes) and Chinese exports declining by 20.6% (54,689 tonnes). Net exports rise by 19,032 tonnes, which drives the ASEAN price down by 12.5%. This result highlights that complete free trade will favor U.S. exporters. As U.S. exports to ASEAN increase, sales in the U.S. domestic market contract by 1.2% (28,290 tonnes) and the U.S. domestic price rises by 2.9%. The decline in Chinese exports results in higher domestic sales of 0.1% (19,792 tonnes), which results in a price decline of 0.2%.

Conclusions and Implications

Since the late 1980s, U.S. apple production and consumption has stagnated, whereas Chinese apple production increased dramatically starting in the early 1990s. An important export market for both U.S. and Chinese apples is the ASEAN's free trade area because this region does not produce apples as a result of the tropical climate. Since the mid-1980s, the ASEAN apple market has been dominated either by U.S. or Chinese exporters. Before 2010, all apple imports by ASEAN were subject to tariffs. However, the ASEAN–Chinese free trade area was implemented starting in 2010, which eliminated the tariff on Chinese apples. Also, if the TransPacific Partnership is finalized, the ASEAN tariff on U.S. apples will be eliminated.

We analyze the competition of U.S. and Chinese apple producers in their domestic markets and exporters in the ASEAN market by developing a trade model based on strategic trade theory. We specify welfare functions for the United States, China, and ASEAN. We derive comparative static results to qualitatively analyze the effect of a change in the ASEAN tariff on U.S. and Chinese apple exports on U.S., Chinese, and ASEAN markets. The analytical results show that elimination of the ASEAN tariff on one country adversely impacts the other country.

Based on the strategic trade model, we derive an empirical specification for an econometric model that is estimated to compute the market power of U.S. and Chinese apple producers in the ASEAN and their domestic markets. We simulate the econometric model to quantify the effects of tariff removal. The simulation results corroborate the comparative static analysis. The results show that the elimination of the Chinese tariff as per the ASEAN–China free trade area contracts U.S. exports to ASEAN. However, complete free trade that would result from the TransPacific Partnership will favor U.S. apple producers as U.S. apple exports displace Chinese apple exports.

The Lerner index results for the ASEAN market is higher for both the U.S. and Chinese exports than in their respective domestic markets, which confirms that more consolidation occurs in the export market than in the domestic markets.

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