An Economic Analysis of Sanitary and Phytosanitary Barriers to Trade

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Abstract

In order to estimate the effects of changing SPS barriers to trade on Washington State apples in China, India, Mexico and Taiwan, we started by characterizing the full export model. The SPS costs elasticities obtained from the export supply equations were used in the revenue simulation. Our results bring some promising information to Washington State apple producers. China is confirmed as an attractive market, regardless of SPS barriers to trade. Exports to Mexico and Taiwan may increase significantly if SPS barriers are reduced. Even though exports to India may decrease if SPS barriers are enforced, the loss may be insignificant.

Keywords: SPS barriers to trade, revenue effects, apples.

JEL Code: F14, Q17, Q18.

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The Sanitary and Phytosanitary Measures Agreement of the World Trade Organization (WTO) allows its members to set standards on food products to protect domestic consumers. In practice, sanitary and phytosanitary (SPS) barriers take the form of import standards or regulations that reflect the country's concern for SPS issues that could harm domestic producers. These concerns include the introduction of disease or other pests, and some claim that SPS barriers exist in certain countries to protect domestic producers from international competition (Yue, Beghin and Hensen 2006).

According to USDA/FAS (2006) "trade issues continue to be a significant barrier for US apples in certain destination markets". Specifically, SPS barriers related to fire blight, codling moth, apple maggot and other pests limit or prohibit US apple exports to some countries (Krissoff, Calvin and Gray 1997). SPS barriers may also reduce the flow of apples into a country by imposing quarantine restrictions that delay shipments. Often the level of SPS requirements is more restrictive than scientists consider necessary to protect the domestic product.[1] SPS barriers sometimes raise unnecessary costs to producers. It is argued that reducing SPS barriers to trade will decrease costs to producers and increase exports. We examine the effect of SPS barriers to trade imposed by China, India, Mexico and Taiwan on the Washington State apple industry. The specific question we answer in this study is what are the effects of changing the level of SPS barriers to trade on the revenue received by Washington State producers.

[1] It should be noted that the scientific levels themselves generate significant debate.

Apple production and exports are important for the United States and Washington State. Apples are the third most valuable fruit crop in the United States, after grapes and oranges (Dimitri, Tegene and Kaufman 2003). The United States is the second largest producer and one of the top five exporters of apples in the world. Nearly 60 percent of the US produced apples, and around 85 percent of the US exported apples are grown in Washington State. However, trade barriers affecting US apples limit the amount of US exports or impose additional costs on US apple producers and exporters, thereby reducing the revenue for the US apple industry.

Some work has been done regarding the demand for US apples in other countries and the effects of removing or reducing trade barriers. Different approaches have been taken. Import demand, export demand, gravity equation and general or partial equilibrium models are commonly used for trade estimation (Arize 2001; Calvin and Krissoff 1998 and 2005; Devadoss and Wahl 2004; Krissoff, Calvin and Gray 1997; Seale, Sparks and Buxton 1992; Yue, Beghin and Jensen 2006). The most common method used to calculate an SPS tariff equivalent is the price wedge approach (Calvin and Krissoff 1998 and 2005; Krissoff, Calvin and Gray 1997; Yue, Beghin and Jensen 2006). The price wedge or tariff equivalent approach measures the difference in price between the imported good and the product in the domestic market (Beghin and Bureau 2001). This difference is attributed to transportation costs, tariffs and non-tariff barriers (NTB). The limitations of this method are: the impossibility to distinguish between the different NTBs; the data available is rarely specific enough to reflect differences in quality of imported products; and even if the data have the level of detail needed, domestic goods are assumed to be perfect substitutes for imported goods, which is a very strong assumption.

We estimate the complete system of equations that characterize the export model, including all stages involved, and we incorporate an estimate of the cost of complying with the

SPS regulations in order to obtain more precise estimates than with the price wedge method. This study complements the literature by including a direct estimate of the SPS compliance costs, by analyzing countries not thoroughly studied before and by estimating price elasticities while including SPS costs in the model. Then, we estimate quantity changes for Washington State apples given specific SPS barrier reductions. This allows us to calculate the associated revenue changes with changes in the SPS restrictions. Our results yield estimates to provide policy recommendations that can be used by the industry to argue for the reduction of SPS barriers in other countries.

Virtually none of the import or export demand models analyze trade barriers. Import and export demand models usually only calculate the corresponding import and export demand elasticities that are then used in different studies. Most of the studies of the effects of trade barriers use price and income elasticities from the literature instead of estimating the elasticities directly. Subsequently, they use those elasticities to analyze the effect of removing trade barriers on the demand for US apples (Krissoff, Calvin and Gray 1997, Calvin and Krissoff 1998 and 2005). However, two studies analyzing trade barriers, Yue, Beghin and Jensen (2006) and Devadoss and Wahl (2004), estimate their own elasticities and analyze the effect of reducing barriers to trade.

Krissoff, Calvin and Gray (1997) analyze the effects of removing SPS requirements in Japan, South Korea and Mexico on US apple exports to those countries. Calvin and Krissoff (1998 and 2005) quantify the SPS barriers for US apples in Japan and estimate the trade and welfare effects for Japan of removing those barriers, specifically for Fuji apples. These authors use a partial equilibrium model to estimate trade flows simulating a reduction in SPS barriers to trade. Yue, Beghin and Jensen (2006) estimate the tariff equivalent of technical barriers to trade

(TBT) for apples in Japan. Afterward, they evaluate the effect of removing the Japanese TBT on US apple exports using the gravity equation. All these studies use the price wedge approach to estimate the tariff equivalent of the SPS barriers to trade. These studies yield different results, while Krissoff, Calvin and Gray (1997) and Calvin and Krissoff (1998 and 2005) find great increase in US apple exports after SPS barriers are removed, Yue, Beghin and Jensen (2006) find limited export increase for US apples after removing the barriers in Japan. Devadoss and Wahl (2004) estimate supply, demand and excess supply equations to examine welfare effects under different trade scenarios reducing the ad valorem tariff for apples in India. They conclude that India will greatly benefit from reducing trade barriers.

There is evidence suggesting that SPS restrictions may greatly reduce the amount of US apple exports. Estimates of the increased value of US apples exported if SPS barriers are removed vary by author and country, ranging from $5 million US dollars (USD) to $280 million USD, with most estimates in the $5 to $50 million USD range (Krissoff, Calvin and Gray 1997; Northwest Horticultural Council 2004; Loveland and Hamilton 2007). These studies suggest that the reduction of SPS barriers could greatly benefit the Washington apple industry.

The rest of the article proceeds as follows. The next section presents the model, including the theoretical background and empirical specification. We then describe the data and empirical issues. Results are then presented. The article ends with some brief conclusions.

Model

Theoretical Background

In order to specify the demand and supply equations used for the revenue simulation, we need to start by examining the Washington State apple industry. Washington State apple producers require the services of warehouses for the commercialization of their product. Some producers own the warehouses, while others contract for the provided services. Nonetheless, warehouses do not buy the apples, they solely provide the intermediary service to the producers, and charge them for it.

Warehouses are in charge of sorting, grading, packing and storing the apples and are also responsible for all the sales, marketing, and paperwork related to exports and regulation compliance. Warehouses may contract with other companies or provide all or some of these services internally. Contracting for services or internalizing usually depends on the country apples are exported to. All the SPS paperwork is done at the warehouse level. Only a few countries, like Japan, require SPS regulations that impose a direct cost on the producer by requiring extra steps in the production method. Most of the time it is the producer who bears the SPS compliance costs.

The importer is responsible for paying the transportation costs from the warehouse to the importing country, and the corresponding ad valorem tariffs and taxes if applicable. The importer pays directly to the warehouse Free On Board (FOB)[2] prices in USD for the apples. These FOB prices are determined internationally by supply and demand forces and depend on the variety, size, grade and packaging of the apples. Exchange rate fluctuations may play an important role since the importer pays the product in USD.

The export model consists of the supply function for warehouses or exporters (export supply equation) and the demand function for importers (import demand equation). Once we characterize the supply and demand equations, we can analyze the revenue changes given different scenarios for SPS barriers.

[2] FOB price quotations include the cost of loading the product onto the transportation carrier, while the transportation cost and insurance are not included.

To derive the export supply and the import demand equations, we start by specifying an industry indirect profit function for exporters in Washington and importers in each country studied. We assume that exporters and importers are price taking firms. This is a valid assumption since China[3], India, Mexico and Taiwan are small players in apple imports. Even though the United States is the second largest apple exporter with a share of apple exports of approximately 16 percent, there are many individual exporting firms in the United States justifying the price taking assumption.

The exporter's profit is a function of output prices, input price, cost of value added activities and services, and SPS costs. Even though the warehouse charges the producer for the SPS compliance paperwork and at the end the producer is the one who bears the SPS compliance cost, these SPS compliance costs also limit the quantity exported by requiring quarantine measures or other fumigation treatments that delay shipments and it makes the apples more expensive. Thus, SPS barriers should be part of the exporter's profit function. The indirect profit function for the exporting industry can be defined in a general form by:

$$(1) \qquad \Pi(p,w,SPS,cost) = \Pi(y(p,w,SPS,cost),x(p,w,SPS,cost)),$$

where $\Pi(p,w,SPS,cost)$ represents the indirect profit function for the exporting industry; *p, w, SPS, cost, y,* and *x* are vectors of output prices, input prices, SPS costs, the cost of value added activities and services, output quantities, and input quantities, respectively.

The conditional factor output supply (export supply) equation for apples is obtained by applying Hotelling's Lemma to the profit function for the exporting industry:

$$(2) \qquad \frac{\partial \Pi(p,w,SPS,cost)}{\partial p} = y(p,w,SPS,cost).$$

[3] China has dramatically increased apple imports in the last 10 years, but it remains a small player in the international arena regarding apple imports.

The importer's profit is a function of output price, input prices, ad valorem tariff, and exchange rate. The indirect profit function for the importing industry can be defined in a general form by:

(3) $$\Pi(p,w,TR,ER) = \Pi(y(p,w,TR,ER),x(p,w,TR,ER)),$$

where $\Pi(p,w,TR,ER)$ represents the indirect profit function for the importing industry; *p, w, TR, ER, y,* and *x* are vectors of output prices, input prices, ad valorem tariffs, exchange rate, output quantities, and input quantities, respectively.

Applying Hotelling's Lemma to the indirect profit function for the importing industry, we derive the conditional factor input demand (import demand) equation for apples:

(4) $$\frac{\partial\pi(p,w,TR,ER)}{\partial w} = -x(p,w,TR,ER).$$

We estimate the export supply (equation 2) and import demand (equation 4) equations as explained in the following section.

Empirical Specification

In order to estimate the effects of SPS barriers to trade we use the specific profit function for the importers and exporters and from these derive the import demand and export supply equations. The normalized quadratic functional form is chosen to describe both importers' and exporters' profit functions. Due to its flexibility and properties such as the estimation of own- and cross-price and substitution elasticities, constant returns to scale and homogeneity in prices (through price normalization), we consider the normalized quadratic to be an adequate functional form (Diewert and Morrison 1986; Featherstone and Moss 1994; Marsh 2005; Shumway, Saez and Gottret 1988). The profit function for the importing industry is given by:

(5) $$\Pi_m^*(mp^*) = \alpha_0 + \sum_{i=1}^{k} \alpha_i mp_i^* + \frac{1}{2}\left(\sum_{i=1}^{k}\sum_{j=1}^{k} \alpha_{ij} mp_i^* mp_j^*\right) + \alpha_t TR + \sum_{i=1}^{k} \alpha_{it} mp_i^* TR + \frac{1}{2}\alpha_{tt}(TR)^2 + \alpha_e ER + \sum_{i=1}^{k} \alpha_{ie} mp_i^* ER + \frac{1}{2}\alpha_{ee}(ER)^2$$

where $\Pi_m^* = \Pi_m / wp$ and $mp_i^* = mp / wp$ represent the normalized profit and import or input prices for importers, and *wp* is the wholesale or output price. Subscript *i* represents the different countries exporting apples to the importing country and subscript *k* represents the number of exporting countries to that country. *TR* is the ad valorem tariff rate and *ER* represents the exchange rate, both are specific for the importing country. The corresponding import demand equations after applying Hotelling's Lemma are:

(6) $$-mq_i = \alpha_i + \sum_{j=1}^{k} \alpha_{ij} mp_j^* + \alpha_{it} TR + \alpha_{ie} ER$$

for *i*=1,…,*k*., where *mq* is the imported quantity from the United States by country *i*. The import demand equation for Mexico also includes an anti-dumping duty variable.[4] Mexico has been imposing anti-dumping duties to US red and golden delicious apples[5] since September 1st, 1997. These duties started at a rate of 101.1 percent and have been eliminated, re-imposed, and decreased since then. The current anti-dumping duty is 47.05 percent for most apple exporters.

The profit function for the exporting industry is:

(7) $$\Pi_x^*(xp^*) = \beta_0 + \sum_{i=1}^{n} \beta_i xp_i^* + \frac{1}{2}\left(\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} xp_i^* xp_j^*\right) + \beta_s SPS + \sum_{i=1}^{n} \beta_{is} xp_i^* SPS + \frac{1}{2}\beta_{ss}(SPS)^2 + \beta_c Cost + \sum_{i=1}^{n} \beta_{ic} xp_i^* Cost + \frac{1}{2}\beta_{cc}(Cost)^2$$

where $\Pi_x^* = \Pi_x / pp$ and $xp_i^* = xp / pp$ represent the normalized profit and export or output prices for exporters, and pp is the producer or input price. Subscript *i* represents the different

[4] Anti-dumping duties are the duties imposed by an importing country when an exporting country prices its product at a price below the own domestic price or below its production cost.
[5] These are the two main varieties exported to the Mexican market.

countries importing apples from Washington State and subscript n represents the number of countries that Washington State exports to. *SPS* represents the cost of complying with the SPS regulations and *Cost* is the cost of the value added activities and services.

SPS costs are specific for the importing country. Mexico and Taiwan require US producers to comply with detailed work plans to be able to export. The work plan for Mexico is related to phytosanitary policies and it includes the inspection of growing and shipping areas, a cold storage treatment, and extensive inspections of the fruit prior to shipping. The work plan for Taiwan includes orchard certifications, packing house registration, a cold storage treatment and extensive inspections. This work plan was implemented in August 2003 after two codling moth incidents in 2002 which disrupted US apple exports to Taiwan (Miller 2003).

The corresponding export supply equations after applying Hotelling's Lemma are:

$$(8) \qquad xq_i = \beta_i + \sum_{j=i}^{n} \beta_{ij} xp_j^* + \beta_{is} SPS + \beta_{ic} Cost$$

for i=1,…,n., where xq is the exported quantity from the United States to country i. The export supply equation for Taiwan also includes a binary variable equal to one for time that the three-strike policy has been in place from August 2003 to date, and zero otherwise. The work plan for Taiwan includes a three-strike system for codling moth detection, in which the whole Taiwanese market is closed to US apples if there are three occurrences of codling moth in independent shipments per apple season. From December 2004 to April 2005 the Taiwanese market was closed to US apples due to three codling moth incidents. There were two codling moth detections in the past season.

Once we obtain the estimated coefficients on the import demand and export supply equations, we calculate the corresponding elasticities. Then, we use those elasticities to simulate revenue and quantity changes for Washington State apple producers when increasing and decreasing SPS costs.

Data and Empirical Issues

The data are monthly from January 1995 to March 2007 for China, Mexico and the United States, from January 1999 to March 2007 for India, and from January 1996 to March 2007 for Taiwan. The import quantities and values for all countries involved in the analysis consist of kilograms (kg) and USD for imports of fresh apples (Harmonized System code 080810) for China, India, Mexico, and Taiwan. Quantities were transformed to 1,000 pounds and prices to USD/pound. The import valuation is done in Cost, Insurance and Freight Import Value (CIF)[6], except for Mexico that reports import valuation in FOB prices. Unit import prices (CIF prices in USD/kg or FOB prices in USD/kg for Mexico) for the United States and its main competitors in each market are obtained by dividing import value by quantity imported for each country. The competitors included in the import demand equation for China are New Zealand and Chile; China and New Zealand are included in the equation for India; Canada, Argentina and Chile are included for Mexico; and Japan, Chile and New Zealand are included for Taiwan. Not all countries import apples from the United States or its main competitors in all months and thus, prices and quantities are not available for the complete time series. These data were obtained from the Global Trade Atlas.

Monthly retail prices of Fuji apples for China from January 1995 to September 2007 were provided by Fred Gale, Senior Economist at the Economic Research Service, USDA. Monthly wholesale prices of apples for India from May 2000 to September 2007 were obtained from the

[6] CIF value includes insurance costs, transportation and miscellaneous charges to the first port of arrival in the importing country.

Agricultural Marketing Net of the Indian Government (website: http://dacnet.nic.in/dmi/agmarkweb/SA_Pri_Month.aspx). Monthly wholesale prices of Red Delicious, Golden Delicious and Starking apples for Mexico from January 1995 to September 2007 were obtained through the Sistema Nacional de Información e Integración de Mercados of the Secretaría de Economía (website: http://www.economia-sniim.gob.mx/). Monthly wholesale prices of Red Delicious, Golden Delicious, and Fuji apples for Taiwan from January 1996 to September 2007 were obtained through Taiwan's Council of Agriculture (website: http://amis.afa.gov.tw).

Information on tariffs was obtained from the Foreign Agricultural Service of the USDA, the TRAINS database of the United Nations Conference on Trade and Development, and the Northwest Horticultural Council website (www.nwhort.org). Monthly exchange rate data for China, India, Mexico and Taiwan were obtained from the Pacific Exchange Rate Service, Sauder School of Business, University of British Columbia. In the import demand equation for Mexico an anti-dumping variable was added. Information on this variable was obtained through the Foreign Agricultural Service of the USDA.

The export quantities and values, similar to the import data, consist of kg and USD for exports of fresh apples for the United States. Quantities were transformed to 1,000 pounds and prices to USD/pound. The export valuation is done in Free Along Ship Export Value (FAS)[7]. Unit export prices (FAS prices in USD/kg) for the United States to each market are obtained by dividing export value by quantity exported to each country. The competitors included in the export supply equation for China and Taiwan are Canada and Mexico; Canada, Mexico and the US retail price are included in the equation for India; and Canada and the United Kingdom are included for Mexico. These data were obtained from the Global Trade Atlas. There are some

[7] FAS value includes the value of exports at the export port including inland transportation, insurance and other costs of placing the goods alongside the carrier. This quotation excludes loading charges, freight, and insurance.

discrepancies in the data depending on the reporting country. US apple exports (reported by the United States) do not necessarily match with imports of US apples (reported by each country studied). Producer prices by month in Washington State were obtained from the National Agricultural Statistics Service. These prices were converted from US cents/pound to USD/pound.

The calculation of SPS costs was done in two parts. First, telephone interviews were conducted. We identified 21 apple exporters in Washington State as potential participants of the interviews. From this sample, we obtained 13 complete interviews. Second, we contacted the Washington State Department of Agriculture (WSDA), to obtain information regarding costs associated with the various certificates and inspections for each country. This information (including changes over time) was provided by Jason Kelly, Communications Director, WSDA. With the information from the telephone interviews to exporters and the WSDA, we were able to calculate the price in USD per 1,000 pounds to comply with the SPS regulations to each of the countries analyzed.

The cost index variable refers to the monthly total food marketing cost index, obtained from the Economic Research Service of the USDA. In the export supply equation for Taiwan a three-strike variable was added. Information on this variable was obtained through the Foreign Agricultural Service of the USDA. Summary statistics for all variables used in the estimation are presented in the appendix.

Empirical Issues

Tests for normality, heteroskedasticity, autocorrelation, seasonality, unit root and endogeneity of prices were performed. The data does not present enough evidence to reject the normality assumption in all equations. The hypotheses of homoskedasticity, unit root and endogeneity of prices were rejected in all equations. Autocorrelation of order one and seasonality were found in most equations (import demand and export supply equations for China and India, export supply equation for Mexico and autocorrelation only in export supply equation for Taiwan).

We correct for heteroskedasticity in the estimation method as described in the results section. A one-month lag of the dependent variable and a binary variable[8] describing the apple season in the corresponding country were added to the corresponding equation to account for autocorrelation and seasonality in the data. There is economic as well as econometric justification to include a one-month lag in the model. Adding a one-month lag of the dependent variable is consistent with the theory of adaptive expectations, given that apple transactions are done in a short term basis.

In the import demand equation for China, the US import price, the NZ import price and the China retail price were normalized using the Chile import price instead of the China retail price due to multicollinearity problems between the Chile import price and the NZ import price. In the import demand equation for India, the US import price, the China import price and the NZ import price were normalized using the India wholesale price. The ad valorem tariff variable was dropped due to not enough variation in the time period studied.[9] In the import demand equation for Mexico, the US import price, the Canada import price, the Argentina import price and the Chile import price were normalized using the Mexico wholesale price. The exchange rate variable was not used due to multicollinearity with the US import price variable. In the import demand equation for Taiwan, the US import price, the Japan import price, the Chile import price and the NZ import price were normalized using the Taiwan wholesale price.

[8] Apple season equals one during the apple season months in the corresponding country and zero otherwise.
[9] The ad valorem tariff in India was 40 percent from January 1999 to December 2000 and 50 percent afterwards.

In the export supply equation for China, the China export price, the Canada export price and the Mexico export price were normalized using the Washington State producer price. In the export supply equation for India, the India export price, the Canada export price and the US retail price were normalized using the Mexico export price due to multicollinearity between the Mexico export price and the India export price when normalized using the Washington State producer price. In the export supply equation for Mexico, the Mexico export price, the Canada export price and the UK export price were normalized using the Washington State producer price. In the equation for Mexico, the monthly packaging food marketing cost index was used instead of the total food marketing cost index due to multicollinearity problems between the total food marketing cost index and the export price. In the export supply equation for Taiwan, the Taiwan export price, the Canada export price and the Mexico export price were normalized using the Washington State producer price.

Results

We estimate the complete set of import demand and export supply equations (equations 6 and 8) as seemingly unrelated estimation for each country using STATA. We consider the import demand and export supply equations as a complete set since they represent a joint export decision (Diewert and Morrison 1986; Goldstein and Khan 1978). The estimation was done in two steps to correct for the heteroskedasticity found in the data. In the first step, ordinary least squares was used to obtain estimates for each equation. In the second step, seemingly unrelated estimation was used to allow for correlation between the import demand and export supply equations and to correct for heteroskedasticity. The result is a single parameter vector and a simultaneous robust covariance matrix.

Results from the seemingly unrelated estimation are reported in tables 1 to 4 for China, India, Mexico and Taiwan, respectively. These results were used to calculate demand and supply elasticities at the mean values for own price, competitors' prices, ad valorem tariff, exchange rate, SPS costs, and cost index for each country, anti-dumping duties for Mexico and three-strikes for Taiwan. These elasticities are presented in tables 5 to 8 for China, India, Mexico and Taiwan, respectively. Subsequently, the elasticities for SPS costs were used to simulate revenue and quantity changes for Washington State apple producers when increasing and decreasing SPS costs. The results for the different scenarios are presented in tables 9 to 12 for China, India, Mexico and Taiwan, respectively.

Estimated own price coefficients on the import demand equations have the expected negative signs. However, only the estimated own price coefficient in the import demand equation for Taiwan is significant.[10] In terms of the import demand equations for apples, it is usual to classify apples from different countries as complements or substitutes based on the geographical location of the countries. That is, apples from countries located in the same hemisphere are expected to be substitutes, since both countries have the same growing season. Conversely, apples from countries located in different hemispheres are expected to be complements, given that their growing seasons are opposite. Nevertheless, given the storability of apples, this it may be more appropriated to think of complements and substitutes through demand oriented characteristics, like apple quality and varieties. Thus, we consider apples of different varieties and/or quality to be complements and apples of the same varieties and/or quality to be substitutes.

[10] The significance level is 10 percent for all results discussed in this section, unless otherwise noted. Specific significance levels are found in the tables.

Following this reasoning, the estimated coefficients on competitors' prices in the import demand equation suggest that China considers domestic and US apples to be complements. Washington apples are not considered close substitutes for Chinese domestic apples (personal communication with Fred Scarlett, Northwest Fruit Exporters and Mark Powers, Vice President, Northwest Horticultural Council). In general, Chinese apples are of different varieties and have lower quality than Washington apples. This situation creates a niche market in China for Washington apples, allowing Washington apple exporters to receive a premium for their product. Imported apples in China have a higher price than domestic apples, differentiating both products and making them attractive to consumers with different characteristics, specifically income.

In the case of Mexico, the estimated coefficients on competitors' prices in the import demand equation suggest that Mexico regards Canadian apples as complements for US apples, and Chilean apples as substitutes for US apples. These results suggest that Canadian and US apples exported to Mexico are of different quality or variety, whereas Chilean and US apples have closer characteristics. Results for the import demand equation for Taiwan suggest that NZ apples are considered complements for US apples, and Chilean and US apples are considered substitutes. As in the case of Mexico, Taiwanese consumers regard Chilean and US apples as similar products. However, they consider NZ and US apples as having different characteristics.

We expect the coefficient on ad valorem tariff to be negative for all countries, given that the tariff represents an extra cost in the transaction. The estimated coefficient on ad valorem tariff is negative as expected for China, but positive for Mexico and Taiwan. Given the little variability observed in this variable for most of the countries, it is quite possible that the coefficient on ad valorem tariff could be capturing some other effect that the model is failing to correctly identify, for example changes in demand over time.

The estimated coefficient on exchange rate is negative for all countries, significant for India and Taiwan and insignificant for China. When the exchange rate increases, the local currency becomes more expensive relative to the US dollar. Therefore, the importing country can now afford fewer apples. Our results are consistent with this argument. The coefficient on anti-dumping duty for Mexico is also expected to be negative, since it acts like a tariff increasing the transaction cost. The estimated coefficient is in effect negative, yet insignificant.

Estimated own price coefficients on the export supply equations have the expected positive sign. All these coefficients are significant. Following a similar reasoning as in the case of the import demand equations, we consider apples being exported to different countries as complements or substitutes given the specific variety and/or quality of the apples. The estimated coefficients on competitors' prices in the export supply equation suggest that the United States regards apples going to the domestic market and India as substitutes. Given that US retailer price is the price for red delicious apples, and this is the main variety exported to India, we expected red delicious apples for the domestic market and for India to be substitutes. Apples exported to Mexico are considered substitutes to apples exported to Canada, and complements to apples exported to the UK. The main varieties exported to Mexico are red and golden delicious and to the UK are pink ladies, which is consistent with our findings. However, the Canadian market receives all varieties and grades of US apples, which explains the substitution effect. When exporting to Taiwan, US exporters regard apples exported to Canada as substitutes and apples to Mexico as complements. Consumers in Taiwan prefer sweeter, larger and higher quality fruit, and fuji apples (especially from Washington State) are the most popular fruits. Since this variety is not very popular in Mexico yet, the US exporters view the Taiwanese and the Mexican markets as complements. However, fuji apples are a popular variety in Canada as well, and thus the substitution between the Canadian and Taiwanese markets.

We expect the coefficient on SPS cost to be negative given that SPS regulations increase costs, paperwork and inspections required to export apples. The estimated coefficient on SPS costs is significantly positive for China, insignificantly negative for India, and significantly negative for Mexico and Taiwan. The case of China is somewhat different that the other countries in this analysis, since fresh produce imports have increase dramatically in the last ten years. Apple imports have increased almost ten-fold from the mid-nineties to 2006. And this trend is expected to increase (Huang and Gale 2006; Shields and Huang 2004; USDA/FAS 2007). Such a large and increasing demand for good quality fresh apples overpowers the true effect of the SPS regulations. Given that the cost of compliance for SPS regulations has increased in the last few years same as apple demand, and thus apple imports, it is not surprising to find a strong positive correlation between SPS costs and apple exports to China. However, this result should not be misinterpreted as implying that as SPS costs increase, apple exports to China are expected to increase.

The food marketing cost index was included to proxy the cost of value added activities and services that the exporters incur when commercializing apples. Consequently, we expect the coefficient on cost index to be negatively correlated with quantity exported. The estimated coefficient on cost index is positive for China and Mexico, and negative for Taiwan. Both the total food marketing cost index and the packaging food marketing cost index have been increasing over time. Thus, it is not surprising that the estimated coefficient for China is positive, as in the discussion regarding the estimated coefficient for SPS costs. However, it is unexpected that the estimated coefficient on cost index for Mexico is positive. The coefficient on the three-strikes variable in the model for Taiwan is expected to be negative given that this policy introduced certifications, cold storage treatment, inspections that increase costs. Nevertheless, the estimated coefficient on this variable is significantly positive.

The estimated coefficient on the one month lagged dependent variable is positive in all equations, as we expected. Imported or exported quantity this month is positively correlated with next month's quantity. The estimated coefficient on apple season is positive for both equations in the system for China, negative in the import demand equation for India, and negative in the export supply equation for Mexico. Results for China suggest that quantity demanded and supplied increases during the apple season in China and the US (it is the same). This result is not quite intuitive. However, it could also be driven by the high quantity demanded by China in the last years. Results for India suggest that demand for US apples decreases during the apple season in India. This result is intuitive given the lack of adequate storage and infrastructure in India to conserve apples through the year. Thus, during Indian apple season, domestic apples have good quality and lower price than imported apples. Results for Mexico suggest that the supply of US apples decreases during Mexican apple season. Given the cold storage requirements for Mexico, this result was expected. Furthermore, this supports the claim that the work plan for Mexico has been effective in keeping US apples out of the Mexican market (or at least decreased the quantity of US apples) until most of the domestic crop has been marketed (Zertuche 1995).

Import demand and export supply elasticities were calculated at the mean values for own price, competitors' prices, ad valorem tariff, exchange rate, SPS costs and cost index for each country, anti-dumping duties for Mexico and three-strikes for Taiwan (tables 5 to 8). All calculated own price elasticities are inelastic. Own price import demand elasticities range from

-0.159 for India to -0.831 for Mexico. Own price export supply elasticities range from 0.482 for China to 0.879 for Taiwan. Import demand elasticities for competitors' prices in China vary from quite inelastic for the China retail price (-0.187) to elastic for the NZ import price (1.732), while the export supply elasticities for competitors' prices are extremely inelastic, -0.063 for Canada export price and 0.037 for Mexico export price.

Elasticities for competitors' prices in India are inelastic for the import demand equation (0.399 for China import price and 0.781 for NZ import price), and for the export supply equation range from inelastic for Canada export price (0.609) to extremely elastic for the US retail price (-3.174). This extremely elastic export supply elasticity suggests a high degree of substitution between red delicious apples for the domestic market and apples exported to India. In the case of Mexico, import demand elasticities for competitors' prices are quite varied, being inelastic for Argentina (-0.079), close to unity for Canada (-0.976) and quite elastic for Chile (1.915). The result for Chile suggests a high substitution effect between Chilean and US apples for Mexican consumers. Export supply elasticities for competitors' prices in Mexico are inelastic, raging from 0.174 for UK export price to -0.458 for Canada export price. Elasticities for Taiwan's import demand equation are also quite varied for competitors' prices: inelastic for Japan import price (-0.097), close to unity for NZ import price (-0.998) and inelastic for Chile import price (1.616). Similar to Mexican consumers, Taiwanese consumers consider Chilean and US apples to have a high degree of substitution. Export supply elasticities for competitors' prices are quite elastic for Taiwan, varying from 1.488 for Mexico export price to -3.225 for Canada export price. US exporters consider apples exported to Canada and Taiwan to have a high degree of substitution, while apples exported to Mexico and Taiwan to be highly complementary.

The elasticity of demand for ad valorem tariff is inelastic for all countries, ranging from 0.078 for Mexico to 0.705 for Taiwan. On the other hand, the elasticity of demand for exchange rate is quite elastic, ranging from -1.221 for Taiwan to -4.991 for India.[11] The anti-dumping duty elasticity is quite inelastic, -0.019. This is a surprising result given the high rate of the duty. The elasticity of supply the SPS costs elasticities are elastic for China (2.159), Mexico (-1.126) and Taiwan (-1.278) and inelastic and insignificant for India (-0.277). The cost index export supply elasticity is elastic, ranging from 1.318 for Mexico to -4.452 for Taiwan.[12] Finally, the three-strike elasticity is quite inelastic, 0.102.

The SPS costs elasticities are used to calculate quantity and revenue changes for Washington State apple producers under five different scenarios (tables 9 to 12). The scenarios considered are: 20 percent increase in SPS costs, 50 percent increase in SPS costs, 20 percent decrease in SPS costs, 50 percent decrease in SPS costs and the complete elimination of SPS costs. Even though simulation results for China are included, we do not consider them to be valid given the previous discussion regarding the large and increasing trend in fresh produce imports.

In general our results are approximately within the range of estimates in the literature. Simulation results for India[13] suggest that increasing SPS costs 20 to 50 percent may decrease revenue for Washington apple producers by 5.54 to 13.85 percent, or $338 to $844 thousand USD on average per year. Conversely, decreasing SPS costs 20 to 50 percent may increase revenue by 5.54 to 13.85 percent, or $338 to $844 thousand USD on average per year. If SPS costs are completely eliminated, revenue for Washington apple producers may increase by 27.7

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[11] The value for China is -7.099, but insignificant.

[12] However, the value for India is close to unity: -0.994, but insignificant.

[13] It should be noted that the coefficient on SPS costs for India is insignificant. Nevertheless, we performed the simulation as it if were significant to provide a baseline for future comparisons.

percent, or $1.7 million USD on average per year. In the case of India, the scenarios including an increase in SPS costs are more relevant. The ad valorem tariff for apples in India has been 50 percent since 2001. This is the maximum rate that the WTO authorizes. The tariff increased from 40 to 50 percent in 2001 when India removed quantitative restrictions on apples. It is believed that SPS barriers have not been enforced in India until now (Deodhar, Landes and Krissoff 2006). However if these SPS barriers are enforced, some believe they could pose a potential threat to Washington apple imports. These results provide a some evidence suggesting that if India increases the SPS barriers for apples the revenue loss for Washington apple producers may not be too large.

Simulation results for Mexico suggest that Washington apple producers may increase revenue by 112.6 percent or $61.6 million USD on average per year if SPS barriers to Mexico are completely eliminated. In a more conservative setting, if SPS costs are decreased 20 to 50 percent, revenue may increase by 22.52 to 56.3 percent, or $12.3 to $30.8 million USD on average per year. On the other hand, if SPS costs increase 20 to 50 percent, then revenue may decrease by 22.52 to 56.3 percent, or $12.3 to $30.8 million USD on average per year. In the case of Taiwan, completely eliminating SPS barriers to trade may increase revenue for producers by 127.8 percent or $50.6 million USD on average per year. Decreasing SPS costs 20 to 50 percent may increase producers' revenue by $10 to $25 million USD on average per year. Whereas increasing SPS costs 20 to 50 percent may decrease producers' revenue by $10 to $25 million USD on average per year. As mentioned before, both Mexico and Taiwan require US producers to comply with an extensive and burdensome work plan. Producer organizations, like the Northwest Fruit Exporters, and government agencies have been lobbying for the reduction and simplification of these work plans. Our results suggest that exports to Mexico and Taiwan may increase significantly if SPS barriers are reduced, which supports the lobbying efforts of the relevant organizations and agencies.

Conclusions

In order to estimate the effects of changing SPS barriers to trade on Washington State apples in China, India, Mexico and Taiwan, we started by characterizing the full export model. We estimate the complete set of import demand and export supply equations and we calculated the corresponding import demand and export supply elasticities. The SPS costs elasticities obtained from the export supply equations were used in the revenue simulation. Specifically, we estimated quantity and revenue changes for Washington State apple producers when increasing SPS costs 20 and 50 percent, decreasing SPS costs 20 and 50 percent, and completely eliminating SPS costs.

Results from this study show that apples are a quite inelastic commodity in terms of own price supply and demand for the countries studied. Regarding competitors' prices, results suggest that domestic US red delicious apples have a high degree of substitution with US apples being exported to India. Mexican and Taiwanese consumers regard US and Chilean apples as highly substitutable. US exporters consider apples exported to Canada and Taiwan to have a high degree of substitution, while apples exported to Mexico and Taiwan to be highly complementary. Elasticities for exchange rate and SPS costs are quite elastic for most countries, suggesting that quantities are extremely sensitive to changes in both variables.

Our simulation results suggest that there are large gains to be made if SPS costs are reduced, especially in Mexico and Taiwan. Revenue for Washington State apple producers may increase between approximately 5 and 64 percent, or $340 thousand to $31 million USD on average per year per country, depending on the specific reduction on SPS costs and country. Furthermore, if SPS costs are completely eliminated in India, Mexico and Taiwan, producers may gain between approximately 28 to 128 percent, or $1.7 to $62 million USD in revenue on average per year per country. Mexico and Taiwan are confirmed as attractive markets for Washington apples if SPS barriers are reduced or eliminated. In India, we find a limited change in apple imports due to the inelastic SPS cost elasticity of supply. This result represents good news for Washington State apple producers, given that it is believed that SPS barriers have not been enforced in India until now and SPS barriers could be enforced if India is required by the WTO to lower its ad valorem tariff. Thus, if India increases the SPS barriers for apples the revenue loss for Washington apple producers may not be too large.

Unfortunately, we could not draw any satisfactory conclusions for China. Results for China seem to be driven by the dramatic increase in fresh produce imports in the last ten years, and thus, it is difficult to identify any other effect. However, it seems that regardless of the SPS restrictions in this country, the demand for quality apples is so high that Chinese consumers are willing to pay a premium for imported apples, making China an extremely attractive market for Washington apples.

Our results bring some promising information to Washington State apple producers. China is confirmed as an attractive market, regardless of SPS barriers to trade. Exports to Mexico and Taiwan may increase significantly if SPS barriers are reduced. Even though exports to India may decrease if SPS barriers are enforced, the loss may be insignificant. In general, we provide further evidence of the potential increase in revenue if SPS barriers are reduced. However, the other side of the story must be analyzed as well. A very interesting area for future research derived from this study is to analyze the effects of changing SPS barriers to trade for US apples in China, India, Mexico and Taiwan.

References

Arize, A.C. 2001. "Traditional Export Demand Relation and Parameter Instability: An Empirical Investigation." *Journal of Economic Studies* 28(6): 378-396.

Beghin, J.C., and J.C. Bureau. 2001. "Quantitative Policy Analysis of Sanitary, Phytosanitary and Technical Barriers to Trade." *Économie Internationale* 87: 107-130.

Calvin, L., and B. Krissoff. 2005. "Resolution of the US-Japan Apple Dispute: New Opportunities for Trade." *Electronic Outlook Report from the Economic Research Service* FTS-318-01, ERS, USDA.

——. 1998. "Technical Barriers to Trade: A Case Study of Phytosanitary Barriers and US-Japanese Apple Trade." *Journal of Agricultural and Resource Economics* 23(2): 351-366.

Deodhar, S.Y., M. Landes and B. Krissoff. 2006. "Prospects for India's Emerging Apple Market." *Electronic Outlook Report from the Economic Research Service* FTS-319-01, ERS, USDA.

Devadoss, S., and T. Wahl. 2004. "Welfare Impacts of Indian Apple Trade Policies." *Applied Economics* 36: 1289-1294.

Diewert, W.E., and C.J. Morrison. 1988. "Export Supply and Import Demand Functions: A Production Theory Approach." In R. C. Feenstra, ed. *Empirical Methods for International Trade.* Cambridge, Mass. and London: MIT Press, pp. 207-222.

Dimitri, C., A. Tegene, and P.R. Kaufman. 2003. "US Fresh Produce Markets: Marketing Channels, Trade Practices, and Retail Pricing Behavior." *Electronic Report from the Economic Research Service* AER-825, ERS, USDA.

Featherstone, A., and C. Moss. 1994. "Measuring Economies of Scale and Scope in Agricultural Banking." *American Journal of Agricultural Economics,* 76(3): 655-661.

Huang, S., and F. Gale. 2006. "China's Rising Fruit and Vegetable Exports Challenge US Industries." *Electronic Outlook Report from the Economic Research Service* FTS-320-01, ERS, USDA.

Krissoff, B., L. Calvin, and D. Gray. 1997. "Barriers to Trade in Global Apple Markets." In *Fruit and Tree Nuts Situation and Outlook* FTS-280, ERS, USDA, pp. 42-51.

Goldstein, M., and M.S. Khan. 1978. "The Supply and Demand for Exports: A Simultaneous Approach." *The Review of Economics and Statistics,* 60(2): 275-286.

Loveland, V., and R. Hamilton. 2007. "The Washington State Report on Foreign Trade Barriers to Food and Agricultural Exports." *Washington State Department of Agriculture,* AGR PUB 200-184 (N/3/07).

Marsh, T.L. 2005. "Economic Substitution for US Wheat Food Use by Class." *The Australian Journal of Agricultural and Resource Economics* 49: 283-301.

Miller, J. 2003. "Taiwan Fresh Deciduous Fruit Annual 2003." *USDA/FAS GAIN Report,* TW3032.

——. 2006. "Taiwan Fresh Deciduous Fruit Annual 2006." *USDA/FAS GAIN Report,* TW6035.

Northwest Horticultural Council. 2004. Submission for the Annual National Trade Estimate Report on Foreign Trade Barriers 2004.

——. 2006. Website: http://www.nwhort.org/

Seale, J.L., A.L. Sparks, and B.M. Buxton. 1992. "A Rotterdam Application to International Trade in Fresh Apples: a Differential Approach." *Journal of Agricultural and Resource Economics* 17(1): 138-149.

Shields, D., and S.W. Huang. 2004. "Chapter 6: China's Fruit and Vegetable Trade." In *Global Trade Patterns in Fruits and Vegetables.* Agriculture and Trade Report Number WRS-04-06, Economic Research Service/USDA, pp. 52-63.

Shumway, C.R., R.R. Saez, and P.E. Gottret. 1988. "Multiproduct Supply and Input Demand in US Agriculture." *American Journal of Agricultural Economics* 70(2): 330-337.

USDA/FAS. 2006. "World Apple Situation and Outlook." *Horticultural and Tropical Products Division*.

USDA/FAS. 2007. "World Markets and Trade: World Apple Situation." *Office of Global Analysis,* May 2007.

Yue, C., J. Beghin, and H.H. Jensen. 2006. "Tariff Equivalent of Technical Barriers to Trade with Imperfect Substitution and Trade Costs." *American Journal of Agricultural Economics* 88(4): 947-960.

Zertuche, C. 1995. "Fresh Deciduous Fruit: The Mexican Market for Apple and Pear Products." *USDA/FAS GAIN Report,* MX5506.

Table 1. Estimation Results for China

Import Demand Equation Dependent Variable: Quantity			Export Supply Equation Dependent Variable: Quantity		
Variable	**Estimate**	**P-Value**	**Variable**	**Estimate**	**P-Value**
US Import Price	-399.09 (1597.11)	0.803	China Export Price	392.02* (204.23)	0.055
NZ Import Price	1964.83 (1545.93)	0.204	Canada Export Price	-40.26 (333.96)	0.904
China Retail Price	-162.41** (77.03)	0.035	Mexico Export Price	32.15 (268.87)	0.905
Ad Valorem Tariff	-1448.15* (756.38)	0.056	SPS Costs	1393.93* (790.17)	0.078
Exchange Rate	-977.67 (999.50)	0.328	Cost Index	8.38*** (2.50)	0.001
1 Month Lag	0.4986*** (0.1054)	0.000	1 Month Lag	0.3157*** (0.0605)	0.000
Apple Season	538.61*** (181.40)	0.003	Apple Season	450.57*** (159.28)	0.005
Constant	7358.69 (7938.78)	0.354	Constant	-6728.71*** (1153.34)	0.000
Observations	77		Observations	105	
R-squared	0.5924		R-squared	0.6247	
Chi-squared	170.66		Chi-squared	764.57	

Note: robust standard errors are reported in parenthesis, demand and supply prices are normalized, and ***, **, * denote 1, 5 and 10 percent significance level, respectively.

Table 2. Estimation Results for India

Import Demand Equation Dependent Variable: Quantity			Export Supply Equation Dependent Variable: Quantity		
Variable	**Estimate**	**P-Value**	**Variable**	**Estimate**	**P-Value**
US Import Price	-542.21 (2511.24)	0.829	India Export Price	1973.11*** (593.79)	0.001
China Import Price	1471.49 (1709.81)	0.389	Canada Export Price	1369.12 (1088.50)	0.208
NZ Import Price	2427.88 (1550.29)	0.117	US Retail Price	-2854.46*** (623.78)	0.000
Ad Valorem Tariff	--- ---	---	SPS Costs	-454.54 (959.04)	0.636
Exchange Rate	-356.47** (173.40)	0.040	Cost Index	-5.70 (7.75)	0.462
1 Month Lag	0.6175*** (0.1134)	0.000	1 Month Lag	0.8371*** (0.0611)	0.000
Apple Season	-2519.08*** (664.35)	0.000	Apple Season	153.23 (276.85)	0.580
Constant	14633.46* (8622.10)	0.090	Constant	10300.88*** (3247.38)	0.002
Observations	29		Observations	79	
R-squared	0.7703		R-squared	0.7887	
Chi-squared	249.72		Chi-squared	1423.88	

Note: robust standard errors are reported in parenthesis, demand and supply prices are normalized, and ***, **, * denote 1, 5 and 10 percent significance level, respectively.

Table 3. Estimation Results for Mexico

Import Demand Equation Dependent Variable: Quantity			Export Supply Equation Dependent Variable: Quantity		
Variable	**Estimate**	**P-Value**	**Variable**	**Estimate**	**P-Value**
US Import Price	-33846.71 (26239.86)	0.197	Mexico Export Price	8262.22*** (1095.39)	0.000
Canada Import Price	-42327.58* (22136.19)	0.056	Canada Export Price	-5454.86*** (1162.44)	0.000
Argentina Import Price	-3705.44 (25573.51)	0.885	UK Import Price	2209.67* (1177.34)	0.061
Chile Import Price	100561.00*** (33534.99)	0.003			
Ad Valorem Tariff	73017.83*** (22476.27)	0.001			
Exchange Rate	--- ---	---	SPS Costs	-12215.64*** (3988.06)	0.002
Anti-dumping Duty	-1547.61 (6162.66)	0.802	Cost Index	69.84*** (20.00)	0.000
1 Month Lag	--- ---	---	1 Month Lag	0.6292*** (0.0087)	0.000
Apple Season	--- ---	---	Apple Season	-6848.92*** (443.16)	0.000
Constant	24439.76*** (9129.24)	0.007	Constant	67.49 (2875.25)	0.981
Observations	21		Observations	134	
R-squared	0.7896		R-squared	0.7405	
Chi-squared	1704.11		Chi-squared	65442.01	

Note: robust standard errors are reported in parenthesis, demand and supply prices are normalized, and ***, **, * denote 1, 5 and 10 percent significance level, respectively.

Table 4. Estimation Results for Taiwan

Import Demand Equation Dependent Variable: Quantity			Export Supply Equation Dependent Variable: Quantity		
Variable	**Estimate**	**P-Value**	**Variable**	**Estimate**	**P-Value**
US Import Price	-9519.80*** (3359.05)	0.005	Taiwan Export Price	8733.74*** (1883.94)	0.000
Japan Import Price	-387.43 (333.05)	0.245	Canada Export Price	-24713.25*** (2139.40)	0.000
Chile Import Price	25225.95*** (8656.64)	0.004	Mexico Import Price	15629.02*** (2890.27)	0.000
NZ Import Price	-15674.51** (6173.68)	0.011	SPS Costs	-7749.11*** (2772.26)	0.005
Ad Valorem Tariff	19470.64** (8419.93)	0.021	Cost Index	-126.53*** (19.43)	0.000
Exchange Rate	-326.51 (457.60)	0.476	Three Strikes	6752.58*** (2139.04)	0.002
1 Month Lag	--- ---	---	1 Month Lag	0.2842*** (0.0240)	0.000
Apple Season	--- ---	---	Apple Season	--- ---	---
Constant	14372.28 (16147.52)	0.373	Constant	103054.70*** (10669.69)	0.000
Observations	34		Observations	120	
R-squared	0.5379		R-squared	0.5158	
Chi-squared	256.57		Chi-squared	22216.41	

Note: robust standard errors are reported in parenthesis, demand and supply prices are normalized, and ***, **, * denote 1, 5 and 10 percent significance level, respectively.

Table 5. Elasticity Results for China

Import Demand Elasticities		Export Supply Elasticities	
Own Price	-0.353	Own Price	0.482*
New Zealand Price	1.732	Canada Price	-0.063
China Retail Price	-0.187**	Mexico Price	0.037
Ad Valorem Tariff	-0.328*	SPS Costs	2.159*
Exchange Rate	-7.099	Cost Index	3.670***

Note: ***, **, * denote significance at the 1, 5 and 10 percent level, respectively.

Table 6. Elasticity Results for India

Import Demand Elasticities		Export Supply Elasticities	
Own Price	-0.159	Own Price	0.639***
China Price	0.399	Canada Price	0.609
New Zealand Price	0.781	US Retail Price	-3.174***
Ad Valorem Tariff	---	SPS Costs	-0.277
Exchange Rate	-4.991**	Cost Index	-0.994

Note: ***, **, * denote significance at the 1, 5 and 10 percent level, respectively.

Table 7. Elasticity Results for Mexico

Import Demand Elasticities		Export Supply Elasticities	
Own Price	-0.831	Own Price	0.503***
Canada Price	-0.976*	Canada Price	-0.458***
Argentina Price	-0.079	UK Price	0.174*
Chile Price	1.915***		
Ad Valorem Tariff	0.078***	SPS Costs	-1.126***
Anti-dumping Duty	-0.019	Cost Index	1.318***

Note: ***, **, * denote significance at the 1, 5 and 10 percent level, respectively.

Table 8. Elasticity Results for Taiwan

Import Demand Elasticities		Export Supply Elasticities	
Own Price	-0.658***	Own Price	0.879***
Japan Price	-0.097	Canada Price	-3.225***
Chile Price	1.616***	Mexico Price	1.488***
New Zealand Price	-0.998**	SPS Costs	-1.278***
Ad Valorem Tariff	0.705**	Cost Index	-4.452***
Exchange Rate	-1.221	Three Strikes	0.102***

Note: ***, **, * denote significance at the 1, 5 and 10 percent level, respectively.

Table 9. Simulation Results for China

	Average Quantity per year (pounds) (1995-2006)	Average Revenue per year (USD) (1995-2006)	Percentage change
Actual	11,524,252	$2,548,036	
20% increase in SPS Costs	16,500,424	$3,648,278	43.18%
50% increase in SPS Costs	23,964,681	$5,298,640	107.95%
20% decrease in SPS Costs	6,548,080	$1,447,794	-43.18%
50% decrease in SPS Costs	-916,178	-$202,569	-107.95%
Elimination of SPS Costs	-13,356,608	-$2,953,173	-215.90%

Table 10. Simulation Results for India

	Average Quantity per year (pounds) (1995-2006)	Average Revenue per year (USD) (1995-2006)	Percentage change
Actual	27,671,294	$6,096,996	
20% increase in SPS Costs	26,138,304	$5,759,222	-5.54%
50% increase in SPS Costs	23,838,820	$5,252,562	-13.85%
20% decrease in SPS Costs	29,204,284	$6,434,769	5.54%
50% decrease in SPS Costs	31,503,768	$6,941,430	13.85%
Elimination of SPS Costs	35,336,243	$7,785,864	27.70%

Table 11. Simulation Results for Mexico

	Average Quantity per year (pounds) (1995-2006)	Average Revenue per year (USD) (1995-2006)	Percentage change
Actual	277,502,916	$54,702,774	
20% increase in SPS Costs	215,009,259	$42,383,710	-22.52%
50% increase in SPS Costs	121,268,774	$23,905,112	-56.30%
20% decrease in SPS Costs	339,996,572	$67,021,839	22.52%
50% decrease in SPS Costs	433,737,057	$85,500,437	56.30%
Elimination of SPS Costs	589,971,199	$116,298,099	112.60%

Table 12. Simulation Results for Taiwan

	Average Quantity per year (pounds) (1995-2006)	Average Revenue per year (USD) (1995-2006)	Percentage change
Actual	176,636,692	$39,573,923	
20% increase in SPS Costs	131,488,354	$29,458,828	-25.56%
50% increase in SPS Costs	63,765,846	$14,286,186	-63.90%
20% decrease in SPS Costs	221,785,031	$49,689,018	25.56%
50% decrease in SPS Costs	289,507,539	$64,861,660	63.90%
Elimination of SPS Costs	402,378,385	$90,149,397	127.80%

Appendix

Table A1. Summary Statistics for China

Variable	Units	Obs.	Mean	Std. Dev.	Min	Max
Quantity	pounds	147	1008.21	1329.82	0.00	5921.22
US Import Price	USD/pound	148	0.23	0.0934	0.08	0.46
Chile Import Price	USD/pound	91	0.27	0.0978	0.13	0.52
New Zealand Import Price	USD/pound	125	0.24	0.0960	0.10	0.41
China Retail Price	USD/pound	153	0.30	0.0683	0.20	0.68
Ad Valorem Tariff	percentage	153	0.29	0.1455	0.10	0.40
Exchange Rate	CYN/USD	153	8.22	0.1726	7.52	8.46
China Export Price	USD/pound	116	0.30	0.0884	0.17	0.81
Canada Export Price	USD/pound	147	0.38	0.0525	0.29	0.50
Mexico Export Price	USD/pound	147	0.28	0.0531	0.19	0.52
WA Producer Price	USD/pound	148	0.22	0.0610	0.10	0.39
SPS Costs	USD/1000pounds	153	1.79	0.1668	1.70	2.08
Cost Index	index	147	499.91	40.78	441.50	582.90

Table A2. Summary Statistics for India

Variable	Units	Obs.	Mean	Std. Dev.	Min	Max
Quantity	pounds	99	2703.21	3309.06	0.00	17151.55
US Import Price	USD/pound	73	0.30	0.0497	0.19	0.50
China Import Price	USD/pound	63	0.27	0.0449	0.15	0.47
New Zealand Import Price	USD/pound	51	0.32	0.0516	0.20	0.57
India Wholesale Price	USD/pound	79	0.28	0.0779	0.10	0.49
Exchange Rate	INR/USD	105	45.27	2.10	40.13	48.96
India Export Price	USD/pound	88	0.29	0.0627	0.14	0.41
Canada Export Price	USD/pound	99	0.38	0.0570	0.29	0.50
Mexico Export Price	USD/pound	99	0.29	0.0568	0.24	0.52
US Retail Price	USD/pound	105	0.97	0.0920	0.81	1.26
SPS Costs	USD/1000pounds	105	1.84	0.1852	1.70	2.08
Cost Index	index	99	521.20	32.23	464.60	582.90

Table A3. Summary Statistics for Mexico

Variable	Units	Obs.	Mean	Std. Dev.	Min	Max
Quantity	pounds	147	23452.87	15573.84	443.87	84578.18
US Import Price	USD/pound	145	0.38	0.0875	0.18	0.62
Canada Import Price	USD/pound	92	0.33	0.0862	0.15	0.53
Argentina Import Price	USD/pound	34	0.35	0.0354	0.25	0.42
Chile Import Price	USD/pound	89	0.33	0.0534	0.24	0.51
Mexico Wholesale Price	USD/pound	153	0.56	0.0976	0.37	0.87
Ad Valorem Tariff	percentage	153	0.10	0.0879	0.00	0.20
Anti-dumping Duty	percentage	153	0.23	0.2944	0.00	1.01
Mexico Export Price	USD/pound	147	0.28	0.0531	0.19	0.52
Canada Export Price	USD/pound	147	0.38	0.0525	0.29	0.50
UK Export Price	USD/pound	147	0.35	0.0906	0.22	0.59
WA Producer Price	USD/pound	148	0.22	0.0610	0.10	0.39
SPS Costs	USD/1000pounds	153	2.08	0.2137	1.94	2.45
Cost Index	index	147	423.63	30.32	386.90	495.60

Table A4. Summary Statistics for Taiwan

Variable	Units	Obs.	Mean	Std. Dev.	Min	Max
Quantity	pounds	135	14578.88	12801.62	0.00	57750.12
US Import Price	USD/pound	128	0.30	0.1006	0.22	0.91
Japan Import Price	USD/pound	104	1.02	0.8687	0.46	3.87
Chile Import Price	USD/pound	88	0.30	0.0594	0.10	0.56
New Zealand Import Price	USD/pound	77	0.30	0.0883	0.10	0.82
Taiwan Wholesale Price	USD/pound	112	0.59	0.1873	0.19	1.47
Ad Valorem Tariff	percentage	141	0.32	0.1270	0.20	0.50
Exchange Rate	TWD/USD	141	32.20	2.25	27.00	35.02
Taiwan Export Price	USD/pound	132	0.29	0.0647	0.14	0.48
Canada Export Price	USD/pound	135	0.38	0.0534	0.29	0.50
Mexico Export Price	USD/pound	135	0.28	0.0545	0.19	0.52
WA Producer Price	USD/pound	136	0.22	0.0622	0.10	0.39
SPS Costs	USD/1000pounds	141	2.39	0.2657	2.18	2.82
Cost Index	index	135	504.81	38.93	448.30	582.90
Three Strikes	binary variable	141	0.35	0.48	0.00	1.00