**A Country-Differentiated Import Demand Model for Fresh Tomatoes in the United States: an Estimation of Price and Income Elasticities for 1991 through 2014**

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Abstract

This study applies the System-Wide approach to demand estimation to U.S. tomato import data to obtain demand sensitivity measure (elasticities) estimates for this commodity. Using the Rotterdam model as a parametrization of the System-Wide approach, a demand model is estimated for monthly aggregated tomato imports from Mexico, Canada, and the rest of world; as well as the U.S. domestic tomato production. Significant estimates for income and own-price and cross-elasticities measures are found for tomatoes from all countries. All tomatoes are found to be own-price inelastic. U.S. and Mexico tomatoes are found to be expenditure elastic, while tomatoes from Canada and the rest of the world are found to be expenditure inelastic. This suggests a low sensitivity of demand for U.S. consumers with respect changes in tomato own-price, regardless of country of origin; while for the case of U.S. and Mexico demand will increase if U.S. tomato expenditure rises, and demand will decrease for Canada and rest of the world tomatoes if U.S. tomato expenditure rises. Additionally a variant of the Rotterdam model is estimated to study the effect of exchange rate fluctuations on the demand for tomatoes, using monthly data for nominal exchange rates between the U.S. and Mexico, and the U.S. and Canada it is found in both cases, that increased U.S. Dollar strength with respect to the currency of either country will result in increased imports.

Keywords: demand estimation, system-wide approach, exchange rates, Rotterdam model.

1. Introduction

Demand elasticities for imported commodities are an important component in international trade economics. As noted by Valdez-Lafarga (2015), their applicability for policy and business decision making can be affected by the level of statistical significance. For the case of U.S. imports of fresh vegetables not many up-to-date estimates exist in the literature with the statistical significance for meaningful interpretation. Some important exceptions are present for the case of the fresh tomato market in the U.S. For example Asci et al (2016) provide significant demand elasticities when analyzing the demand for Field-grown and Greenhouse-grown fresh tomatoes in the U.S. and Valdez-Lafarga (2015) provides significant demand elasticity estimates for aggregated fresh tomato import demand in the U.S. While both articles mentioned provide new up-to-date elasticity estimates with statistically significant results, and in particular Asci et al (2016) provides additional analyses on the effects of current trade policies among the U.S. and Mexico, neither of them analyzes the effect of additional factors, from international trade, that could affect demand such as exchange rate fluctuations between the participating countries. In particular changes in exchange rates could be expected to provide additional incentive for foreign exporters to increase their trade volumes (Acharya and Schmitz, 2004). Considering the relevance of increased precision in the estimation of demand sensitivity measures, improvements in such measures may allow to determine the welfare obtained by both consumers and producers in an increasingly global economy-driven agriculture; which, in turn, should advise improved policy decision making related to international agricultural trade. This study extends upon the work of Asci et al (2016), Valdez-Lafarga (2015), and Acharya and Schmitz (2004) to present results of research aimed at obtaining more recent demand sensitivity measures, such as expenditure and price elasticities, while also providing an analysis of the effects of exchange rate fluctuations for the case of the fresh tomato market in the U.S. In particular the effects of Mexican and Canadian exchange rates with respect to the U.S. dollar are analyzed to obtain a more comprehensive understanding of the factors affecting consumption of this commodity.

## 2. Background

### 2.1 The U.S. fresh tomato market.

Tomatoes are considered the highest valued horticulture product in the U.S. While the U.S. is still among the leading producers of tomatoes in the world, China is the largest producer. The U.S. imports about 37% of the total amount consumed of this commodity. An increase from 20% with respect to the 1990s (USDA: ERS, 2012). Until 2010 domestic production captured the largest share of the market, but it is now dominated by imports from Mexico, followed by U.S. production, imports from Canada, and the rest of the world. The share of volume by each country is shown in Figure 1 for the 1991-2014 period, in accordance to data from the U.S. Department of Commerce (2014) and U.S. Department of Agriculture Economic Research Service (USDA:ERS) (2014).

According to the USDA; ERS (2012) an important factor in the increased market share of Mexico in the U.S. tomato market can be attributed to large investments by Mexican producers in production technologies such as greenhouse production, which can contribute to increases in quality and food safety. It is important to note while Mexico, since 2010, has the largest volume share in the market, it does not have the highest market prices. The highest prices are held by Canadian and other country tomatoes (Figure 2). According to data from the U.S. Department of Commerce (2014) and the USDA ERS (2014), out of the imported tomatoes, Mexico receives the lowest prices per kilogram for the 1991-2014 period, only followed by the U.S. grown tomatoes which receive the overall lowest prices within the same period.

For case of Mexican tomatoes, imported tomatoes from Mexico compete with tomato production mostly from Florida during the winter and early spring window (October to June). Tomatoes from Mexico are primarily from the state of Sinaloa, where the peak of production is during the winter and early spring months (December-April), and production declines during the late spring early summer months (May-June). On the other hand, Florida tomatoes have their production peak in the months of April and May, with a production decline in June (USDA;ERS, 2012). Mexican production is mostly shipped to the western

U.S., while Florida production is shipped primarily to the Eastern U.S. Because of the low prices, Mexican tomatoes can capture about 43-68% of the U.S. market during their winter production peak (January-April) (Cook and Calvin, 2005). Information from the USDA;ERS (2015), and the U.S. Department of Commerce (2014) shows that while domestic tomato production has remained stable within the U.S. imports of this commodity have steadily increased over the 1991-2014 period (Figure 3).

Given the increased market share of Mexican imports, trade conflicts arisen, that resulted in accusations of dumping directed towards Mexican tomato producers by U.S. producers. In 1978, three Florida producer groups filed an anti-dumping case against Mexican winter vegetables. The U.S. Department of Commerce did not find any evidence to support the dumping, and consequently dropped the case (Bredahl et al, 1987). A subsequent lawsuit was filed by Florida producers with the U.S. International Trade Commission (USITC) in 1996. This new lawsuit alleged that Mexican fresh tomato imports could be a threat for U.S. domestic production (USITC, 1996). USITC found that a threat of material injury to U.S. domestic production of tomatoes was possible and proposed the implementation of anti-dumping tariffs. However, in December of 1996, the U.S. Department of Commerce and Mexico reached an agreement to suspend the anti-dumping investigation. Through the agreement, Mexican producers voluntarily reduced the volume of their exports and agree to a minimum reference price (price floor) of $0.4647 per kilogram, which was effective in May, 1997 (U.S. Department of Commerce, 1997). In 1998 two additional regions in Mexico also started exporting tomatoes to the U.S., which resulted in an agreement with two price floors, because one region has a peak production in the summer and the other in the winter. The new price floors were $0.4647 per kilogram in the winter (November-June), and $0.3792 per kilogram for the summer (July-October). By 2002, given the refusal of a number of Mexican producers to commit to the agreement, the 1998 agreement was repealed, and the U.S. Department of Commerce resumed its anti-dumping investigation until December of 2002, when a new suspension agreement was reached (Baylis and Perloff, 2010). In January 22, 2008 this same agreement was renewed with a new price floor for winter tomatoes of $0.4782 per kilogram (USDA;ERS, 2012). In March 4 2013, yet another suspension agreement was negotiated which provided a more detailed assignment of price floors. Price floors were placed on open field and adapted environment tomatoes of $0.6834 and $0.5418 per kilogram respectively for winter and summer. Price floors were also placed on controlled environment tomatoes for winter and summer of $0.9038 and $0.7167 per kilogram respectively. Packed specialty variety tomatoes also received price floors for winter and summer of 1.3007 and 1.0315 per kilogram respectively. Finally loose specialty variety tomatoes received price floors of $0.9921 and $0.7866 per kilogram respectively. It is important to note that while these price floors have served as reference prices for Mexican tomato imports within the U.S. market, they have never been binding since their application (at least at the monthly level of aggregation). Therefore they have never represented actual minimum prices for Mexican tomatoes within the U.S. Market in accordance to data compiled from the U.S. Department of Commerce (2014) and the USDA: ERS (2014) (Figure 4). Also, The U.S. market for fresh tomatoes may also be affected by other international trade economic aspects such as exchange rates. According to data compiled form the USDA;ERS (2015), the U.S./Canada exchange rates has been generally stable, but the U.S./Mexico exchange rate has depreciated (Figure 5). The depreciation of the Mexican Peso with respect to the U.S. dollar is expected to result in increased exports to the U.S.

Considering all the aspects described before, any attempt to understand the dynamics of the fresh tomato market in the U.S. must take into account the effect of trade policies in place, such as price floors, and exchange rate fluctuations. However, while price floors could be considered an important aspect affecting demand through their effect on prices in the future, they have not as yet been binding (through 2014). Therefore, this study focuses on the effects of past exchange rate fluctuations on the demand for fresh tomatoes in the U.S.

## 2.2 Demand Estimation for imported agricultural commodities.

Past econometric modeling efforts of a country's demand for imported commodities, in particular vegetables, has been mostly characterized by applications of the demand systems. Given the aims of this study to obtain more demand sensitivity measures accounting for additional economic factors such as exchange rates, a discussion is presented with respect to more recent applications of these models aimed at agricultural commodity imports, including tomatoes in the U.S. and other markets.

Schmitz and Seale (2002) analyzed the sensitivity of demand for imported fruit to changes in consumer income. Using yearly aggregated imports by Japan for different produce over a period of 30 years, the authors estimate a general differential demand system. The system nests the Rotterdam model, the Central Bureau of Statistics (CBS) model, the Almost Ideal Demand System (AIDS) model, and the National Bureau of Research (NBR) into one model. Applying Seemingly Unrelated Regression (SUR) and Maximum Likelihood Estimation (MLE) methods, the authors found that the Rotterdam model specification could not be rejected by the data, while other model specifications were rejected, concluding that the Rotterdam model specification is more adequate for the data set employed. The approach of Schmitz and Seale (2002) provides an important insight into the pertinence of applying system-wide models for the problem of agricultural commodity imports, and also demonstrates that for such case a Rotterdam model specification can be adequate to describe such markets.

VanSickle and Seale (2005) analyzed the demand sensitivity to prices and income for domestic and imported tomatoes in the U.S., using yearly regarding imported and domestic tomato consumption, the authors estimated a Double-log, Rotterdam, and AIDS model specifications. They found that the U.S. tomato demand is not very sensitive (inelastic) to changes in prices, regardless of the country from which the product originates. Tomatoes from different countries were found to be substitutes among each other, with consumers purchase decisions being primarily driven by lower prices. However the limited time period used in the analysis may affect the significance of the obtained parameter estimates.

Grant, Lambert and Foster (2010) conducted a study using the system-wide approach as well to explain the substitution patterns of tomatoes from different countries within the U.S. market. Using monthly import data, the authors apply an Inverse AIDS model to obtain demand sensitivity measures. The authors argue that the use of monthly allows the model to account for seasonality. The authors find that the majority of imports fill the demand for tomatoes in seasons where domestic production may be limited. A major contribution of this work is the application of monthly data that allow for controlling effects of seasonality in supply that may also have an effect on the demand for tomatoes.

Seale, Zhan, and Traboulsi (2013) applied the system-wide approach through a Rotterdam model specification to obtain measures of demand sensitivity to prices and income for imported produce in the U.S. market (including tomatoes). Using yearly import data from the USDA;ERS, the researchers found that the studied commodities are more sensitive to income changes. Therefore, more expensive produce would benefit from increased incomes. Similar to VanSickle and Seale (2005) this study also suffers from lack of statistical significance in its cross-price parameter estimates due its short period of analysis (1989-2009).

A more recent study by Asci, Seale, Onel, and VanSickle (2016) analyzed the demand sensitivity to price and income for fresh tomatoes in the U.S. by applying the system-wide approach. Similar to Schmitz and Seale (2002) the authors test different specifications (Rotterdam, CBS, AIDS, NBR, and a general model including aspects of the previous four). Using monthly data for imports and domestic production of field grown and greenhouse grown tomatoes the researchers find that the general model cannot be rejected by the data, and that regardless of production method (field grown or greenhouse grown) tomatoes from the U.S. and Mexico in particular act as competing substitutes. Additionally, the authors explore the implications of the 2013 suspension agreement between the U.S. and Mexico through a series of simulations with their parameter estimates for different price floor scenarios. Their findings suggest that most policies will result in increased consumption of imported tomatoes and a decrease in domestic consumption. While changes in price floor may affect the consumption of the commodity in the future, current historical data does not support that any prices have been binding for Mexican tomatoes. Therefore any effects may be a subject of speculation. However this study similarly to Grant, Lambert and Foster (2010) demonstrates that monthly data may provide more precise and significant estimates by controlling for the effects of seasonality in tomato production.

Analyzing other potential effects on the demand of agricultural commodities, in particular the effect of exchange rate fluctuations is important. Exchange rate effects may be confounded within the effects of import prices (Dormbusch (1987); Froot and Klemperer (1989); Goldenberg and Knetter (1997)) Following this argument and extensions to the system-wide approach to incorporate preference variables (Brown and Lee, 2002), Acharya and Schmitz (2004) extended the Rotterdam model specification to account for effects of exchange rate fluctuations in the demand for apple imports in several countries. The authors found that exchange rate fluctuations may also be incorporated into the model in order to measure their impact on demand.

Considering the applicability of the system-wide approach to obtain demand sensitivity measures for agricultural commodity import demand, and the lack of further studies on the effect of exchange rates, this study both controls for effects of seasonality, using monthly data, and provides an estimate of the effects of exchange rate fluctuations for the particular case of the fresh tomato market in the U.S.

## 3. Methodology

### 3.1 The Rotterdam Model

A parametrization of the system-wide approach to demand is the Rotterdam model. Developed by Thiel (1965), the model is derived using a differential approach to solve a system of equations that represent a generalization of the consumer utility maximization problem subject to a budget constraint:

$$(1) \qquad \max U(q) \quad \text{s.t.} \quad \sum_i \left( p_i q_i \right) = M,$$

where $U(q)$ is utility as a function of consuming a vector $q$ of goods. $M$ is the total income for the consumer, $p_i$ and $q_i$ are the price and quantity of the i[th] good respectively. Using the differential approach to solve the problem requires total differentiation of the budged constraint in (1) which results in:

$$(2) \quad dM = \sum q_i dp_i + \sum p_i dq_i$$

Dividing (2) by $M$ , multiplying and dividing the first term of the right hand side by $p_i$ , and similarly the second term by $q_i$ results in

$$(3) \quad \frac{dM}{M} = \sum \left( \frac{p_i q_i}{M} \right) \left( \frac{dp_i}{p_i} \right) + \sum \left( \frac{p_i q_i}{M} \right) \left( \frac{dq_i}{q_i} \right)$$

Letting $w_i = \left( p_i q_i \right) / M$ be the budget share of the i[th] good. And applying the rule that for any given variable *X*, dX/X = d(lnX), equation (3) may be rewritten as:

$$(4) \quad d\left(\ln M\right) = \sum w_i d\left(\ln p_i\right) + \sum w_i d\left(\ln q_i\right)$$

Using the definition of the Divisia price index $d\ln P = \sum w_i d\left(\ln p_i\right)$, and the Divisia volume index $d\ln Q = \sum w_i d\left(\ln q_i\right)$ equation (4) becomes:

$$(5) \quad d\ln M = d\ln P + d\ln Q$$

Applying properties of logarithms equation (5) can be written as:

$$(6) \quad d\left[\ln\left(M / P\right)\right] = d\ln Q$$

Equation (6) states that the natural logarithm of the change in income deflated by the price index is equal to the Divisia volume index. Using this definition in conjunction with Barten’s (1964) fundamental matrix, the utility maximization problem leads to the specification of the Rotterdam model (Schmitz, and Seale, 2002):

$$(7) \quad w_i d\ln q_i = \theta_i d\ln Q + \sum_j \pi_{ij} d\ln p_j$$
$$i = 1, 2, ..., n$$

Where $w_i = \left(w_{it} + w_{i,t-1}\right)/2$ is the average value share for good $i$ (subscript $t$ standing for time). $d\ln q_i = \ln\left(q_i / q_{i,t-1}\right)$ is the natural logarithm of the change in consumption level for good $i$, and $d\ln p_i = \ln\left(p_i / p_{i,t-1}\right)$ is the natural logarithm of the change in the price of good $i$. $d\ln Q$ is the Divisia volume index for the change in real income as in equation (6).

From the solution to the utility maximization problem through Barten's (1964) fundamental matrix we obtain the demand parameters

$$(8) \quad \theta_i = p_i\left(\partial q_i / \partial M\right) \text{ and } \pi_{ij} = \left(p_i p_j / M\right) s_{ij}$$

Where $s_{ij} = \partial q_i / \partial p_j + q_j \partial q_i / \partial M$ , $M$ is the total budget, and $s_{ij}$ is the (*i*, *j*)th element of the Slutsky substitution matrix. The parameter $\theta_i$ represents the marginal budget share for good *i*, and $\pi_{ij}$ is a compensated price effect. Both parameters are assumed to be constant, and they are expected to adhere to the following restrictions from demand theory:

$$(9) \text{ adding up } \sum_i \theta_i = 1$$
$$\sum_i \pi_{ij} = 0$$
$$(10) \text{ Homogeneity } \sum_j \pi_{ij} = 0$$
$$(11) \text{ Slutsky symmetry } \pi_{ij} = \pi_{ji}$$

## 3.2 Import demand sensitivity measures

Measures such as income (expenditure) and price elasticities can be obtained from the parameters $\theta_i$ and $\pi_{ij}$ as follows. Conditional import expenditure elasticities for each good *i* can be recovered from the parameters using:

$$(12)\ \eta_i = \theta_i / w_i$$

In this study, import expenditure elasticities are calculated at the sample mean conditional budget share within the time period of the data. These measures indicate the consumers' propensity to purchase of goods. Above unity, an increase in the consumer's income would result in increased consumption of the good. Below unity, increased consumer income will result in decreased consumption of the good. In this case the propensity of U.S. consumers to purchase tomatoes from different exporting countries is compared.

Own-price elasticities can be estimated as Conditional Slutsky (compensated) price elasticites. Which indicate the percentage response in quantities demanded resulting from a one percent change in price, holding real expenditures on the imported good constant. Using:

$$(13)\ S_i = \pi_{ii} / w_i$$

Conditional Slutsky elasticities measure the sensitivity that quantity demanded for the good will have with respect to increases in its price. Above unity, the good will be elastic or highly sensitive to changes in price. Below unity the good will be inelastic, or of a low sensitivity to changes in its price. In this case, the price sensitivity for the tomatoes of each exporting country is determined. In addition, Slutsky (conditional) cross-price elasticities can be calculated. The cross-price elasticity indicates the percentage response in the quantity demanded for good *i* that results from a one percent change in the price of another good *j*. The conditional Slutsky cross-price elasticities is:

$$(14)\ S_{ij} = \pi_{ij} / w_i$$

The sign of is the cross-price elasticity is important. A positive sign indicates that the two products are substitutes, while a negative sign indicates they are complements. In this case the nature of the relationships between the tomatoes imported into the U.S. from different countries is determined.

In addition to Conditional Slutsky (compensated) price sensitivity measures, it is also possible to calculate the Conditional Cournot (uncompensated) price sensitivity measures, or elasticities. Which indicate the percent change in consumption resulting from a unitary percent change in price, while holding nominal expenditures on the commodity constant. The Cournot own-price elasticities are:

$$(15) \quad C_i = \pi_{ii} / w_i - \theta_i$$

While the Cournot cross-price elasticities are:

$$(16) \quad C_{ij} = (\pi_{ij} - \theta_i w_j) / w_i$$

3.3 Extending the Rotterdam model to account for exchange rate fluctuation effects.

Following the extension proposed originally by Brown and Lee (2002) to add preference variables, Acharya and Schmitz (2004) argued that exchange rates could be viewed as a “sticky” preference variable that could have an influence on purchasing decisions.

As in Theil’s framework the model begins by solving the consumer maximization problem:

$$(17) \quad \text{Maximize } u = u(q, z)$$

$$\text{Subject to } p'q = m$$

where $u$ is a utility function with well behaved properties. $p$ and $q$ are price and quantity vectors respectively, while $m$ represents total expenditure. The vector $z$ represents a set of preference variables, which are viewed as a “sticky” portion of exchange rate effects under the hypothesis (testable) that exchange rate effects do not pass through completely their effects into prices. Solving the first order conditions for this system yields a set of demand equations, from which a variant of the Rotterdam model can be approximated (Brown and Lee, 2002). Through total differentiation, the resulting set of demand equations is like follows:

$$(18)\quad Udq - pd\lambda = \lambda dp - Vdz$$

$$p'dq = dm - q'dp$$

The resulting relationship (18) is a variant of Barten's fundamental matrix for consumer demand. Solving (18) results in the income-compensated demand equations:

$$(19)\quad dq = \frac{\partial q}{\partial m} = (dm - q'dp) + S(dp - \frac{Vdz}{\lambda})$$

where $\frac{\partial q}{\partial m} = \frac{U^{-1}p}{pU^{-1}p}$, $\frac{\partial \lambda}{\partial m} = \frac{1}{pU^{-1}p}$, and $S = \lambda U^{1} - (\frac{\partial q}{\partial m})(\frac{\partial q}{\partial m})'(\frac{\lambda}{\frac{\partial \lambda}{\partial m}})$. For the purposes of this study, the result of most importance from (19) is that the effect of the preference variable (exchange rate in this case) can be written as: $\frac{\partial q'}{\partial z} = -SV/\lambda$. Given this result, it is possible to write a variant of the Rotterdam model in log changes as follows (Brown and Lee, 2002):

$$(20)\quad w_i dlnq_i = \theta_i dlnQ + \sum_j \pi_{ij} dlnp + \beta_i dlnz \qquad \text{i=1, 2, ...., n}$$

where again $w_i = p_i q_i / m$ is the budget share for good I; $\theta_i = p_i(\frac{\partial q_i}{\partial m})$ is the marginal propensity consume; $dlnQ = \sum w_i dlnq_i$ is the Divisia volume index; $\pi_{ij} = \left(\frac{p_i p_j}{m}\right) s_{ij}$ is the Slutsky coefficient, and $s_{ij} = (\frac{\partial q_i}{\partial p_j} + \frac{q_j \partial q_i}{\delta m})$ is the $(i,j)^{th}$ element of the substitution matrix S; $\beta_i = w_i(\frac{\partial lnq_i}{\partial z})$ is the exchange rate coefficient.

The theoretical demand restrictions for the model according to Brown and Lee (2002) become:

$$(21)\ \text{Adding up:}\ \sum_i \theta_i = 1 \qquad \sum_i \pi_{ij} = 0 \quad \sum_i \beta_i = 0;$$

$$(22)\ \text{Homogeneity:}\ \sum_j \pi_{ij} = 0;$$

$$(23)\ \text{Symmetry:}\ \pi_{ij} = \pi_{ji}$$

Similar to the specification of the Rotterdam model done in equation (7), coefficients $\theta_i$ and $\pi_{ij}$ are still considered constants during estimation. However according to Brown and Lee (2002) it is not appropriate to treat $\beta_i$ as constants, since it would not account for the fact that $\partial q/\partial z' = -SV/\lambda$. The resulting estimates may not satisfy the general restrictions on demand described by (21), (22) and (23). Instead the following specification is employed:

$$(24) \quad \beta_i = \sum_h \pi_{ih}\gamma_h \quad \text{i=1,2,….,n}$$

where $\gamma_h = \partial \ln(\partial u/\partial q_h)/\partial lnz$ is the elasticity of the marginal utility of good h with respect to preference variable z (Brown and Lee, 2002). The adding-up and other restrictions can be imposed on $\gamma_i$ instead of the $\beta_i$. Thus the system described by equation (7) can be estimated directly by eliminating the nth equation and performing an iterative seemingly unrelated regression on the resulting equation below:

$$(25) \quad w_i dlnq_i = \theta_i dlnQ + \sum_{j=1\ldots n-1} \pi_{ij}[dlnp_j - dlnp_n + \gamma_j^n dlnz], \ \text{i=1, …., n-1}$$

where $\gamma_j^n = \gamma_j - \gamma_n$. Within equation (25) a change in the exchange rate (z) is viewed as resulting in adjusted price changes. The first term following the Slutsky coefficient corresponds to the jth product's actual price change, with the subtraction of the impact of the exchange rate on the jth product's marginal utility relative to the nth product's price change, with the subtraction of the impact of the exchange rate on the nth product's marginal utility (Acharya, and Schmitz, 2004).

In practice, estimating equation (25) in an unrestricted manner will yield only one reduced form coefficient ($\beta_i$) for each of the *i* equations associated with $dlnz$. This coefficient is, in reality, comprised of *j-1* components that take the form described by equation (24). While, in the unrestricted case, the individual $\gamma_j$ cannot be identified, a linear combination of them is recoverable from $\beta_i$ through the relationship:

$$(26) \quad (\gamma^* - t\gamma_n) = -\pi^{*-1}\beta^*$$

$$where\ \gamma^* = (\gamma_1 \ldots .\gamma_{n-1}), \pi^* = (\pi_1 \ldots .\pi_{n-1}), \beta^* = (\beta_1 \ldots .\beta_{n-1})$$

and $t$ is the summation vector.

The parametrization described by equation (25) for the Rotterdam model variant, along with the relationships described by equation (26) allow for the imposition of further restrictions on exchange rate cross parameter effects. For the empirical application subsequently described, only one exchange rate of an exporting country with respect to the U.S. is studied at a time. Under this specification it is possible to identify the effect of the exchange rate on (only) one particular exporting country on U.S. consumption of fresh tomatoes. In this study, we therefore impose the following restrictions the exchange rate parameter:

(27) $\gamma_1^n = \gamma_1$ and $\gamma_j^n = 0$ for all j=2,..,n

Under restrictions (27) parameter $\gamma_1$ becomes identifiable, and by obtaining an estimate for $\gamma_1$ the parameters $\beta_i$ can be found with the relationship:

$$(28) \quad \beta_i = -\pi_{ij}\gamma_1$$

It is important to note that the adding up conditions are now satisfied through the $\gamma_i$, allowing the $\beta_i$ to be, to some extent, free from the adding up restriction. This is of critical importance as it is not possible to have $\beta_1$(coefficient associated with the exchange rate of the exporting country with respect to the U.S.) be non-zero while all other $\beta_i$ (the ones associated with other exporting countries) be zero, since it would violate the adding up restrictions for $\beta_i$ from equation (21). For this study the validity of restrictions on the impact of exchange rates is tested empirically in the following sections.

## 3.4 Estimation procedure.

Due to the singularity problem described by Barten (1969) for the n x n matrices for the n goods studied under a Rotterdam system, and its variant (due the adding-up restriction), it is necessary to drop one of the model equations when estimating the parameters $\theta_i$ and $\pi_{ij}$. For this reason, the system is estimated for n-1 equations through iterative seemingly unrelated regression (SUR) through an available procedure in the STATA statistical software. To obtain the proper estimates, restrictions must be imposed on model parameters. Firstly constants are restricted to zero to satisfy the adding up condition from demand theory. Also homogeneity and Slutsky symmetry from demand theory are imposed. By usage of a macro loop compensated price effects $\pi_{ij}$ are restricted to add up to zero (thereby imposing adding-up and homogeneity restrictions for these parameters). For the case of Slutsky symmetry another macro loop is defined to force the equality of corresponding off-diagonal terms in the compensated price effect matrix; therefore, the restrictions of Slutsky symmetry are imposed for the system of equations. Additionally, the restriction defined by equation (27) is also imposed.

## 4. Data

To estimate the Rotterdam model and its variant previously described, monthly tomato import data (total kilograms imported) by country of origin, and value (total U.S. dollar value) were obtained from the U.S. Department of Commerce from its U.S. Imports of Merchandise database for the years 1990 through 2014. The database contains monthly observations for the amount, value, entry point unit of measure, origin, and import fees paid for all merchandise imported by the U.S. which enters the country through each of its ports. These records were collected through monthly compact disc copies available at State libraries such as the Arizona State Library and Land-grant Universities, such as University of Arizona and New Mexico State University. The data was first read from its original files present in database format (.dbf) for the year 1990-2008, and in text format (.txt) for the years 2009-2014. Data formats were carefully inspected to maintain information correspondence. Table 1 below lists the 10 digit USITC commodity codes selected to account for imports of fresh tomatoes and their description as it appeared in the database. From Table 1 it is important to note that repetitions of some commodity codes account for the fact that the description for the code could have changed over the years. Also, the codes were selected such that all tomatoes imported into the U.S. year-round were accounted for. Furthermore, it was determined from the database that the countries the U.S. imports tomatoes from are/were Mexico, Canada, The Netherlands, Belgium, Israel, Dominican Republic, Mozambique, New Zealand, Niger, Norway, Poland, Somalia, Spain, Sweden, Switzerland, Thailand, Trinidad and Tobago, United Kingdom, Venezuela, Argentina, Bahamas, Botswana, Brazil, Chile, Colombia, Costa Rica, Denmark, Ecuador, France, Gaza Strip, Germany, Guatemala, India, Italy, Luxemburg, Mauritius, and Morocco. Given that this study is primarily focused on understanding the consumption behavior of imported tomatoes in the U.S. Market from its commercial partners in the North American Free Trade Agreement (NAFTA), Mexico and Canada are the only countries analyzed individually. Additionally these two countries account for the largest share of the imports market for tomatoes. Tomatoes from other countries were aggregated into a Rest of the World (ROW) category in our analysis. Additionally data for monthly U.S. domestic tomato production and prices is obtained from shipping-point reports from the USDA;ERS (2014) from 1990 to 2010. This data was complemented, up to December 2014 with daily shipping point reports by the USDA: Agricultural Marketing Service (2015). This domestic information was aggregated into monthly observations in a manner similar to Asci et al (2016) in which all varieties of tomatoes are aggregated by country of origin.

For the estimation of the variant of the Rotterdam model monthly data for nominal exchange rates between the U.S. and Mexico (USD/Mexican Pesos), and the U.S. and Canada (USD/ Canadian Dlls) were obtained from the USDA;ERS website for the period of 1990 – 2014. Nominal amounts are used given that the data regarding the value of imports, and domestic production, is in Nominal dollars.

## 5. Results

### 5.1 Rotterdam model without exchange rate effects.

Before proceeding with the estimation of the variant of the Rotterdam model that incorporates the effects of exchange rates, an initial model was estimated with the monthly information for imports of fresh tomatoes from Mexico, Canada and the ROW to compare these parameter estimates to the ones obtained from the inclusion of the U.S. domestic production of fresh tomatoes. These models serve as a starting point to understand the substitution and complementarity behavior between U.S. domestic production and imports from other countries.

#### 5.1.1 Restriction tests

To test if the theoretical restrictions of homogeneity and Slutsky symmetry would hold for the Rotterdam model, firstly an unrestricted model was estimated using equation (7). Subsequently models with homogeneity, and homogeneity-and-Slutsky symmetry imposed were estimated to test whether the demand theory restrictions would hold for the data. Table 2 below contains the log-likelihood values for each of the models estimated. The log-likelihood ratio test was conducted to determine the appropriateness of imposing the restrictions on the model. The test statistic for the log-likelihood ratio test (LRT) is defined as $LRT = 2[LogL(\theta^*) - LogL(\theta)]$, where $\theta^*$ is the vector of parameter estimates without the restrictions, $\theta$ is the vector of parameter estimates with restrictions, and $LogL(*)$ is the logged valued of the likelihood function (Harvey, 1990). The value of the LRT is compared to a critical value of a $\chi^2(q)$where $q$ is the number of restrictions imposed. Depending on the model $q$ may be calculated as:

$q = c - 1$ for the model restricted for homogeneity

$q = (c-1) + \left(\frac{(c-1)(c-2)}{2}\right)$ for the model restricted for both homogeneity and symmetry where $c$ is the number of countries analyzed in each model.

The comparison between the unrestricted models and the restricted ones is done by obtaining the value of the test statistic for the homogeneity restricted, and the symmetry and homogeneity restricted models with respect to unrestricted model. For each of the group of countries described the values of LRT and the corresponding critical value for $\chi^2(q)$ (considering a 1% significance level) where the following (Table 3). Comparing the LRT values to their respective critical values for a $\chi^2(q)$ at a 1% significance level there is no evidence to reject the restrictions as the LRT values are higher than the critical values.

### 5.1.2 Rotterdam parameter estimates

Parameter estimates for tomatoes from Mexico, Canada and the ROW are obtained for $\theta_i$ (conditional marginal share of expenditure on tomatoes from exporting countries), and $\pi_{ij}$ (Slutsky price effects of changes in prices on the amount consumed for each commodity) are presented in Table 4.

From Table 4 we find that Mexico has the largest marginal share (0.94) followed by Canada (0.04) and the ROW (0.03). All marginal expenditure share parameters are statistically significant at the 1% level. For the Slutsky price effect parameters, own price parameters had the expected negative sign from demand theory, and all parameter estimates are statistically significant at the 5% level. Cross price parameters, which determines the complementarity or substitution relationships among tomatoes from different countries are also statistically significant (at 10% and 5% levels). All of the cross-price Slutsky parameters are positive, indicating that tomatoes from different countries are substitutes among each other.

If U.S. domestic production is added as one of the sources of consumption, the results are as follows (Table 5). U.S. domestic tomatoes have the largest marginal expenditure share (0.58), followed by Mexico (0.37), Canada (0.032), and the ROW (0.014). All of these marginal expenditure share parameters are statistically significant at a 1% and 5% significance levels. In terms of the Slutsky price parameters, all own price parameters are negative, in accordance with demand theory, and are statistically significant at a 1% level. Cross-price parameters are only significant (at the 1% level in all cases) for the relationships between Mexico and the U.S., Canada and the U.S., and U.S. and the ROW. All of these significant cross-price parameters are positively signed, which indicates a substitution relationship among tomatoes of the importing countries and the domestic production, which is to be expected.

#### 5.1.3 Income and Price sensitivity measure estimates from Rotterdam model

The parameter estimates previously described, and the formulae for income (expenditure) and price elasticities are used to determine the elasticities for the case of U.S. fresh tomato market. Table 6 below presents the income compensated (Slutsky) elasticities for the Rotterdam model without accounting for U.S. domestic production. From Table 6 we find that for income (expenditure) elasticities, Mexico is conditionally expenditure elastic, due to an elasticity value above unity, which implies an increased consumption in Mexican tomatoes if the total expenditures dedicated to tomatoes increase. On the other hand both Canada and ROW tomatoes are found to be conditionally expenditure inelastic, due to elasticity values below unity, implying a decreased market share of these tomatoes if expenditures dedicated to tomatoes increase. In terms of Own-Price elasticities, tomatoes from all countries are found to be own-price inelastic. Accounting for the U.S. domestic production these elasticities are as in Table 7 below:

Mexico tomatoes are conditionally expenditure elastic, while Canada and ROW tomatoes are conditionally expenditure inelastic. U.S. domestic tomatoes are conditionally expenditure elastic; therefore, increased expenditures in tomatoes will result in increased expenditures on U.S. tomatoes. Like the imported tomatoes, U.S. domestically produced tomatoes are own-price inelastic. Also U.S. tomatoes are substitutes for imported tomatoes which is to be expected.

The Cournot income-uncompensated elasticities are provided below (Table 8). These results do not differ drastically for conditional expenditure elasticities, and own-price elasticities. Mexican tomatoes are expenditure elastic, while Canadian and ROW tomatoes are expenditure inelastic. Tomatoes from all countries are own-price inelastic. However, Mexican and Canadian tomato imports are complementary to each other if income effects are accounted for in the calculation of the cross-price elasticities.

Accounting for U.S. domestic production, obtained Cournot (uncompensated) elasticites are provided below (Table 9). From Table 9, while tomatoes from all countries remain own-price inelastic if the effect of income is accounted in the calculation of the price elasticities, most cross-price elasticities show that the U.S. tomatoes are complements to other country tomatoes, which may imply that accounting for income consumers may choose to buy tomatoes from all countries.

### 5.2 Variant of Rotterdam Model Parameter estimates.

To estimate the variant of the Rotterdam model, accounting for the effects of exchange rates, iterative SUR is used to estimate equation (20). However as the parameters $\gamma_h$ from equation (25) are more appropriate to account for theoretical restrictions for demand as discussed by Brown and Lee (2002), the parameters are recovered using the relationship from equation (24). It is important to note that at the time of this writing a proper set of restrictions could not be defined to account for multiple exchange rates, the restriction defined in (27) is imposed on the data in order to obtain preliminary parameter estimates for the variant of the Rotterdam model, which are presented below (Table 10), first for the effect of the exchange rate between the Mexican Peso and the U.S. Dollar, and subsequently for the Canadian Dollar and the U.S. Dollar.

From Table 10 we find that parameter estimates for marginal expenditure shares $\theta_i$, and Slutsky price effects $\pi_{ij}$do not differ much, in terms of magnitude, from the parameter estimates found for the case of the Rotterdam model without accounting for exchange rates for the same grouping of countries. Statistical significance remains mostly the same. The estimate for the parameter $\beta$ is obtained by restricting the estimation to only a parameter for the effect of the exchange rate between the Mexican Peso and the U.S. Dollar. The parameter is statistically significant at the 1% level, which means increases in the strength of the U.S. Dollar results in increased imports from Mexico. For the case of the effect of the Canadian Dollar exchange rate with the U.S. Dollar the results were as follows (Table 11):

From Table 11 marginal expenditure share parameters, and Slutsky price effect parameters do not differ much from those resulting from the estimation of the Rotterdam model for the same grouping of countries. The parameter $\beta$ is significant at the 1% level, Using the relationship from equation (28) the resulting $\gamma$ parameter is positive, which indicates that an increase in the strength of the U.S. Dollar results in increased imports from Canada, These estimates provide evidence of a significant effect of exchange rate fluctuations on imports from Mexico and Canada into the U.S. fresh tomato market.

## 6. Conclusions and Further Research

Using the differential approach to demand, with the Rotterdam model, and a variant of the same model, this study provides measures for sensitivity of demand for the U.S. fresh tomato market, when accounting for the effects of other economic variables such as the fluctuation of exchange rates. These effects may affect, in addition to prices, the amount of agricultural imports a country may consume. Therefore it is critical that these economic conditions be controlled for when studying the market for a commodity between commercial partners such as the NAFTA countries.

An important implication of these findings is that given the inelastic nature of the expenditure elasticity for Mexican tomato imports, and the positive exchange rate parameter, Mexican producers are able to benefit from a stronger U.S. economy in which consumer income may be larger, and the U.S. dollar may be stronger against the Mexican Peso. However, these results also suggest that U.S. domestic production might also benefit from increases in U.S. expenditure on tomatoes. Additionally the marginal share of U.S. domestic tomatoes, for all estimated models, remains close to 60% of consumer income.

An important limitation of this study is the lack of further testing of model restrictions for exchange rate effects. Also, it would be helpful in the future to account for more than one exchange rate at a time in order to obtain more precise measures of the magnitude of these effects. Future research will involve relaxation of the restrictions on the $\gamma$ parameters in order to account for multiple exchange rate parameters.

While the models in this study do not add other policy variables such as the price-floors agreed to by the U.S. and Mexico, the data does not provide evidence that they were binding and represent the lowest possible prices for the 1990-2014 period. Future research could also entail simulation of possible future price floor agreements where the price-floors would be binding in order to analyze potential demand scenarios that could emerge under these policy effects on the market.

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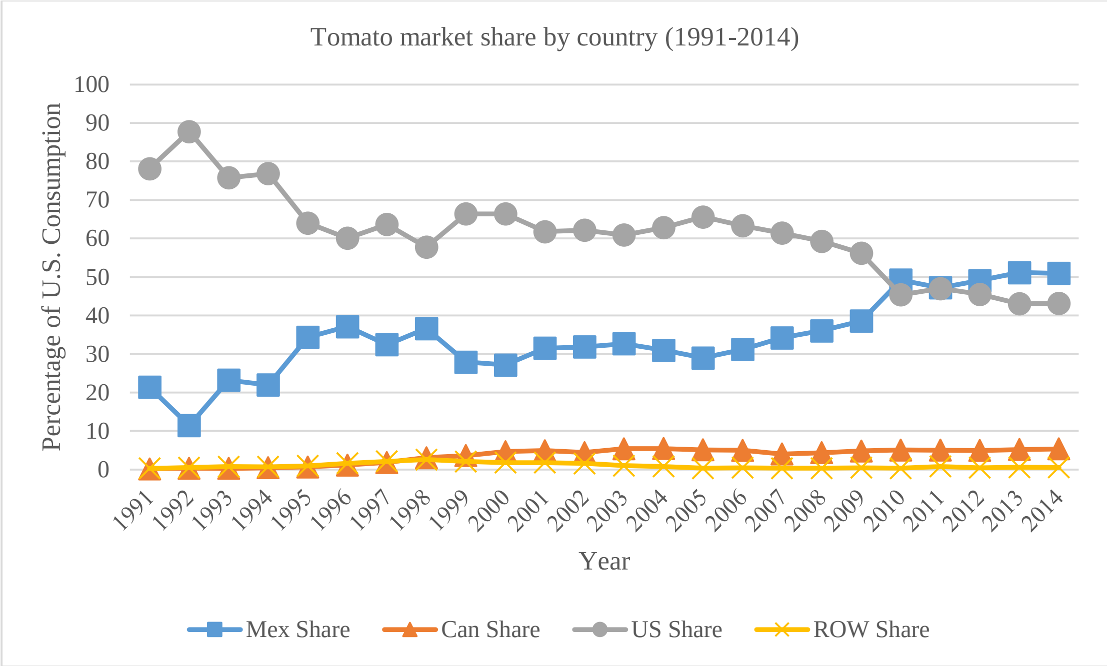


Figure 1: Market share percentage by country for U.S. tomato market
Source: authors' calculations.

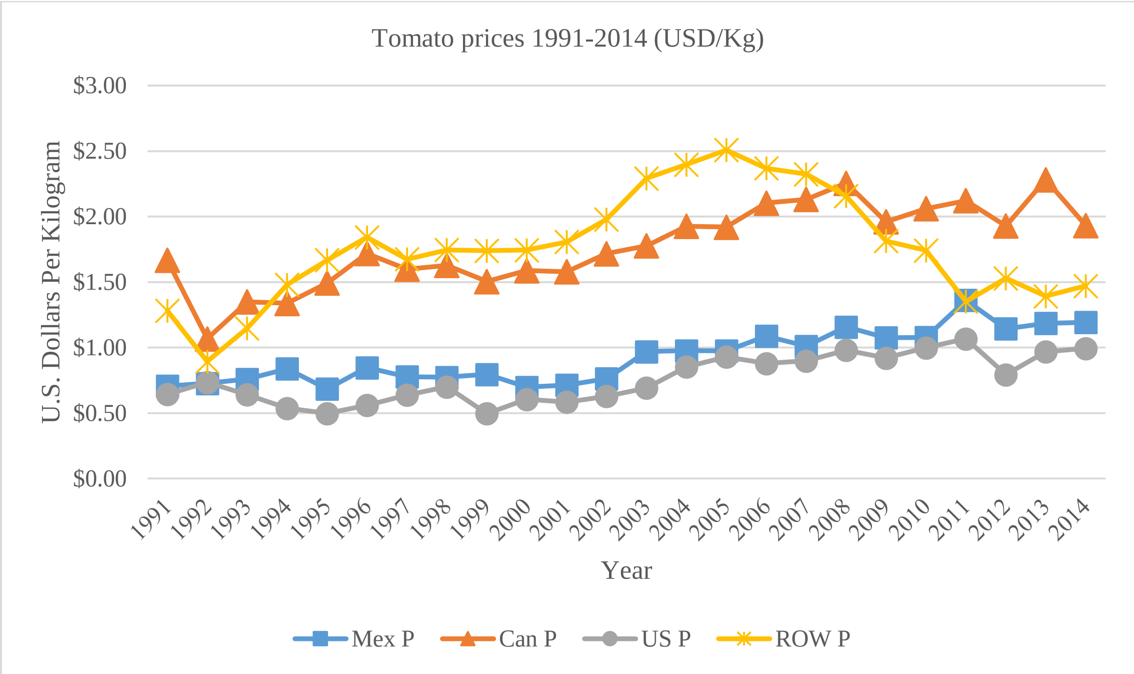


Figure 2. Prices received by country for tomatoes in the U.S. market
Source: authors' calculations.

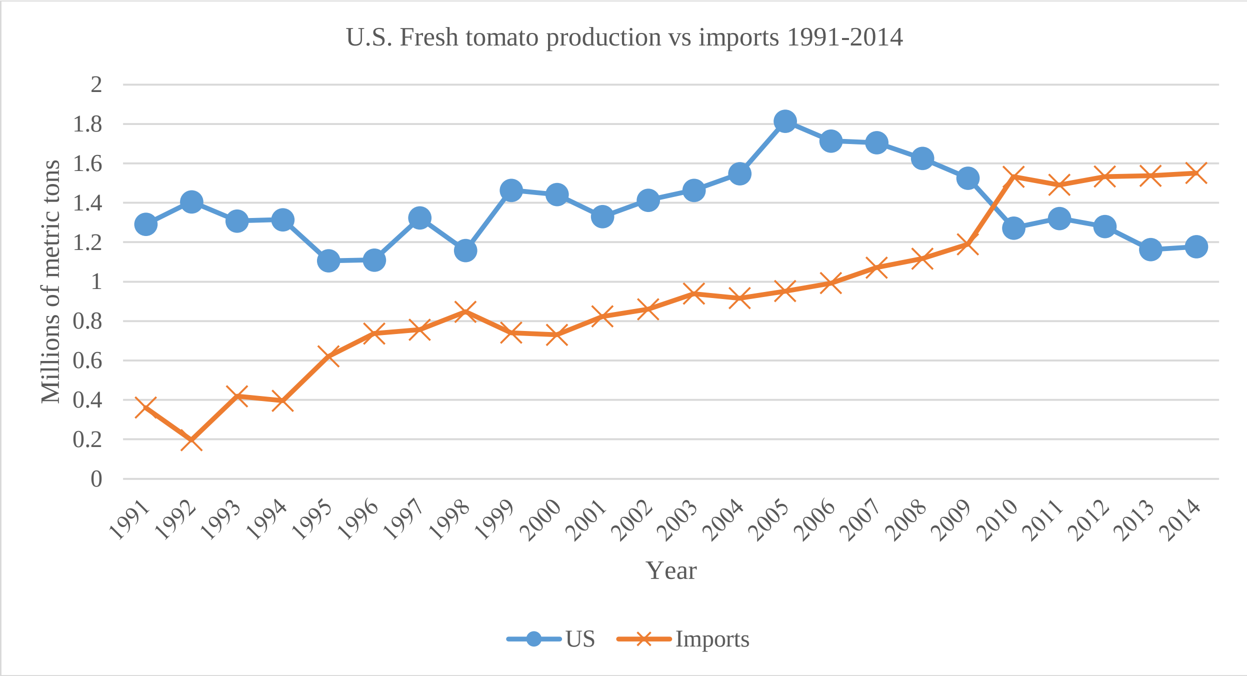


Figure 3. U.S. Fresh tomato production volume vs. import volumes
Source: authors' calculations.

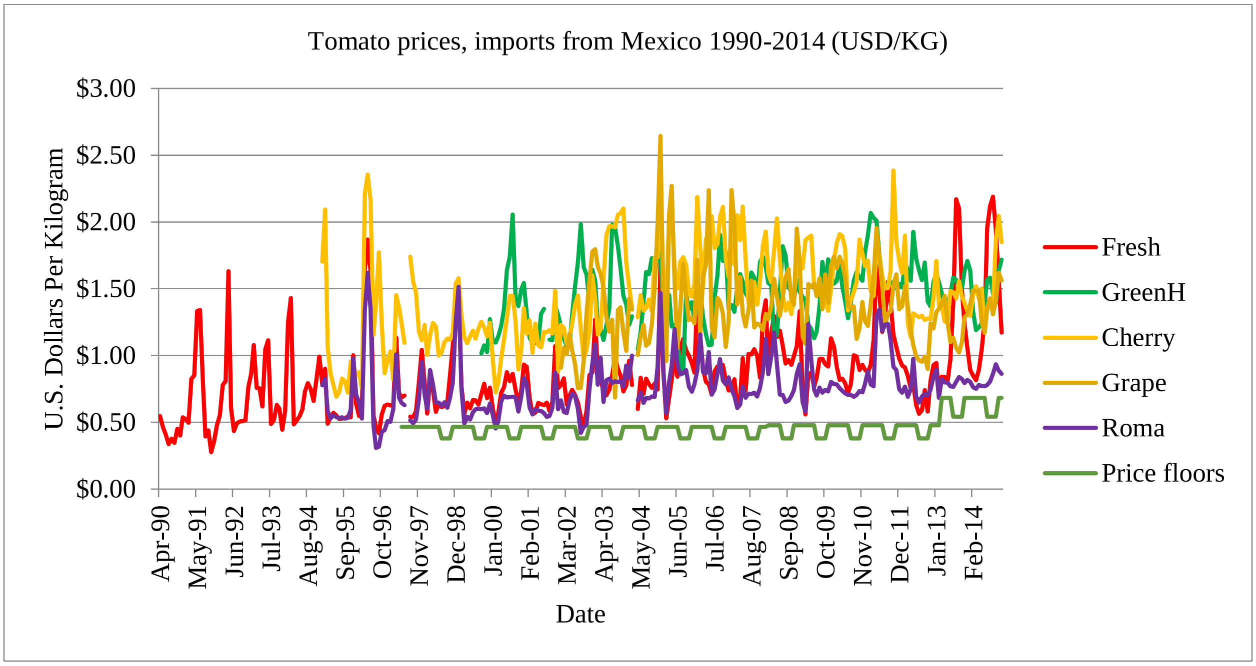


Figure 4: Mexican tomato prices in the U.S. market and price floors
Source: authors' calculations.

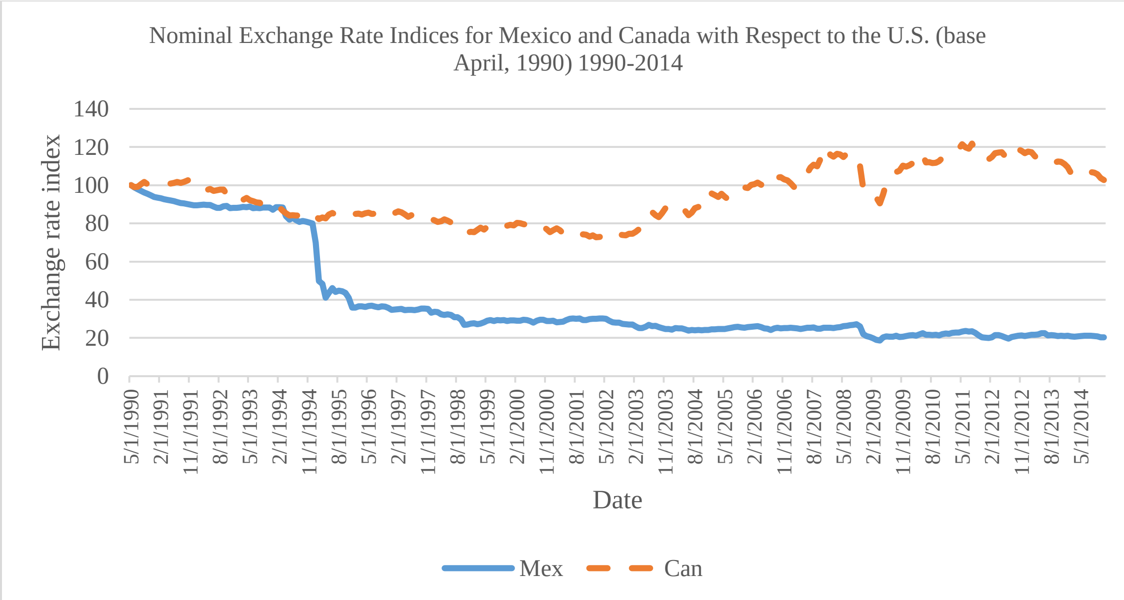


Figure 5: Nominal exchange rate index for Mexico and Canada with respect to U.S
Source: authors's calculations.

Table 1. 10-digit commodity codes for imports of fresh tomatoes, and their description.

| Commodity code | Description |
|---|---|
| 702002000 | Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from September 1 to November 14, inclusive, fresh or chilled |
| 702002010 | Greenhouse Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive, fresh or chill |
| 702002030 | Cherry Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive, fresh or chilled |
| 702002035 | Cherry Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive, FR/CH, NESOI* |
| 702002045 | Grape Tomatoes NESOI, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive, fresh or chilled |
| 702002060 | Roma Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive fresh or chilled |
| 702002065 | Roma Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive fresh or chilled, NESOI |
| 702002090 | Tomatoes, NESOI, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive, fresh or chilled. |
| 702002095 | Other Tomatoes, NESOI, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive, fresh of chilled |
| 702002099 | Tomatoes, entered during the period from March 1 to July 14, inclusive, or the period from Sept 1 to November 14, inclusive fr/ch NESOI |
| 702004000 | Tomatoes, entered, during the period from July 15 to August 31, inclusive, in any year, fresh or chilled |
| 702004010 | Greenhouse Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled |

| | |
|---|---|
| 702004030 | Cherry Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled |
| 702004035 | Cherry Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled, except greenhouse tomatoes |
| 702004045 | Grape Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled |
| 702004046 | Grape Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled, except greenhouse tomatoes |
| 702004060 | Roma Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled |
| 702004065 | Roma (Plum type) Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled, except greenhouse tomatoes |
| 702004090 | Tomatoes, NESOI, entered during the period from July 15, to August 31, inclusive, in any year, fresh or chilled |
| 702004098 | Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled, NESOI |
| 702004099 | Tomatoes, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled, NESOI |
| 702004099 | Tomatoes, NESOI, entered during the period from July 15 to August 31, inclusive, in any year, fresh or chilled |
| 702006000 | Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled |
| 702006010 | Greenhouse Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled |
| 702006030 | Cherry Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled |
| 702006035 | Cherry Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled, NESOI |
| 702006045 | Grape Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled, NESOI |
| 702006060 | Roma Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled, |
| 702006065 | Other Roma Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled, |
| 702006090 | Tomatoes, NESOI, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled. |
| 702006095 | Other Tomatoes, NESOI, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled. |
| 702006099 | Tomatoes, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled, NESOI |
| 702006099 | Tomatoes, NESOI, entered during the period from November 15, in any year, to the last day of the following February inclusive, fresh or chilled. |

*Not elsewhere specified or included.

Table 2, Log-likelihood values of Rotterdam demand systems estimated for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1991-2013.

| Model | Restriction | Log-likelihood value |
|---|---|---|
| Mexico, Canada, ROW | Unrestricted | 1026.0 |
| | Homogeneity | 1021.4 |
| | Homogeneity and Symmetry | 1021.3 |
| Mexico, Canada, US, ROW | Unrestricted | 1915.7 |
| | Homogeneity | 1910.7 |
| | Homogeneity and Symmetry | 1908.1 |

Table 3 LRT test statistic values and critical values for $\chi^2(q)$

| LRT | Critical value of $\chi^2(q)$ (1% significance level) |
| --- | --- |
| $LRT_{MCR_H} = 2$(1026.02-1021.41)=9.22 | $\chi^2(2)$ critical value = 9.21 |
| $LRT_{MCR_S} = 2$(1026.02-1021.34)=9.36 | $\chi^2(3)$ critical value = 11.345 |
| $LRT_{MCUR_H} = 2$(1915.80-1910.78)=10.04 | $\chi^2(3)$ critical value = 11.345 |
| $LRT_{MCUR_S} = 2$(1915.80-1908.13)=15.34 | $\chi^2(6)$ critical value = 16.812 |

Table 4, Conditional parameter estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014.

| | Parameters | | | |
| --- | --- | --- | --- | --- |
| | Price $\left(\pi_{ij}\right)$ | | | |
| Country | Mexico | Canada | ROW | Marginal Shares $\left(\theta_i\right)$ |
| Mexico | -0.036*** (0.0106) | 0.0149* (0.008) | 0.021*** (0.005) | 0.936*** (0.011) |
| Canada | | -0.026** (0.009) | 0.011** (0.005) | 0.038*** (0.009) |
| ROW | | | -0.032*** (0.005) | 0.025*** (0.010) |

*,**, *** stand for statistical significance at 10%, 5%, and 1% respectively

Table 5, Conditional parameter estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014, accounting for U.S. domestic production.

| | Parameters | | | | |
| --- | --- | --- | --- | --- | --- |
| | Price $\left(\pi_{ij}\right)$ | | | | |
| Country | Mexico | Canada | U.S. | ROW | Marginal Shares $\left(\theta_i\right)$ |
| Mexico | -0.0883*** (0.0119) | -0.0002 (0.0119) | 0.0855*** (0.0116) | 0.003 (0.0026) | 0.3733*** (0.0472) |
| Canada | | -0.0093*** (0.0039) | 0.0082*** (0.0025) | 0.0013 (0.0024) | 0.0323*** (0.009) |
| U.S. | | | -0.1002*** (0.012) | 0.0065*** (0.002) | 0.5796*** (0.0481) |
| ROW | | | | -0.011*** (0.0019) | 0.01436** (0.0062) |

“*”,“**”, “***” stand for statistical significance at 10%, 5%, and 1% respectively

Table 6, Conditional expenditure and Slutsky (compensated) Price Elasticity estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014.

| | | | Cross-Price Elasticities | | |
|---|---|---|---|---|---|
| Country | Expenditure Elasticities | Own-Price Elasticities | Mexico | Canada | ROW |
| Mexico | 1.217*** | -0.047*** | -- | 0.019* | 0.028*** |
| Canada | 0.219*** | -0.150** | 0.086* | -- | 0.064** |
| ROW | 0.449*** | -0.570*** | 0.375*** | 0.194** | -- |

"*","**", "***" stand for statistical significance at 10%, 5%, and 1% respectively

Table 7, Conditional expenditure and Slutsky (compensated) Price Elasticity estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014.

| | | | Cross-Price Elasticities | | | |
|---|---|---|---|---|---|---|
| Country | Expenditure Elasticities | Own-Price Elasticities | Mexico | Canada | U.S. | ROW |
| Mexico | 1.075*** | -0.254*** | -- | -0.0007 | 0.246*** | 0.008 |
| Canada | 0.432*** | -0.124*** | -0.003 | -- | 0.110*** | 0.017 |
| U.S. | 1.041*** | -0.180*** | 0.153*** | 0.014*** | -- | 0.011*** |
| ROW | 0.663** | -0.509*** | 0.154*** | 0.064 | 0.289*** | -- |

"*","**", "***" stand for statistical significance at 10%, 5%, and 1% respectively

Table 8, Conditional expenditure and Cournot (uncompensated) Price Elasticity estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014.

| | | | Cross-Price Elasticities | | |
|---|---|---|---|---|---|
| Country | Expenditure Elasticities | Own-Price Elasticities | Mexico | Canada | ROW |
| Mexico | 1.217*** | -0.983*** | -- | 0.192* | 0.041*** |
| Canada | 0.219*** | -0.188** | -0.082* | -- | 0.051** |
| ROW | 0.449*** | -0.595*** | 0.029*** | 0.116** | -- |

"*","**", "***" stand for statistical significance at 10%, 5%, and 1% respectively

Table 9, Conditional expenditure and Cournot (uncompensated) Price Elasticity estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014.

| | | | Cross-Price Elasticities | | | |
|---|---|---|---|---|---|---|
| Country | Expenditure Elasticities | Own-Price Elasticities | Mexico | Canada | U.S. | ROW |
| Mexico | 1.075*** | -0.627*** | -- | -0.081 | -0.352*** | -0.014 |
| Canada | 0.432*** | -0.157*** | -0.153 | -- | -0.130*** | 0.008 |
| U.S. | 1.041*** | -0.759*** | -0.207*** | -0.063*** | -- | -0.010*** |
| ROW | 0.663** | -0.523*** | -0.075*** | 0.015 | -0.079*** | -- |

"*","**", "***" stand for statistical significance at 10%, 5%, and 1% respectively

Table 10, Conditional parameter estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014, accounting for U.S. domestic production and Exchange rate between Mexican Peso and U.S. Dollar.

| | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Price $(\pi_{ij})$ | | | | | | |
| Country | Mexico | Canada | U.S. | ROW | $\beta$ | $\gamma$ | Marginal Shares $(\theta_i)$ |
| Mexico | -0.0889*** (0.0121) | -0.0005 (0.003) | 0.0851*** (0.0118) | 0.0043 | 0.0197*** (0.003) | 0.223*** | 0.3757*** (0.0481) |
| Canada | | -0.0096*** (0.0034) | 0.0083*** (0.0024) | 0.0018 | 0.00012 | 0 | 0.0323*** (0.009) |
| U.S. | | | -0.100*** (0.012) | 0.0065 | -0.01892 | 0 | 0.5800*** (0.0484) |
| ROW | | | | -0.128 | -0.0009 | 0 | 0.0118 |

"*","**", "***" stand for statistical significance at 10%, 5%, and 1% respectively

Table 11, Conditional parameter estimates for U.S. Import Demand for Fresh Tomatoes from selected countries for the period 1990-2014, accounting for U.S. domestic production and Exchange rate between Canadian Dollar and U.S. Dollar.

| | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Price $(\pi_{ij})$ | | | | | | |
| Country | Mexico | Canada | U.S. | ROW | $\beta$ | $\gamma$ | Marginal Shares $(\theta_i)$ |
| Mexico | -0.0885*** (0.0120) | -0.00006 (0.003) | 0.0855*** (0.0117) | 0.002 | -0.0002 | 0 | 0.3733*** (0.0476) |
| Canada | | -0.0092*** (0.0034) | 0.0072*** (0.0024) | 0.001 | 0.033 (0.007) | 3.588*** | 0.0291*** (0.009) |
| U.S. | | | -0.100*** (0.012) | 0.007 | -0.026 | 0 | 0.5797*** (0.0484) |
| ROW | | | | -0.012 | -0.006 | 0 | 0.0177 |

"*","**", "***" stand for statistical significance at 10%, 5%, and 1% respectively