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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. Although only the United States and Mexico are signatories to the agreement, Canada was also included because the U.S. minimum price distorts prices across the region. Three tomato categories—field, greenhouse, and cherry and grape—are studied because 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, United States, welfare

JEL Classifications. F13, F14

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 66% and 75% of tomatoes for the fresh market. Florida supplies tomatoes during the winter months (October–May), and California during the summer months (June–September). Outside of the winter months, Canada also supplies tomatoes, primarily those grown in greenhouses; however, it is a net importer of field tomatoes because of their short growing season. Between 2011 and 2014, 16% of greenhouse tomatoes imported by the United States came from Canada (U.S. Department of Agriculture, Economic Research Service [USDA-ERS], 2016).

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1 The leading Mexican export is beer.

During the winter months, Mexico and Florida supply approximately 97% 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, Wilde, and Caswell, 2010). Mexico continues to deny that it engages in dumping. Economists term this long-lasting trade dispute the "Great Tomato War" (Bredahl, Schmitz, and Hillman, 1987).

In 1996, the United States completed an antidumping investigation into Floridian growers' claim against Mexico; however, before determining whether to impose antidumping duties, the two countries signed an agreement to suspend the antidumping investigation (hence the name "Suspension Agreement") and set a price floor (minimum price or reference price) for Mexican fresh tomatoes to enter the United States. Although this agreement was modified on several occasions, it remained in effect for 16 years.[2] However, 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. 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 raised the minimum price for imported tomatoes (Wingfield and Cattan, 2012). This new agreement increased the minimum price by nearly 10 cents per pound and instituted new price minimums for all categories of tomatoes (U.S. Department of Commerce, International Trade Administration, Enforcement and Compliance, 2016b). These categories include greenhouse, field, specialty tomatoes (loose), and specialty tomatoes (packaged).

The objective of this study is to investigate the effects of the new Suspension Agreement on three broad categories of tomatoes: greenhouse, field, and small (cherry and grape) tomatoes.[3] As each category has a different minimum import price, we compute the effects of the new policy on prices, supply, demand, trade, and welfare for each category of tomatoes in the United States, Mexico, and Canada in order to understand the gains and losses of producers and consumers.

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

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, Skully, and Somwaru, 2000). In 2008, the minimum prices were $0.2169 and $0.172 per pound for winter and summer tomato imports, respectively (U.S. Department of Commerce, International Trade Administration, Enforcement and Compliance, 2016a). Note that all dollar amounts are in U.S. dollars.

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

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

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a voluntary export quota. Although Canada is exempt from the minimum price, Canadian prices do increase as the United States imports less from Mexico but more from Canada.

The goal of the minimum price is to eliminate alleged dumping by raising the export price of Mexican tomatoes. Whether dumping, comparative advantage, or other economic reasons lead to Mexico's ability to sell in the United States at a lower price than U.S. producers, a binding minimum price essentially acts to equalize the Mexican cost of production plus transportation costs and the U.S. price. Historically, the minimum price was frequently nonbinding. The 2013 agreement contains a provision to simplify the process of changing the minimum price, allowing for greater ease in increasing the minimum price if Mexican producer prices fall substantially below the U.S. producer price (U.S. Department of Commerce, International Trade Administration, 2013).

The rest of the article is organized as follows. Section 2 presents background information into the tomato dispute and minimum price policy. Section 3 develops a three-country theoretical model of trade and incorporates the minimum import price policy. Section 4 describes the data and calibrates the parameters used in the empirical analysis. Section 5 presents the empirical results. Section 6 summarizes the article and discusses important implications of the results.

2. Background of the Dispute and Literature

The North American Free Trade Agreement (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. In 1996, the two countries signed an agreement to suspend the antidumping investigation and set a price floor or minimum price at which Mexican fresh tomatoes are to be imported. 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 (Baylis and Perloff, 2010; Zahniser, Skully, and Somwaru, 2000). Thus, it is important to consider all tomatoes, not just Florida winter tomatoes, in studying this dispute.

After the advent of the U.S.-Mexican dispute, Canada has begun to grow significant quantities of greenhouse tomatoes in recent decades. Even though the Canadian 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% of all U.S. imports

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(USDA-ERS, 2016). As a result of the Suspension Agreement, diversionary effects from Mexico to Canada have occurred (see Baylis and Perloff, 2010). Because approximately 98.5% of all fresh tomato imports originate from Mexico and Canada, a three-country trade framework is suitable for this study.

Although many commodity groups lobby for trade barriers, commodities facing greater competition from imports are often awarded the most protection. This may be the result of a government's support for loss avoidance of a particular producer group (Freund and Özden, 2008). For instance, NAFTA increased overall U.S. welfare; however, increased tomato imports from Mexico lowered U.S. 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 to the increase in Mexican exports, rather than NAFTA or dumping (Padilla-Bernal and Thilmany, 2000).

During the investigation in 1996, the U.S. Department of Commerce estimated that dumping margins ranged from 4.16% to 188.45%. In addition to the wide range in these estimates, two additional elements complicate the issue of dumping. First, historically, antidumping laws were merely an extension of antitrust laws. Currently, dumping includes selling at a lower price in the United States than in other countries or pricing below average total costs, even though it is legal for U.S. companies to price below average total costs in the domestic and export markets (Gould and Gruben, 1994). This problem is magnified when dealing with highly perishable agricultural commodities, which sometimes have to be sold below the cost of production or risk even higher losses. Schmitz, Firch, and Hillman (1981) researched dumping in perishable products and uncovered flaws in the U.S. Department of Commerce and U.S. International Trade Commission (USITC) processes and concluded that by considering any sales below costs of production as evidence of dumping, a country (like Mexico) can be found to be dumping even when U.S. growers are allowed to sell below their own costs of production. Schmitz, Firch, and Hillman (1981) recommended that highly perishable agricultural exports either be exempt from antidumping suits or that economists develop new models for perishable agricultural imports that incorporate normal business practices rather than only looking at cost of production.

Second, an additional concern relates to the belief that Mexico heavily subsidizes tomato farmers, thus providing rationale for the minimum price to counteract Mexican price supports. However, the Organization for Economic Cooperation and Development (2016) reports that Mexico has no subsidies or price supports for tomatoes apart from the Suspension Agreement's minimum price. Although Mexico has consumption subsidies, production subsidies for fruits and vegetables significantly declined throughout the 1980s and 1990s as Mexico opened its economy and reduced price supports.

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Regardless of the reasons for the increased tomato imports or the degree of dumping, 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 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. Similarly, Asci et al. (2016) found that, as a result of the new price minimums, demand for U.S. field tomatoes may decline as consumers substitute for Mexican field and greenhouse tomatoes. Our study extends the literature by analyzing the effects of the Suspension Agreement on both producer surplus for the United States and Canada and producer welfare (surplus plus quota revenues) for Mexico, in addition to examining the changes in consumer surplus for each country.

3. Theoretical Analysis

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. The three categories of tomatoes—greenhouse, field, and small (cherry and grape) tomatoes—are denoted by the index $i = 1, 2, 3$, respectively.

3.1. Supply and Demand

Because 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 linear functions:

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

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

We consider a constant elasticity of substitution (CES) utility function. To derive the CES demand function, consider the consumer's problem with utility function

$$U = A\frac{\sigma}{\sigma - 1}\left(\delta_1 x_1^{\left(\frac{\sigma-1}{\sigma}\right)} + \delta_2 x_2^{\left(\frac{\sigma-1}{\sigma}\right)} + \delta_3 x_3^{\left(\frac{\sigma-1}{\sigma}\right)}\right) + x_0,$$

where δ_i indicates the share parameter of the three tomato varieties and $\delta_3 = 1 - \delta_1 - \delta_2$, x_i is consumption of tomato category i, x_0 is consumption of all

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other goods, and σ is the elasticity of substitution between varieties of tomatoes. The consumer maximizes the utility function subject to the budget constraint $Y = p_1^c x_1 + p_2^c x_2 + p_3^c x_3 + x_0$, where p_i^c is the consumer price of the ith category of tomato and the price for x_0 is normalized to 1. The Lagrangian for this maximization is

$$L = A\frac{\sigma}{\sigma - 1}\left(\delta_1 x_1^{\left(\frac{\sigma-1}{\sigma}\right)} + \delta_2 x_2^{\left(\frac{\sigma-1}{\sigma}\right)} + \delta_3 x_3^{\left(\frac{\sigma-1}{\sigma}\right)}\right) + x_0 + \lambda\left(Y - p_1 x_1 - p_2 x_2 - p_3 x_3 - x_0\right).$$

Solving the first-order conditions and introducing superscripts $j = U, M, C$ and c to denote consumer yields the following demand functions for all three categories of tomatoes in all three countries:

$$D_i^j = \left(\frac{p_i^{c,j}}{A_i^j \delta_i^j}\right)^{-\sigma_i}, \quad i = 1,2,3, \quad j = U, M, C, \tag{2}$$

where D_i^j is the quantity of tomato category i consumed in country j and $p_i^{c,j}$ is the consumer price of tomato category i in country j.

Under the Suspension Agreement, the United States sets the minimum import price at $\bar{p}_i^{p,U}$ for imports of the ith tomato category from Mexico.[5] The producer price linkage between Mexico and the United States is

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

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 resulting from a binding minimum price. The producer price linkages for Canadian exports of greenhouse and cherry and grape tomatoes to the United States and for Canadian imports of field tomatoes from Mexico are as follows:

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

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

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

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

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

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

5 This holds when the minimum import price is binding.

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The U.S. excess demand ($Q^U_{i,ED}$) for the ith category of tomato is the difference between its demand (D^U_i) and supply (S^U_i):

$$Q^U_{i,ED} = \left(\frac{p^{c,U}_i}{A^U_i \delta^U_i}\right)^{-\sigma_i} - \left(c^U_i + d^U_i p^{p,U}_i\right), \quad i = 1,2,3. \tag{8}$$

Mexican excess supply ($Q^M_{i,ES}$) for the ith category of tomato is the difference between its supply (S^M_i) and demand (D^M_i):

$$Q^M_{i,ES} = c^M_i + d^M_i p^{p,M}_i - \left(\frac{p^{c,M}_i}{A^M_i \delta^M_i}\right)^{-\sigma_i}, \quad i = 1,2,3. \tag{9}$$

Similarly, Canadian excess supply of tomato categories $i = 1,3$ ($Q^C_{i,ES}$) is the difference between its supply (S^C_i) and demand (D^C_i), and excess demand ($Q^C_{2,ED}$) of the field tomato category ($i = 2$) is the difference between its demand (D^C_2) and supply (S^C_2):

$$Q^C_{i,ES} = c^C_i + d^C_i p^{p,C}_i - \left(\frac{p^{c,C}_i}{A^C_i \delta^C_i}\right)^{-\sigma_i}, \quad i = 1,3,$$

$$Q^C_{2,ED} = \left(\frac{p^{c,C}_2}{A^C_2 \delta^C_2}\right)^{-\sigma_2} - \left(c^C_2 + d^C_2 p^{p,C}_2\right). \tag{10}$$

The regional market-clearing conditions are as follows:

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

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

Once all the price linkage equations (equations 3, 5, and 6) are substituted into the market-clearing conditions, we can solve the simultaneous equations (in equations 11 and 12) for Mexican producer price ($p^{p,M}_i$) for the ith category of tomatoes.

3.2. *Welfare Effects*

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

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

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In the United States, because of this Suspension Agreement, producers receive the higher minimum price ($\bar{p}_P^{p,U}$) 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 $QR_i^M = (\bar{p}_i^{p,U} - p_i^{p,M})(S_i^M - D_i^M)$, that is, 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 that are positive. The sum of producer surplus loss and export quota revenues could be a gain or loss, which is an empirical question covered subsequently in the empirical analysis. Bredahl, Schmitz, and Hillman (1987) have shown that if two countries could cooperate and agree to a VER, rents for producers in both countries could rise. That is, the minimum price under the 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 the Suspension Agreement, for greenhouse and cherry and 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 as a result of the U.S. minimum import price policy. Consequently, the field tomato price in Canada declines and the producer surplus is

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

The consumer surplus is the area left of the demand curve between the new consumer price ($p_i^{c,j}$) and the free trade price (p_i^{c*}) under the 2013 Suspension

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Agreement. U.S. consumer surplus is

$$\int_{\tilde{p}_i}^{p_i^{c*}} \left(\frac{p_i^{c,U}}{A_i^U \delta_i^U} \right)^{-\sigma_i} dp_i, \quad i = 1, 2, 3. \tag{17}$$

Because the minimum price increases the price relative to free trade, U.S. consumer surplus is negative.

For Mexico, consumer surplus for each category of tomatoes is

$$\int_{p_i^M}^{p_i^{c*}} \left(\frac{p_i^{c,U}}{A_i^U \delta_i^U} \right)^{-\sigma_i} dp_i, \quad i = 1, 2, 3. \tag{18}$$

Contrary to the United States, Mexican consumer surplus is positive because the Mexican price declines under the Suspension Agreement.

Finally, Canada's consumer surplus is

$$\int_{p_i^{c,C}}^{p_i^{c*}} \left(\frac{p_i^{c,U}}{A_i^U \delta_i^U} \right)^{-\sigma_i} dp_i, \quad i = 1, 2, 3, \tag{19}$$

which is negative for greenhouse and cherry and grape tomatoes because the new price in Canada resulting from the Suspension Agreement is higher than the free trade price. However, for field tomatoes the consumer surplus is positive because when Canada is an importer, the increased imports from Mexico resulting from the U.S. minimum price reduce the Canadian consumer price in comparison with free trade.

4. Data and Calibration

We collected data from several sources for 2014 and compared them to ensure that they are accurate. Subsequently, 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.

The USDA's National Agricultural Statistics Service (USDA-NASS, 2015) 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 the USDA's Agricultural Marketing Service (USDA-AMS, 2016a) to obtain the percentages of greenhouse and field tomato production and applied these percentages to the total production data from USDA-NASS (2015) to disaggregate production data for greenhouse and field tomatoes. The production data for cherry and grape tomatoes are not directly available from any sources. Consequently, we used

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shipping and movement information from USDA-AMS (2016a) to construct the production data for cherry and grape tomatoes.[6,7]

Mexico provides a detailed set of data for various types and varieties of tomatoes (Servicio de Información Agroalimentaria y Pesquera [SIAP], 2015). We used this data to construct the production data for the three categories of tomatoes. Canada reports greenhouse and field tomato production separately (Statistics Canada, 2011, 2015). We include only field tomatoes that are used for fresh consumption. Furthermore, Canada groups cherry and grape tomatoes along with greenhouse tomatoes. To separate the cherry and grape tomato production from greenhouse tomato production, we estimate that approximately 10% of greenhouse tomatoes are cherry and grape tomatoes based on reports by Korevaar (2007), USITC (2002), and the growth rate of cherry and grape tomato production.

For U.S. imports and exports, we used information from USDA-ERS (2016), 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 used data from Statistics Canada (2016) to determine import and export data, and for consistency, we compared that data with U.S. imports from Canada. Because Mexico does not report trade data, we used the data for the U.S. and Canadian tomato trade with Mexico and information from Cook and Calvin (2005), which indicates that Mexicans only consume 15% of domestically produced greenhouse tomatoes. 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 (2016) indicated that the minimum price was the same for all categories until 2013 and generally nonbinding for Mexican greenhouse exports to the United States. Because USDA-ERS (2016) does not report price data for greenhouse tomatoes and a binding Suspension Agreement equalizes prices for Mexican exports and U.S. producers, we used the 2013 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 USDA-ERS (2016). Cherry and 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 and cherry and grape tomatoes

6 We acknowledge Suzanne Thornsbury for helping us to obtain these data and also with the process of constructing the production data for cherry and grape tomatoes.

7 Because the total shipment of greenhouse and field tomatoes collected from USDA-AMS (2016a) is similar to the total production data for these two categories of tomatoes reported in USDA-NASS (2015), we felt it was appropriate to use the cherry and grape shipping data in USDA-AMS (2016a) to construct the production data for this category of tomatoes.

were determined through the price-linkage equations. Field tomato prices were obtained from the price-linkage equations and compared with data from SIAP (2015) and FAOSTAT (2016). 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 determined from the reference prices.

Canadian prices are similar to those in the United States for greenhouse tomatoes Statistics Canada (2016). After disaggregating cherry and grape tomatoes from all greenhouse tomatoes, we estimated a producer price of $0.38/lb. Prices for field and cherry and grape tomatoes were not readily available. As a result, we utilized the price-linkage equations to estimate the field and cherry and grape tomato prices and compared field tomato prices with data from FAOSTAT (2016).

Consumer prices were readily available for the United States through USDA-AMS (2016b). These prices are reported by tomato type (i.e., vine ripened, cherry, grape, plum, etc.) and further disaggregated into greenhouse and field-grown categories. We utilized a weighted average national retail price for greenhouse plum and vine-ripened tomatoes for our study, as well as weighted averages for field and cherry and grape tomatoes.

Mexican consumer prices for field tomatoes were obtained from Numbeo (2014), which lists average prices from grocery stores for tomatoes. Greenhouse and cherry and grape tomato prices were also difficult to ascertain; consequently, prices found in Walmart in Mexico were used as a proxy (Walmart, 2014). For Canada, we again 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 and 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 ($p_i^{c,j}$) from producer price ($p_i^{p,j}$).

We utilized the previously mentioned price and quantity data for 2014 to calibrate the parameters in the model. The parameters needed for the empirical analysis include the expenditure share parameters for tomato categories (δ_i^j), price wedges (T_i), supply parameters (c_i^j and d_i^j), the share parameter A_i^j in the demand function, and the elasticity of substitution parameter (σ). Expenditures on each category of tomatoes in each country were determined by multiplying retail price times consumption for each category of tomatoes. Similarly, the share parameter was found by dividing the spending on a particular commodity by the total expenditure on tomatoes in each country. Table 1 presents these data.

For the free trade scenario, the price wedges (T_i) were set to 1, 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: $T_1 = 1.14$, $T_2 = 1.40$, and $T_3 = 1.04$. These price wedges were estimated by utilizing the price-linkage equations and data

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Table 1. Tomato Consumption Share Parameters for the United States, Mexico, and Canada

	Share of Budget		
$j = U, M, C$	δ_1^j	δ_2^j	δ_3^j
United States	0.42	0.45	0.13
Mexico	0.16	0.80	0.04
Canada	0.40	0.47	0.13

on Mexican producer price, U.S. producer price, and transportation costs. 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 ($t_i^{M,U}$) was estimated at \$0.06/lb. in 2007 by Bayard, Chen, and Thompson (2007). We considered a slightly higher value of \$0.08/lb. for greenhouse and field tomatoes in 2014 because of higher gas prices and general inflation since 2007. In addition, we estimated transportation costs of \$0.15/lb. for cherry and grape tomatoes because of packaging requirements. We used similar estimates for transportation costs from Canada to the U.S. border ($t_i^{C,U}$).

Although numerous studies have estimated the elasticity of demand for aggregate tomatoes (see Huang, 1985; Málaga, Williams, and Fuller, 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 $\varepsilon^U = \varepsilon^C = 0.12$ (the weighted average of summer and winter elasticities) and $\varepsilon^M = 0.07$. Based on Salazar, Williams, and Málaga (2005), the Canadian elasticity of supply was assumed to be equal to that of the United States. The 2014 production quantities (S_i^j) and producer prices ($p_i^{p,j}$) are used to calibrate the coefficients of the supply functions (see equation 1). Finally, we consider an elasticity of substitution, σ, equal to 1.10, which is reported by Jung (2004). Parameters A_i^j ($i = 1 - 3$, $j = U, M, C$) were calibrated to reproduce the data.

5. Analysis and 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 welfare and consumer surplus). Toward this goal, we run two simulation scenarios: baseline and alternate. The baseline scenario is free trade, where the price wedges are set to 1.[8] The alternate scenario is the 2013 Suspension Agreement, where the price

8 Technically, it would be the price given the existing conditions in the United States and Mexico, which may not be equal to true free trade.

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Table 2. Impacts of Suspension Agreement on Tomato Prices and Quantities

Variable	United States %	Mexico %	Canada %
Greenhouse			
Producer price ($/lb.)	3.65	− 8.39	4.44
Supply (million lb.)	0.43	− 0.65	0.52
Consumer price ($/lb.)	0.97	− 3.88	0.87
Demand (million lb.)	− 1.05	4.45	− 0.95
Imports/exports (million lb.)	− 1.51	− 2.06	2.41
Field			
Producer price ($/lb.)	14.57	− 14.01	− 8.49
Supply (million lb.)	1.36	− 1.32	− 1.08
Consumer price ($/lb.)	3.74	− 3.95	− 1.82
Demand (million lb.)	− 3.96	4.53	2.04
Imports/exports (million lb.)	− 13.37	− 11.02	22.04
Cherry and grape			
Producer price ($/lb.)	0.50	− 3.22	0.65
Supply (million lb.)	0.06	− 0.23	0.08
Consumer price ($/lb.)	0.10	− 0.61	0.09
Demand (million lb.)	− 0.11	0.68	− 0.10
Imports/exports (million lb.)	− 0.35	− 0.41	14.80

wedges are $T_1 = 1.14$, $T_2 = 1.40$, and $T_3 = 1.04$. Mexican producer price for each tomato category i is endogenously determined using the market-clearing conditions (equations 11 and 12), which we use to find the remaining consumer and producer prices in each country j through the price-linkage equations. 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 2 presents these results.

Under the 2013 Suspension Agreement, the minimum import prices for all three categories of tomatoes are higher in the United States compared with those under free trade because these prices are binding. For greenhouse tomatoes, U.S. producers see their price rise by approximately 3.65% compared with that under free trade, which leads to a small increase in supply of 0.43%. In response to this policy, consumer price rises by 0.97%, and demand for greenhouse tomatoes falls by 1.05%. The magnitude of price changes for consumers is less than that of producers. With higher producer price for greenhouse tomatoes, imports decline by 1.51%.

Because the minimum import price reduces U.S. import demand for Mexican greenhouse tomatoes, prices in Mexico fall. Mexican producer prices decline by 8.39%. In response to the fall in producer prices, Mexican greenhouse tomato supply declines by 0.65%. Because of the decline in exports of 2.06%, Mexican

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consumer prices decline by 3.88%, and the quantity of greenhouse tomatoes sold domestically increases by 4.45%.

The Suspension Agreement induces a trade diversionary effect; that is, some of the 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 2.41%. As a result of the increased Canadian exports, the greenhouse tomato producer price in Canada rises by 4.44%, and the consumer price by 0.87%. In response to higher prices, supply increases by 0.52%, whereas demand declines by 0.95%. It is worth pointing out that because Canada's quantities are much smaller, changes in the volume (not percentage changes) are smaller compared with those of the United States and Mexico, indicating that 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 Suspension 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. Because 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 fall by 13.37%, which leads to an increase in U.S. producer price of 14.57%. This price increase boosts U.S. supply by 1.36%. With this reduction in imports, the consumer price increases by 3.74%, and demand declines by 3.96%.

The impacts of the Suspension Agreement's higher minimum price on the Mexican field tomato market are substantial. This policy significantly restricts Mexican exports of field tomatoes to the United States by 11.02%. Consequently, Mexico sells more in the domestic market, which reduces the producer and consumer price by 14.01% and 3.95%, respectively. The lower price leads to a 1.32% decrease in supply and a 4.53% increase in demand.

Canada is an importer of field tomatoes. Because Mexico exports less to the United States under the minimum import price policy, it diverts its exports to Canada. Field tomato imports to Canada rise by 22.04%. Although the percentage change is high, the actual quantity only increases by 23.44 million pounds. As a result of more imports coming into Canada, field tomato prices in Canada decline by 8.49% for producers, leading to a supply decline of 1.08%. However, consumer prices for field tomatoes fall by only 1.82%, resulting in a demand increase of 2.04%.

The final category is cherry and 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 and Canadian cherry and grape tomato exports to the United States decline by 0.35%. Similarly, the changes in prices and quantities are also minimal. For example, the producer price in the United States increases by only 0.50%, a much smaller increase than

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Table 3. Changes in Producer Gains, Consumer Surplus, and Net Welfare from the Suspension Agreement (in millions of dollars)

	United States	Mexico	Canada
Greenhouse			
Producer welfare	9.96	12.09	9.13
Consumer surplus	−41.99	15.07	−5.11
Net welfare	−32.03	27.16	4.02
Field			
Producer welfare	108.80	−29.50	−19.02
Consumer surplus	−165.84	76.35	22.33
Net welfare	−57.04	46.85	3.31
Cherry and grape			
Producer welfare	0.84	0.02	0.21
Consumer surplus	−1.43	0.57	−0.20
Net welfare	−0.59	0.59	0.01

those of greenhouse or field tomatoes. Consumer prices rise by only 0.10%. Supply (demand) increases (decreases) by 0.06% (0.11%).

Because the minimum price is closer to the free trade price, the domestic price in Mexico for producers (consumers) only declines by 3.22% (0.61%). These small impacts lead to correspondingly minor changes in supply (demand) of −0.23% (0.68%). Canada, as a net exporter of cherry and grape tomatoes, also experiences only minor changes. Canada is a very minor player in the trade of cherry and grape tomatoes, and the 14.80% increase in exports of cherry and grape tomatoes corresponds to an increase of only approximately 0.11 million pounds. Because Canada augments its exports to the United States, Canadian producer and consumer prices increase by 0.65% and 0.09%, respectively. These prices increases lead to a supply increase of 0.08% and a demand decrease of 0.10%.

In summary, the higher minimum prices benefit U.S. producers and hurt U.S. consumers. In contrast, Mexican producers incur producer surplus losses from the price minimum policy compared with free trade, whereas consumers gain. We quantify these welfare changes using producer surplus (PS) and consumer surplus (CS). Producer surplus values for the United States and Canada were determined through equations (13) and (15). For Mexican producers, we computed producer surplus loss plus quota revenues using equation (14). CS for each country was computed using equations (17)–(19). Table 3 reports the results of these welfare measures.

For the United States, producer surplus is positive for each category because producers gain from higher prices under the minimum import prices. Although greenhouse tomato producers experience a moderate $9.96 million increase in producer surplus, field tomato producers gain the most, by $108.80 million.

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Cherry and grape tomatoes, which saw the smallest price increase and also represent the smallest tomato category, have the smallest increase in producer surplus of $0.84 million. Overall, U.S. tomato producer surplus increases by $119.60 million for all three categories. Although producers benefit from price increases in all three categories of tomatoes, consumer surplus falls. Greenhouse tomato consumer surplus falls by $41.99 million, and field tomato consumer surplus has the most substantial loss of $165.84 million. Cherry and grape consumer surplus has a modest decline of just $1.43 million. Summing consumer surplus across all categories, the total decline is $209.26 million.

For Mexico, producer welfare includes both producer surplus loss and quota revenues. The greenhouse tomato category has a net gain of $12.09 million for Mexican producers, with quota revenues of $80.08 million and a producer surplus loss of $68.00 million. Because the domestic consumption of greenhouse tomatoes in Mexico is only 15%, 85% of the production is exported. As a result, quota revenues from the Suspension Agreement are significantly larger. Consequently, the sum of positive quota revenues and negative producer surplus is positive. Field tomato producers experience a welfare loss of $29.50 million (quota revenues of $89.39 million and producer surplus loss of $118.90 million) because the magnitude of the price decline is the highest and 70% of all Mexican-produced field tomatoes are consumed domestically. For cherry and grape tomatoes, producer welfare increases by a miniscule $0.02 million, which is composed of $3.52 million in quota revenues and producer surplus loss of $3.50 million. This positive producer welfare results from the small level of domestic consumption and large quantity of exports. Summing the producer welfare of all three categories of tomatoes yields a net loss of $17.30 million. Without quota revenues accruing to Mexican producers, the reduction in producer surplus would be $190.40 million. Consumers gain in every category of tomato consumption. Consumer surplus gains in greenhouse, field, and cherry and grape are, respectively, $15.07, $76.35, and $0.57 million. The overall consumer surplus gain is $91.99 million.

Canada experiences price increases in greenhouse and cherry and grape tomatoes, which are net exports, and a price decrease in field tomatoes, which is an import. Consequently, Canada sustains mixed producer and consumer surplus results. Greenhouse and cherry and grape tomato producers experience a gain of $9.13 and $0.21 million, respectively, as Canadian prices for these tomatoes rise. In contrast, field tomato producers lose $19.02 million as increased imports Mexico lead to price declines. Total Canadian producer surplus over all three categories was a loss of $9.68 million. For consumers, the gain in field tomato consumer surplus of $22.33 million dominates consumer surplus losses in greenhouse and cherry and grape tomatoes (−$5.11 and −$0.20 million, respectively). As a result, Canadian consumers gain $17.02 million.

Summing producer welfare and consumer surplus yields the net welfare effects. For greenhouse tomatoes, the United States loses $32.03 million, whereas Mexico

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and Canada gain $27.16 and $4.02 million, respectively. For field tomatoes, the United States has a high net loss of $57.04 million, whereas Mexico has a gain of $46.85 million. Canada has a small net gain of $3.31 million. The cherry and grape tomato minimum price has smaller net effects, with the United States losing $0.59 million and Mexico and Canada gaining $0.59 and $0.01 million, respectively. For each category of tomatoes, the sum of welfare of all three countries is a net loss. Thus, the minimum price policy leads to a deadweight loss.

6. Implications and Conclusions

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 tomato producers to keep prices from falling because of 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 because 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 in the United States, as well as producers of greenhouse and cherry and grape tomatoes in Canada, benefit from the Suspension Agreement. Much of Mexican producer surplus loss is ameliorated because of quota revenues, even resulting in a net gain for greenhouse and cherry and grape tomatoes. This indicates that the Suspension Agreement has caused Mexican production to shift from field tomatoes to greenhouse tomatoes, demonstrating their comparative advantage in greenhouse production. Until this most recent agreement, the trade in both greenhouse and cherry and grape tomatoes was not binding because the minimum import price was too low to restrict trade. Now, however, the minimum 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. Interestingly, Canada is now investigating alleged dumping of Mexican tomatoes in Canada, likely a result of the 2013 Suspension Agreement's trade diversionary effects (Mann, 2014). The

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category most affected by the new minimum price is field tomatoes, the price of which was already binding even before the 2013 agreement.

Although most U.S. consumers are unaware of the Suspension Agreement, this policy does have aggregate adverse impacts on consumers. Because tomatoes are a commonly consumed product, 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, consumer surplus declines significantly, particularly for field tomatoes. In examining the welfare effects of the 2013 Suspension Agreement, this study quantifies the effects of this trade policy on both producers and consumers. Overall, although Mexico and Canada gain, the United States loses from these minimum import prices.

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