Welfare Analysis of the U.S.-Mexican Tomato Suspension Agreement

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Abstract

This study develops a three-county trade model of the United States, Mexico, and Canada to analyze the effects of the 2013 Suspension Agreement on prices, production, consumption, trade flows, and welfare in each country due to the U.S. minimum import price on Mexican tomatoes. While only the United States and Mexico are signatories to the agreement, Canada was also included since the U.S. minimum price distorts prices across the region. Three tomato categories—field, greenhouse, and cherry & grape—are studied since each has a distinct minimum price. The overall welfare effects are positive for Mexico and Canada, but negative for the United States.

Keywords: Canada, Mexico, Tomato Trade Agreement, the United States, Welfare Analysis

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1 Introduction

Tomatoes are an important export commodity for Mexico because they are the second most valuable agricultural export for Mexico (Baylis, 2003).[1] The United States is the second largest producer of tomatoes worldwide (processing and fresh markets combined), with Florida and California producing between two-thirds and three-quarters of tomatoes for the fresh market. Florida supplies tomatoes during the winter months (October-May) and California in the summer months (June-September). Outside of winter months, Canada also supplies tomatoes, primarily those grown in greenhouses, but it is a net importer of field tomatoes due to their short growing season. Between 2011-2014, 16% of greenhouse tomatoes imported to the United States came from Canada (ERS, 2015). During the winter months, Mexico and Florida supply about 97 percent of all tomatoes in the United States (Calvin and Barrios, 1999). Since the late 1960s, when U.S. tomato imports from Mexico started to increase, Floridian growers have claimed that Mexico dumps (i.e., sells at a price below the cost of production) tomatoes on the U.S. winter market, causing domestic prices to fall (Johnecheck et al., 2010). Mexico continues to deny that it engages in dumping. Economists term this long-lasting trade dispute the "Great Tomato War" (Bredahl et al., 1987).

NAFTA was supposed to bring a new age of free trade between the United States and Mexico. However, this trade war escalated when the United States initiated an antidumping investigation against Mexico shortly after the signing of NAFTA in 1994. But in 1996, the two countries signed an agreement to suspend the antidumping investigation (hence the name Suspension Agreement) and set a price floor or minimum price at which Mexican fresh tomatoes are to be imported. The minimum price is generally set above Mexican price plus transportation cost from Mexico to the United States. In other words, the minimum price is designed to equalize the Mexican producer price for exports sold in the United States and the U.S. producer price. If the United States pursued the investigation and were to find that Mexico had dumped, heavy tariffs could have been imposed on Mexican tomatoes. Though this trade war originally dealt with winter tomatoes, which predominantly included Florida and a few Mexican states because they harvest the majority of their tomatoes during these months, summer tomatoes were also brought into this cross-border trade conflict (Zahniser et al., 2000; Baylis and Perloff, 2010). Thus, it is important to consider all tomatoes, not just Florida winter tomatoes, in studying this dispute.

While the trade dispute arose due to Mexican tomatoes, in recent decades Canada has begun to grow significant quantities of greenhouse tomatoes. Even though their climate does not allow for large amounts of conventionally-grown field tomatoes, the use of greenhouses allows for large-scale production in all seasons except winter. Between 2010 and 2014, Canadian greenhouse tomato exports to the United States accounted for between 15 and 24 percent of all U.S. imports (ERS, 2015). Because of the Suspension Agreement, diversionary effects from Mexico to Canada has occurred (see (Baylis and Perloff, 2010)). Since about 98.5% of all fresh tomato imports originate from Mexico and Canada, a three-country trade framework is suitable for this study. Thus, our analysis includes Mexico and Canada as exporters and the United States as an importer.

In 2012, after heavy lobbying from Florida growers who claimed that Mexico continues to dump tomatoes on the U.S. market, the U.S. government decided to terminate the Suspension Agreement, which had been in effect in various forms for 16 years.[2] In response, Mexico threatened to institute $1.9 billion worth of retaliatory tariffs. Instead of escalating this trade war, both countries ultimately signed a new agreement, which was implemented in 2013 and raises the minimum price for imported tomatoes (Wingfield and Cattan, 2012). This new agreement increases the minimum price by nearly ten cents per pound and institutes new price minimums for all categories of tomatoes (USDA, 2014). These categories include greenhouse, field, small tomatoes (loose), and small tomatoes (packaged). In this paper, we investigate the effects of the new Suspension Agreement for three broad categories of tomatoes: greenhouse, field, and small (cherry & grape) tomatoes.[3] As each category has different minimum import prices, we look at the effects of the minimum import price policy on prices, supply, demand, trade, and welfare for each category of tomatoes in all three countries.

This minimum price policy can be understood as a voluntary export restraint (VER)[4] in that a) the volume of Mexican exports at this set minimum price is fixed, similar to an export quota under VER, and b) in both policies, the quota revenues accrue to exporters. Consequently, the welfare results are identical to a voluntary export quota. While Canada is exempt from the minimum price, Canadian prices do increase as the United States imports less from Mexico but more from Canada.

While many commodity groups lobby for trade barriers, commodities facing greater competition from imports are often awarded the most protection. This may be a result of a government's support for loss-avoidance of a particular producer group (Freund and Ozden, 2008). For instance, NAFTA increased overall U.S. welfare; however, increased tomato imports from Mexico lowered the prices and production (Guajardo and Elizondo, 2003). This can explain why tomato producers lobbied for and received new trade barriers against imports from Mexico soon after the signing of NAFTA. However, other studies indicate that the Mexican peso devaluation of 1995 was the primary contributing factor for the increase in Mexican exports, rather than NAFTA or dumping (Padilla-Bernal et al., 2000).

Regardless of the reasons for the increased tomato imports, the Suspension Agreement has significant effects on welfare. Despite this, very little research has been conducted into examining the benefits and losses of this agreement for producers and consumers. Jung (2009) estimated an inverse almost ideal demand system (IAIDS) to quantify the effects of the Suspension Agreement on consumers. However, she did not estimate changes in producer welfare but hypothesized that producer surplus could decline if U.S. consumers substitute away from domestic tomatoes and toward Mexican tomatoes as a result of the increased prices caused by the price floor. In contrast, our study analyzes the effects of the Suspension Agreement on both consumer and producer welfare resulting from price and quantity changes. For consumer welfare, we utilize equivalent variation (EV) because we allow substitution among the three categories of tomatoes, which causes the prices of these tomatoes to change simultaneously. We also compute the quota revenue accrued to Mexican producers.

The rest of the paper is organized as follows. Section 2 develops a three-country theoretical model of trade and incorporates the minimum import price policy. Section 3 describes the data and calibrates the parameters used in the empirical analysis. Section 4 presents the empirical results. Section 5 summarizes the paper and discusses important implications of the results.

2 Theoretical Analysis

The three types of tomatoes–greenhouse, field, and small (cherry & grape) tomatoes–are denoted by index $i = 1, 2, 3$, respectively. The three countries included in the model are Mexico (M), Canada (C), and the United States (U). This section formulates a theoretical trade model with demand and supply components for each category of tomato and country and presents the welfare analysis of the Suspension Agreement.

2.1 Supply and Demand

Since this study analyzes the short-run effects of the new Suspension Agreement, we assume that producers cannot immediately substitute one category of tomatoes for the other in the production process. This is particularly true for field and greenhouse tomatoes, which have different land requirements, capital, and farming practices. For supply, we consider simple linear functions:

$$S_i^j = -c_i^j + d_i^j p_i^{p,j}, \quad i = 1, 2, 3, \; j = U, M, C, \tag{1}$$

where $p_i^{p,j}$ is the producer price for the ith tomato category in country j.

To allow for substitutions among the three categories of tomatoes, we consider a constant elasticity of substitution (CES) demand function for tomato category i in country j:

$$D_i^j = \frac{y^j \left(\frac{p_i^{c,j}}{\delta_i^j} \right)^{-\sigma}}{\left[\sum_{i=1}^{3} \left(\delta_i^j \right)^{\sigma} \left(p_i^{c,j} \right)^{(1-\sigma)} \right]}, \; i = 1, 2, 3, \; j = U, M, C, \tag{2}$$

where D_i^j is the quantity of tomato category i consumed in country j, $p_i^{c,j}$ is the consumer price of tomato category i in country j, y^j is the spending on all categories of tomatoes in country j, δ_i^j is the share parameter of spending on tomato category i in country j, and σ is the elasticity of substitution.[5]

Under the Suspension Agreement, the United States sets the minimum import price at $\bar{p}_i^{p,U}$, for imports of ith tomato category from Mexico.[6] The producer price linkage between Mexico and the United States is

$$\bar{p}_i^{p,U} = p_i^{p,M} * T_i + t_i^{M,U}, \tag{3}$$

where T_i is the price wedge caused by the minimum price and $t_i^{M,U}$ is the transportation cost from Mexico to the U.S. border. As discussed in the introduction, this price wedge is the difference in producer prices for tomatoes sold domestically in Mexico and tomatoes sold for export in the United States. Ultimately, the goal of the minimum price is to equalize U.S. producer prices and Mexican producer prices for exports sold in the United States. The producer price linkages for Canadian exports of greenhouse and cherry & grape tomatoes to the United States and for Canadian imports of field tomatoes from Mexico are

$$\bar{p}_i^{p,U} = p_i^{p,C} + t_i^{C,U} \text{ or } p_i^{p,C} = \bar{p}_i^{p,U} - t_i^{C,U}, \; i = 1, 3 \tag{4}$$

$$p_i^{p,C} = p_i^{p,M} * T_i + t_i^{M,U} - t_i^{C,U}, \; i = 1, 3 \tag{5}$$

$$p_i^{p,C} = p_i^{p,M} + t_i^{M,C},\ i = 2. \tag{6}$$

The price linkage between the producer and consumer price $\left(p_i^{c,j}\right)$ at the retail market in each country is

$$p_i^{c,j} = p_i^{p,j} + m_i^j, \quad i = 1, 2, 3;\ j = U, M, C, \tag{7}$$

where m_i^j denotes the transport cost within the country and the market margin.

The U.S. excess demand $\left(Q_{i,ED}^U\right)$ for the *ith* category of tomato is the difference between its demand $\left(D_i^U\right)$ and supply $\left(S_i^U\right)$:

$$Q_{i,ED}^U = \frac{y^U \left(\dfrac{p_i^{c,U}}{\delta_i^U}\right)^{-\sigma}}{\left[\displaystyle\sum_{i=1}^{3} \left(\delta_i^U\right)^{\sigma} \left(p_i^{c,U}\right)^{(1-\sigma)}\right]} - \left(-c_i^U + d_i^U p_i^{p,U}\right),\ i = 1, 2, 3. \tag{8}$$

Mexican excess supply $\left(Q_{i,ES}^M\right)$ for the *ith* category of tomato is the difference between its supply $\left(S_i^M\right)$ and demand $\left(D_i^M\right)$:

$$Q_{i,ES}^M = -c_i^M + d_i^M p_i^{p,M} - \frac{y^M \left(\dfrac{p_i^{c,M}}{\delta_i}\right)^{-\sigma}}{\left[\displaystyle\sum_{i=1}^{3} \left(\delta_i\right)^{\sigma} \left(p_i^{c,M}\right)^{(1-\sigma)}\right]},\ i = 1, 2, 3. \tag{9}$$

Similarly, Canadian excess supply of tomato categories $i = 1, 3$ $\left(Q_{i,ES}^C\right)$ is the difference between its supply $\left(S_i^C\right)$ and demand $\left(D_i^C\right)$ while excess demand $\left(Q_{2,ED}^C\right)$ of the field tomato category $(i = 2)$ is the difference between its demand $\left(D_2^C\right)$ and supply $\left(S_2^C\right)$:

$$Q^C_{i,ES} = -c^C_i + d^C_i p^{p,C}_i - \frac{y^C \left(\frac{p^{c,C}_i}{\delta_i}\right)^{-\sigma}}{\left[\sum_{i=1}^{3} (\delta_i)^\sigma \left(p^{c,C}_i\right)^{(1-\sigma)}\right]} i = 1, 3, \tag{10}$$

$$Q^C_{2,ED} = \frac{y^C \left(\frac{p^{c,C}_i}{\delta_i}\right)^{-\sigma}}{\left[\sum_{i=1}^{3} (\delta_i)^\sigma \left(p^{c,C}_i\right)^{(1-\sigma)}\right]} - \left(-c^C_i + d^C_i p^{p,C}_i\right).$$

The regional market-clearing conditions are

$$Q^U_{i,ED} = Q^M_{i,ES} + Q^C_{i,ES}, \; i = 1, 3 \tag{11}$$

$$Q^U_{2,ED} + Q^C_{2,ED} = Q^M_{2,ES}. \tag{12}$$

Once all the price linkage equations (3) and (4-6) are substituted in the above market-clearing condition, we can solve the simultaneous equations in 11 and 12 for Mexican producer price $\left(p^{p,M}_i\right)$ for the ith category of tomatoes.

2.2 Welfare Effects

To analyze the welfare effects of the minimum-support price policy, we obtain producer surplus, quota revenues, and EV measures. The producer surplus is the area left of the supply curve between the free trade price (p^{p*}_i) and new producer price $\left(p^{p,j}_i\right)$ under the 2013 Suspension Agreement. U.S. producer surplus is

$$\int_{p^{p,U*}_i}^{\bar{p}^{p,U}_i} \left(-c^U_i + d^U_i p^{p,U}_i\right) dp^{p,U}_i, \quad i = 1, 2, 3. \tag{13}$$

In the United States, because of this Suspension Agreement, producers receive the higher minimum price $\left(\bar{p}_P^{p,U}\right)$ and increase their production. Consequently, the producer surplus is positive.

With the Suspension Agreement, Mexican producers face lower prices. However, they receive quota revenues for their exports to the United States. Mexican producer surplus and quota revenues are

$$\int_{p_i^{p,M}}^{p_i^{p,M*}} \left(-c_i^M + d_i^M p_i^{p,M}\right) dp_i^{p,M} + QR_i^M, \quad i = 1, 2, 3, \tag{14}$$

where $QR_i^M = \left(\bar{p}_i^{p,U} - p_i^{p,M}\right)\left(S_i^M - D_i^M\right)$, i.e., the price difference between the United States and Mexico times the quantity of Mexican exports to the United States. The Suspension Agreement policy lowers the Mexican producer price from the free trade price $p_i^{p,M*}$ to $p_i^{p,M}$. As $p_i^{p,M}$ decreases, Mexican producers supply less, and consequently producer surplus declines. However, they receive export quota revenues which are positive. The sum of producer surplus loss and export quota revenues could be a gain or loss, which is an empirical question covered below in the empirical analysis. Bredahl et al. (1987) have shown that if two countries could cooperate and agree to a Voluntary Export Restraint, rents for producers in both countries could rise. That is, the minimum price under this Suspension Agreement could be set such that both U.S. and Mexican producers could gain. However, in reality the minimum price is not selected to maximize the gain of both producers. As a result, the welfare gain of U.S. producers is positive, but gains to Mexican producers could be positive or negative.

Because of this Suspension Agreement, for greenhouse and cherry & grape tomatoes, the United States imports less from Mexico, which causes Canada to export more to the United States. As a result, the price in Canada increases which augments Canadian producer surplus:

$$\int_{p_i^{p*}}^{p_i^{p,C}} \left(-c_i^C + d_i^C p_i^{p,C}\right) dp_i^{p,C}, \quad i = 1, 3. \tag{15}$$

For field tomatoes, Canada imports more from Mexico because Mexico diverts its sales from the United States to Canada due to the U.S. minimum import price policy. Consequently, the field tomato price in Canada declines and the producer surplus is

$$\int_{p_i^{p,C}}^{p_i^{p*}} \left(-c_i^C + d_i^C p_i^{p,C}\right) dp_i^{p,C}, \; i = 2. \tag{16}$$

We use equivalent variation (EV) to measure the welfare of consumers because consumer prices of all three categories of tomatoes change as a result of this Suspension Agreement policy. In addition, since each category of tomatoes is a function of all three prices, EV, rather than consumer surplus, is the appropriate measure of consumer welfare. Next, to derive EV, we obtain the indirect utility and the expenditure functions. Substituting the demand functions (2) into the utility function (A.1), we get the indirect utility function:

$$u^j\left(p_1^j, p_2^j, p_3^j, y^j\right) = y^j \left(\sum_{i=1}^{3} \left(\delta_i^j\right)^\sigma \left(p_i^j\right)^{(1-\sigma)}\right)^{\left(\frac{1}{\sigma - 1}\right)}, \tag{17}$$

The expenditure function is obtained by minimizing the budget constraint subject to the CES utility function:

$$e(p_1^j, p_2^j, p_3^j, u^j) = u^j \left[\sum_{i=1}^{3} \left(\delta_i^j\right)^\sigma p_i^{j(1-\sigma)}\right]^{\left(\frac{1}{1-\sigma}\right)} \tag{18}$$

The equivalent variation (EV) measures welfare change resulting from price changes due to different policy regimes. The EV is the amount of compensation that needs to be paid to the consumer which will enable the consumer to attain the final utility level as the initial prices. Mathematically, $EV = e(\mathbf{p}^0, u^1) - e(\mathbf{p}^0, u^0)$ (Devadoss and Stodick, 2005).

For our study, prices and utility levels resulting from free trade $\left(p_i^{c,j*}, u^{j*}\right)$ are our baseline policy while prices and utility resulting from the 2014 Suspension Agreement policy $\left(p_i^{c,j}, u^j\right)$ are our alternate scenario. The equation used to find EV is found below:

$$EV = u^j \left[\sum_{i=1}^{3} \left(\delta_i^j\right)^{\sigma} p_i^{j*(1-\sigma)}\right]^{\left(\frac{1}{1-\sigma}\right)} - u^{j*} \left[\sum_{i=1}^{3} \left(\delta_i^j\right)^{\sigma} p_i^{j*(1-\sigma)}\right]^{\left(\frac{1}{1-\sigma}\right)}, \quad j = U, M, C \quad (19)$$

3 Data and Calibration

To calibrate the model, we collected data from a variety of sources and cross-checked the data from different sources to ensure the data was accurate. The model was calibrated using 2012 data, which was selected based on availability of all required data and because it was the most representative year with no large supply shocks. For instance, Mexican supply in 2011 was 51% of 2012's supply due to adverse weather conditions (Servicio de Informacion Agroalimentaria y Pesquera (SIAP), 2015). Below we explain in detail the data sources for all variables in the following order: production, imports/exports, consumption, prices, and additional parameters for the United States, Mexico, and Canada.

NASS (2012) combines the production data for U.S. greenhouse and field tomatoes and reports it as a single category. We used the shipping and movement data from AMS (2015a) to obtain the percentages of greenhouse and field tomato production and applied these percentages to the total production data in NASS (2012) to disaggregate production data for greenhouse and field tomatoes. The production data for cherry & grape tomatoes are not directly available from any sources. Consequently, we used shipping and movement information from AMS (2015a) to construct the production data for cherry & grape tomatoes.[7,8]

Mexico provides a detailed set of data for various types and varieties of tomatoes (SIAP, 2015). We used this data to construct the production data for the three categories of tomatoes. Canada does not report data for greenhouse and field tomatoes separately. However, for 2011 it does report the greenhouse tomato production (Statistics-Canada, 2013). We used this 2011 data for greenhouse tomato production and the total tomato production in 2012 to construct the greenhouse and field tomato production in 2012 (Statistics-Canada, 2015). Furthermore, Canada groups cherry & grape tomatoes along with greenhouse tomatoes. To separate the cherry & grape tomato production from greenhouse tomato production, we used Canada's imports and exports of cherry & grape tomatoes.

For U.S. imports and exports, we used information from ERS (2015) which separates data by greenhouse, roma, round, cherry, and grape tomatoes. To obtain estimates for field tomatoes, we combined roma and round tomatoes. For Canada, we again used Statistics-Canada (2015) and (Statistics-Canada, 2013) to determine import and export data, and for consistency we compared that data with U.S. imports from Canada. Since Mexico does not report trade data, we used the data for U.S. and Canadian tomato trade with Mexico. Finally, consumption was determined as domestic production plus imports minus exports.

We collected producer and retail price data for each tomato category in all three countries. Greenhouse tomato prices were higher than field tomato prices. Examination of price data from USITC (2015) indicated that the minimum price was the same for all categories until 2013 and generally non-binding for Mexican greenhouse exports to the United States. ERS (2015) does not report price data for greenhouse tomatoes. Since the minimum price was designed to equalize prices for Mexican exports and U.S. producers, we used the new 2014 greenhouse minimum price plus transportation costs to determine the U.S. producer price. For U.S. field tomatoes, we utilized the average producer price from ERS (2015). Cherry & grape tomato prices were derived in a similar fashion to greenhouse tomatoes as the 2008 Suspension Agreement's price minimum was not binding.

For Mexican producers, we had to determine both domestic and export prices. Mexican producer prices for greenhouse tomatoes were determined in a similar process to the United States by realizing that the previous Suspension Agreement was not binding, implying that producers received identical prices in the domestic and export markets, excluding transport costs. Mexican producer prices for field tomatoes in the domestic market were obtained from SIAP (2015). Mexican prices reported in SIAP were listed in terms of pesos but were converted to U.S. dollars using the peso-dollar exchange rate. Mexican export prices for field tomatoes were collected from USITC (2015). In 2012, producers received \$0.17 for field tomatoes sold domestically and \$0.22 (the weighted average minimum price for both summer and winter under the previous Suspension Agreement) for field tomatoes sold in the United States.

Canadian prices are similar to those in the United States for greenhouse tomatoes. Statistics-Canada (2015) reports a price of \$0.52 per pound for greenhouse producers, though this price also includes higher-priced cherry tomatoes. After disaggregating cherry & grape tomatoes from all greenhouse tomatoes, we estimated a producer price of \$0.50. Prices for field and cherry & grape tomatoes were not readily available. As a result, we utilized equations (5) and (6) to estimate the field and cherry & grape tomato prices.

Consumer prices were readily available for the United States through AMS (2015b). However, these prices are reported by tomato type (i.e., vine-ripened, cherry, grape, plum, etc.) and these types do not correspond perfectly with the minimum price categories. Since greenhouse tomatoes are largely vine-ripened tomatoes, we used this price as a proxy for all greenhouse tomatoes. We used a weighted average of plum, roma, and large tomato prices for field tomato prices. Finally, we used a weighted average of cherry & grape tomato prices.

For Mexico, we assumed a similar magnitude price difference between greenhouse and field tomatoes as in the United States since direct price information was only available for field tomatoes. Consumer prices for field tomatoes were obtained from Numbeo (2014) which lists average prices from grocery stores for tomatoes. Cherry & grape tomato prices were also difficult to ascertain; consequently, prices found in Wal Mart in Mexico were used as a proxy (Walmart, 2015). For Canada, we utilized Numbeo (2014), which lists the average price per pound for tomatoes. We used this price for field tomatoes and assumed an equal magnitude difference in price for greenhouse and cherry & grape tomatoes as in the United

States. With these consumer and producer prices, the in-country transport costs and retail margins were found by subtracting consumer price $\left(p_i^{c,j}\right)$ from producer price $\left(p_i^{p,j}\right)$.

The remaining parameters to estimate include spending on tomatoes (y^j), the expenditure share parameters for tomato categories $\left(\delta_i^j\right)$, price wedges (T_i), supply parameters $\left(c_i^j \text{ and } d_i^j\right)$, and the elasticity of substitution parameter (σ). Expenses in each country was determined by multiplying retail price times consumption for each category of tomatoes and summing these expenses. Similarly, the share parameter was found by dividing the spending on a particular commodity by the total expenses. Table 1 presents this data.

Table 1: Income and Share Parameters

	y^j	δ_1^j	δ_2^j	δ_3^j
$j = U, M, C$	million \$	share of budget		
United States	9136.36	0.46	0.44	0.10
Mexico	2623.29	0.38	0.58	0.04
Canada	2730.35	0.08	0.87	0.04

For the free trade scenario, the price wedges (T_i) were set to one, implying no price difference for Mexican tomatoes sold within the country and those sold for export, excluding transport cost. For the 2013 minimum price policy, we computed the price wedges: $T_1 = 1.10$, $T_2 = 1.37$, and $T_3 = 1.06$. These price wedges were estimated by collecting the producer price in Mexico and the export price in the United States for each category of tomatoes. Field tomatoes have the highest price wedge because this category already faced a binding minimum price before the new, higher minimum price. The average transport cost from interior Mexico to the U.S. border $\left(t_i^{C,U}\right)$ was estimated at \$0.06 per pound in 2007 by Bayard et al. (2007). We considered a slightly higher value of \$0.08 per pound for greenhouse and field tomatoes in 2012 due to higher gas prices. In addition, we estimated transportation costs of \$0.10 per pound for cherry & grape tomatoes due to packaging requirements. We used similar estimates for transportation costs from Canada to the U.S. border $\left(t_i^{C,U}\right)$.

While numerous studies have estimated elasticity of demand for aggregate tomatoes (see Huang, 1985; Málaga et al., 2001), only one estimated the elasticity of supply for aggregate tomatoes (Jung, 2004). We used the elasticity estimates from this study as a basis to construct the supply elasticity of $\varepsilon = 0.98$. The 2012 production quantities $\left(S_i^j\right)$ and producer prices $\left(p_i^{p,j}\right)$ are used to calibrate the coefficients of the supply functions (see equation (1)). Table 2 reports the calibrated supply parameters for each country j and tomato category i.

Table 2: Supply Parameters

$j = U, M, C$	c_1^j	d_1^j	c_2^j	d_2^j	c_3^j	d_3^j
United States	2.78	724.32	1.60	6000.31	2.12	198.11
Mexico	55.23	8017.21	9.34	$16,000.78$	1.21	380.52
Canada	1.02	1724.07	0.03	4307.24	0.10	65.43

Finally, we consider an Armington elasticity of substitution, σ, equal to 1.10, which is reported by Jung (2004).

4 Results

This section presents the impacts of the 2013 Suspension Agreement's higher minimum prices on endogenous variables (prices, supply, demand, and trade) for all three categories of tomatoes and also welfare measures (producer surplus and EV). Towards this goal, we run two simulation scenarios: baseline and alternate. The baseline scenario is free trade, with price wedges set to one. The alternate scenario is the 2013 Suspension Agreement policy, where the price wedges are $T_1 = 1.10$, $T_2 = 1.37$, and $T_3 = 1.06$. Mexican producer price for each tomato category i is endogenously determined using the market clearing condition (11 and 12), which we use to find the remaining consumer and producer prices in each country j through the price linkage equations (3), (4), (5), (6) and (7). With these prices, we compute the supply, demand, and trade for each category of tomatoes under the two scenarios and also the percentage changes between the two scenarios to quantify the impacts of the Suspension Agreement policy. Table 3 presents these results.

Table 3: Impact of Suspension Agreement on Tomato Prices and Quantities

$j = U, M, C$	United States		Mexico		Canada	
Variable	Baseline	%Δ	Baseline	%Δ	Baseline	%Δ
Greenhouse						
Producer Price	0.45	5.53	0.37	−2.97	0.37	6.74
Supply	471.18	3.80	2889.24	−3.02	632.18	6.75
Consumer Price	1.60	1.55	0.94	−1.16	1.55	1.60
Demand	2445.68	−1.53	1152.02	1.11	174.91	−1.12
Imports/Exports	1974.50	−2.81	1737.23	−5.76	457.27	9.76
Field						
Producer Price	0.32	18.77	0.24	−8.79	0.40	−5.30
Supply	1934.19	18.78	3872.69	−8.81	1041.39	−5.34
Consumer Price	1.42	4.26	0.83	−2.56	1.25	−1.70
Demand	2780.62	−4.23	1380.61	3.97	1264.21	−2.74
Imports/Exports	483.08	−50.16	2096.08	−15.89	222.82	40.47
Cherry & Grape						
Producer Price	0.53	2.64	0.43	−2.58	0.43	3.26
Supply	272.31	1.01	161.33	−2.60	42.85	2.13
Consumer Price	3.44	0.41	2.60	−0.42	3.11	0.45
Demand	426.93	−0.10	41.91	0.25	34.64	−0.63
Imports/Exports	154.62	−2.05	119.42	−3.60	8.21	13.78

Under the 2013 Suspension Agreement, the minimum import prices for all three categories of tomatoes is higher in the United States compared to those under free trade because these prices are binding. For greenhouse tomatoes, U.S. producers see their price increase by about 5.53% compared to that under free trade, which leads to a rise in supply of 3.80%. In response to this policy, consumer price rises by 1.54% and demand for greenhouse tomatoes falls by 1.53%. Since we allow substitution between tomato types in consumption, the magnitude of price and quantity changes for consumers is less than that of producers. With higher producer price for greenhouse tomatoes, imports decline by 2.81%.

Since the minimum import price reduces U.S. import demand for Mexican greenhouse tomatoes, prices in Mexico fall. Mexican producer prices decline by 2.97%. In response to the fall in producer price, Mexican greenhouse tomato supply declines by 3.02%. Because of the decline in exports of 5.76%, Mexican consumer prices decline by 1.16% and the quantity of greenhouse tomatoes sold domestically increases by 1.11%.

The Suspension Agreement induces a trade diversionary effect, i.e., Mexican exports are diverted from the United States to Canada. Consequently, with a higher U.S. price, Canada increases its exports to the United States by 9.76%. As a result of the Canadian increased exports, the greenhouse tomato producer price in Canada rises by 6.74% and the consumer price by 1.60%. In response to higher prices, supply increases by 6.75% while demand declines by 1.12%. It is worth pointing that, although the percentage changes are generally largest in Canada, since Canada's quantities are much smaller, changes in the volume are smaller compared to those of the United States and Mexico, indicating Canada is a relatively small player in all three tomato markets.

Field tomatoes, which already had a binding minimum price even before the new 2013 Agreement, experience the largest magnitude changes of all three tomato categories. The higher the wedge between the free trade and the minimum import price, the more distortionary the effects. Since the minimum import price is substantially higher than the free trade price, U.S. imports from Mexico are significantly reduced, causing a greater increase in domestic price. As a result of the policy, U.S. field tomato imports falls by 50.16%, which leads to an increase in U.S. producer price by 18.77%. This price increase boosts U.S. supply by 18.78%. With this reduction in imports, the consumer price increases by 4.26% and quantity demanded declines by 4.23%. Once again, the impacts on producers outweigh the effects on consumers as a result of substitution between tomato categories in consumption.

The impacts of the Suspension Agreement's higher minimum price on Mexican field tomato market are substantial. This policy significantly restricts Mexican exports of field tomatoes to the United States by 15.89%. Consequently, Mexico sells more in the domestic market which reduces the producer and consumer price by 8.79% and 2.56%, respectively. The lower price leads to a 8.81% decrease in supply and a 3.97% increase in demand.

Canada is an importer of field tomatoes. Since Mexico exports less to the United States under the minimum import price policy, it diverts its exports to Canada. Mexican field tomato exports to Canada rise by 40.47%. As a result of more imports coming into Canada, field tomato prices in Canada decline by 5.30% for producers, leading to a supply decline of 5.34%. Because of substitution among the three types of tomatoes, consumer prices for field tomatoes fall by only 1.70%, resulting in a demand increase of 2.74% .

The final category is cherry & grape tomatoes. With the smallest price wedge between the free trade and minimum price, the impacts on trade are smaller than those of the greenhouse and field tomatoes. Mexican cherry & grape tomato exports to the United States decline by 3.60%. Similarly, the changes in prices and quantities are also minimal. For example, the producer price in the United States only increases by 2.64%, a much smaller increase than those of greenhouse or field tomatoes. Consumer prices rise by only 0.41%. Supply (demand) increases (decreases) by 2.60% (0.10%).

Since the minimum price is closer to the free trade price, the domestic price in Mexico for producers (consumers) only declines by 2.58% (0.42%). These small impacts lead to correspondingly minor changes in supply (demand) of -2.60% (0.25%). Canada, as a net exporter of cherry & grape tomatoes, also experiences only minor changes. Canada is a very minor player in the trade of cherry & grape tomatoes and the 13.78% increase in exports of cherry & grape tomatoes corresponds to an increase of only about one million pounds. Since Canada augments its exports to the United States, Canadian producer and consumer prices increase by 3.26% and 0.45%, respectively. This increase in prices leads to a supply increase of 2.13% and a demand decrease of 0.63%.

In summary, the higher minimum prices benefit U.S. producers and hurts U.S. consumers. In contrast, Mexican producers incur producer surplus losses from the price minimum policy compared to free trade, while consumers gain. We quantify these welfare changes using producer surplus (PS) and EV. Producer surplus for the United States and Canada were determined through equations (13) and (15). For Mexican producers, we compute producer surplus loss plus quota revenues (see (14)). EV for each country is computed using equation (19), which accounts for price changes of all three categories of tomatoes. Table 4 reports the results of these welfare measures.

Table 4: Producer and Consumer Welfare in Millions of Dollars

	United States	Mexico	Canada
Producer Welfare for Greenhouse Tomatoes	8.17	27.35	16.17
Producer Welfare for Field Tomatoes	128.13	67.06	−21.61
Producer Welfare for Cherry & Grape Tomatoes	1.44	1.12	0.39
Equivalent Variation for all categories	−13.59	13.24	9.67

For the United States, producer surplus is positive for each category because producers gain from higher prices under the minimum import prices. While greenhouse tomato producers experience a moderate $8.17 million increase in producer surplus, field tomato producers gain the most, by $128.13 million. Cherry & grape tomatoes, which saw the smallest price increase and also represent the smallest tomato category, have the smallest increase in producer surplus of $1.44 million. Overall, U.S. tomato producer surplus increases by $137.74 million for all three categories. The consumer welfare of −$13.59 million takes into account the substitution among three categories resulting from simultaneous and relative changes in all prices. Since equivalent variation and producer surplus are not directly comparable, we cannot conclude that total welfare is positive for the United States by simply adding PS and EV. Suffice it to say that U.S. producers gain and U.S. consumers lose.

For Mexico, producer welfare includes both producer surplus loss and quota revenues. The greenhouse tomato category shows a net positive welfare gain of $27.35 million for Mexico producers, which includes a loss of $30.99 million in domestic producer surplus resulting from lower prices and a gain of $58.34 million in quota revenues. Field tomato producers also benefit substantially, with a gain of $67.06 million which consists of a $78.94 million loss in producer surplus and a gain of $146.00 in quota revenues. For cherry & grape tomatoes, producer welfare increases by $1.12 million, which is comprised of a producer surplus loss of $1.76 million and a quota revenue gain of $2.87 million. Summing the producer welfare of all three categories of tomatoes yields a net increase of $95.53 million. Consumers gain from the lower prices and their EV is $13.24 million.

Canada, which had price increases in greenhouse and cherry & grape tomatoes and a price decrease in field tomatoes, has mixed welfare results. Greenhouse tomato producers experience a gain of $16.17 million while field tomato producers lose $21.61 million as imports from Mexico leads to price declines. Cherry & grape producers see a slight increase in surplus of $0.39 million. Total Canadian producer surplus for all three categories was a loss of $5.05 million. For consumers, the price decline in field tomatoes dominated over the price increases in greenhouse and cherry & grape tomatoes. As a result, Canadian consumers gain $9.67 million.

5 Conclusions and Implications

The tomato war between Mexican and U.S. producers has lasted several decades, with no end in sight. This war started in the 1960s when Mexico began exporting tomatoes to the United States. U.S. tomato producers are hurt by increased tomato imports from Mexico. However, those same imports increase the welfare of U.S. consumers through lower prices. Under the Suspension Agreement, as with any import restriction, producers gain and consumers lose. In instituting the minimum import price, the United States is primarily concerned about the interest of domestic producers. This preference for producers is likely because of heavy lobbying by the tomato producers to keep prices from falling due to greater imports from Mexico. Furthermore, the U.S. government is less concerned about losses to consumers because these losses are negligible to individual consumers, making them unlikely to lobby the government to oppose import restrictions. The Suspension Agreement with Mexico is a prime example of such preference by the U.S. government since U.S. producers experience a substantial gain, while individual U.S. consumer's losses are very small.

Despite widespread agreement by economists that free trade increases net welfare, nations tend to impose trade barriers because governments focus on loss to a particular group rather than the overall net gain from free trade. In this study, we find that producers generally gain. Even Mexican producers experience gains in all three tomato categories due to quota revenues. However, those gains are unlikely to continue if the United States increases the minimum prices in the future. Until this most recent agreement, the trade in both greenhouse and cherry & grape tomatoes were not binding since the minimum import price was too low to restrict trade. Now, however, the prices of these two categories are higher, leading to binding trade restrictions which causes the United States to divert its imports from Mexico to Canada. The category most impacted by the new minimum price is field tomatoes, whose price was already binding even before the 2013 agreement.

While most U.S. consumers are unaware of the Suspension Agreement, this policy does have aggregate adverse impacts on consumers. Since tomatoes are a commonly consumed produce, the overall effect of the Suspension Agreement on consumer welfare is large, even though it only minimally affects each individual consumer. With the United States experiencing higher consumer prices, the EV declines. In examining the welfare effects of the 2013 Suspension Agreement, this study quantifies the effects of the 2013 Suspension Agreement on both producers and consumers. Without being able to directly compare producer surplus and EV, we cannot ascertain whether this policy has a negative or positive impact on each country or the region as a whole. However, we can conclude that this policy has substantial diversionary and welfare effects.

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Notes

[1]The leading Mexican export is beer.

[2]After 1996, Suspension Agreements were renewed in 2002 and 2008, along with several amendments in other years. In 1996, the price minimum was \$0.2068 per pound for all tomato

imports (Zahniser et al., 2000). In 2008, the minimum prices were \$0.2169 and \$0.172 per pound for winter and summer tomato imports, respectively (USDA, 2013).

[3]Loose and packaged small tomatoes are combined into small (cherry & grape) tomatoes.

[4]This comparison holds only under perfect competition and no uncertainty.

[5]We derived these demand functions using utility function $U = X^{\alpha}Q^{(1-\alpha)}$, where Q is the composite good and X is the aggregation of the CES sub-utility function:

$$\left[\delta_1 D_1^{\left(\frac{\sigma-1}{\sigma}\right)} + \delta_2 D_2^{\left(\frac{\sigma-1}{\sigma}\right)} + \delta_3 D_3^{\left(\frac{\sigma-1}{\sigma}\right)}\right]^{\left(\frac{\sigma}{\sigma-1}\right)}. \tag{A.1}$$

The demand function resulting from the sub-utility function is denoted D_i and the utility level is u.

[6]This minimum import price is generally binding; otherwise, there is no need for this policy.

[7]We acknowledge Suzanne Thornsbury for helping us to obtain this data and also with the process of constructing the production data for cherry & grape tomatoes.

[8]Since the total shipment of greenhouse and field tomatoes collected from AMS (2015a) is similar to the total production data for these two categories of tomatoes reported in NASS (2012), we felt it was appropriate to use the cherry and grape shipping data in AMS (2015a) to construct the production data for this category of tomatoes.