



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

**AN INVERSE ALMOST IDEAL DEMAND SYSTEM
FOR FRESH TOMATOES IN THE U.S.**

Jason H. Grant¹

Kenneth A. Foster

Department of Agricultural Economics
Purdue University
403 W State Street
West Lafayette, IN
47907-2056
Tel: 765-494-5816
Fax: 765-494-9176
jhgrant@purdue.edu

Department of Agricultural Economics
Purdue University
403 W State Street
West Lafayette, IN
47907-2056
Tel: 765-494-1116
Fax: 765-494-9176
kfoster@purdue.edu

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27, 2005.

*Copyright © 2005 by Jason H. Grant and Kenneth A. Foster. All rights reserved.
Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.*

¹ Jason H. Grant is a PhD student in the Department of Agricultural Economics at Purdue University and Kenneth A. Foster is a professor in the Department of Agricultural Economics at Purdue University.

Introduction

The North American Free Trade Agreement (NAFTA) was signed on January 1st, 1994 between Mexico, Canada and the United States (U.S.). This agreement effectively removed border restrictions in the form of tariffs that had previously limited the extent of tomato trade.² Multilateral free trade agreements often change the pattern of supply and consumption across countries by increasing the number of product varieties and shifting production in line with a member's comparative advantage. This is especially true in the case of the fresh tomato market in NAFTA where seasonality and perishability often limit a country's capacity to provide year round supplies. In this sense, a member's comparative advantage is better described as the ability to supply tomatoes to a market when significant excess demand exists.

Fresh tomatoes are the most important vegetable crop traded in North America. In 2003, imports accounted for one-third of U.S. tomato consumption (USDA 2004). Likewise, tomatoes have been the most important vegetable export for Mexico. More recently, Canadian hydroponics tomatoes which are produced in greenhouses have competed for U.S. market share. However, the historical seasonality of U.S. supply and demand, differing cost structures in producing fresh tomatoes in Mexico and Canada and geographically related climatic conditions have formed a specific window of opportunity for Mexican and Canadian exports to the U.S. For fresh greenhouse and field tomatoes, higher capital costs to maintain the optimal greenhouse temperature coupled with hot, dry summers in Mexico suggests that these tomatoes originating from Mexico tend to enter

² Not all border measures have been eliminated. For example, the NAFTA agreement allows countries to invoke a special safeguard tariff when significant import surges or price declines occur. The rules for imposing special safeguard tariffs are governed under the NAFTA "snap-back" provisions and Article 5 of the WTO Agreement on Agriculture.

the U.S. market over the months of January through April. On the other hand, Canada, which is the largest greenhouse tomato producer in North America, is hindered by higher heating costs in the winter months. Thus fresh greenhouse tomatoes originating from Canada tend to be marketed in the U.S. during the spring and summer months April through August, although Canadian producers would like to provide year round supplies to the much larger U.S. market.

Figure 1 illustrates the timing of Mexican and Canadian fresh market tomato exports to the U.S. market. The mean share of fresh tomatoes originating from Mexico, Canada and the U.S. are shown on the vertical axis.³ The shares are calculated by averaging the monthly shipments by country (domestic or imports) over the sample period 1990-1999. Clearly, the peak supply of Mexican tomatoes to the U.S. market occurs during the winter months January through April although Mexico does supply tomatoes year round. Immediately following Mexican imports, Canadian greenhouse tomatoes enter the U.S. market from May through August. In total, imports make up one-third of U.S. consumption of which over 95 percent is supplied by Mexico and Canada. For example, consumption of fresh tomatoes in the U.S. in 1999 was 4.8 billion pounds while production was only 3.5 billion pounds. In terms of tomato trade, the U.S. is predominantly a net importer. In 1999, the U.S. imported 1.6 billion pounds of fresh tomatoes after exporting only 334.5 million pounds.

Together with more liberalized trade, consumption and production of fresh tomatoes has increased in the 1990's. Figure 2 shows consumption increasing from 12.1

³ In this study fresh market tomatoes include the Cherry, Roma and Nesoi varieties which represent the bulk of fresh market tomato varieties produced as either field tomatoes (as in Mexico and the U.S) or greenhouse tomatoes (as in Canada) in North America. More details on the data are provided in the data section.

pounds per capita in the 1960's to nearly 18 pounds per capita in 1999. Production has expanded from 19.1 million pounds to nearly 32 million pounds. Interestingly, after the signing of NAFTA in 1994, production has leveled off, and in some years has declined. On the demand side, the steady increase in per capita consumption may be due to a structural change in consumer diets from increased health awareness, or it may reflect the fact that more liberalized NAFTA trade increased the availability of fresh tomatoes. On the production side, it seems likely that U.S. tomato production has leveled off because Mexican and Canadian fresh tomatoes are forming an important component of domestic consumption bundles after the signing of NAFTA.

Previous literature on fresh tomato markets in the U.S. has focused predominantly on the supply side as well as the welfare and trade effects of NAFTA (Acosta, Foster and Sullivan 2004). Very few studies have focused on the demand side, however. One of the reasons for this as argued by Padilla and Thilmany (2002) is that fresh tomatoes do not have any close substitutes. Cook and Calvin (2005) provide a nice overview of the changing structure of the fresh tomato industry with an emphasis on how greenhouse tomatoes have changed the dynamics of the North American market. Thompson's (2003) study is closest to ours. The author employs a Quadratic Almost Ideal Demand System (QAIDS) to estimate own and cross substitution elasticities for five fresh tomato varieties in the U.S. market. However, Thompson's study uses sales data from several major supermarket chains and he cannot distinguish between domestic and foreign tomato varieties (i.e. U.S. versus Mexican or Canadian varieties). Acosta et al. (1994) specify an ad hoc inverse retail demand function to estimate own and income flexibilities which are then used in a simulation model of NAFTA tomato trade. Their price dependent

specification, however, treats Canadian and Mexican tomato quantities as perfect substitutes.

Armington (1969) showed that country of origin may be an important source of product differentiation. Armington elasticities are based on the differentiation of products with respect to their origin and the imperfect substitution in demand between imports and domestic supply. However, an Armington *model* is not necessarily an appropriate specification for modeling fresh tomatoes for two reasons. First, the supply of fresh tomatoes is often predetermined, and it is primarily the adjustment of prices to relatively fixed short run quantities that clear the market. Second, fresh tomatoes are highly perishable and must be consumed shortly after harvest. Thus, it seems more appropriate to model the demand side of this market using price as the dependent variable. To our knowledge, there are no studies to date that have estimated substitution elasticities (flexibilities) in the North American fresh market tomato industry where tomato varieties are differentiated by county of origin. Yet the results of this study have important policy implications given the recent antidumping investigations by the U.S. on Mexican and Canadian fresh (or chilled) tomatoes.

With this in mind, we estimate an inverse almost ideal demand system (IAIDS) that controls for the seasonality of tomato trade (figure 1) using monthly data on the retail price of fresh tomatoes, U.S. domestic shipments (not for export) and Canadian and Mexican import volumes. Specifically, this study has two important objectives. First, using the IAIDS model with Canadian and Mexican tomato quantities as related goods, we calculate the degree of flexibility (substitutability) between U.S., Canadian and Mexican fresh tomatoes from the perspective of the U.S. market. Second, we use the

calculated substitution flexibilities to provide useful insights into the recent and any future dumping conflicts between NAFTA members.⁴

This study is organized as follows. Based on the work of Eales and Unnevehr (1993), the next section develops an extended inverse almost ideal demand system (IAIDS). A brief discussion of the data follows in section three. Section four presents the results of the estimation, and section five concludes.

The Inverse Almost Ideal Demand System⁵

A number of studies have applied the inverse almost ideal demand system (See, for example, Huang; Barten and Bettendorf; Moschini and Vissa; and Eales and Unnevehr). The majority of these applications are to agricultural markets because conditions suggest that supply may be predetermined. The development of the IAIDS proceeds with the dual of the cost function, the distance function. The distance function measures the proportional amount by which quantities must be scaled back to reach a particular indifference curve (Deaton and Muellbauer, p. 54). It possesses the same properties as the cost function; it is linear homogeneous, concave and non-decreasing in quantities (as opposed to prices) and it is decreasing in utility (as opposed to increasing) (Diewart). We define the distance function as $U\{q/D(u,q)\}=u$, where u equals utility, q is quantity, and D is distance. Differentiation of the distance function with respect to a quantity of a particular good yields the compensated “inverse” demand for that good in the same way that differentiation of the cost function with respect to a particular price yields a compensated demand function. Following Deaton and Muellbauer’s (1980) AIDS model, we can define a logarithmic distance function as

⁴ The trade conflicts involving tomato trade between NAFTA members have become known as “the tomato wars.”

⁵ The development of the IAIDS follows the work of Eales and Unnevehr (1993).

$$[1] \quad \ln D(u, q) = u \ln b(q) + (1-u) \ln a(q)$$

Where, as in the AIDS model $\ln a(q)$ and $\ln b(q)$ are,

$$[2] \quad \ln a(q) = \alpha_0 + \sum \alpha_j \ln q_j + \frac{1}{2} \sum_i \sum_j \gamma_{ij}^* \ln q_i \ln q_j \quad \text{and,}$$

$$[3] \quad \ln b(q) = \beta_0 \prod_j q_j^{-\beta_j} + \ln a(q).$$

Substituting [2] and [3] into [1] yields,

$$[4] \quad \ln D(u, q) = \alpha_0 + \sum \alpha_j \ln q_j + \frac{1}{2} \sum_i \sum_j \gamma_{ij}^* \ln q_i \ln q_j + u \beta_0 \prod_j q_j^{-\beta_j}$$

Differentiating [4] gives the compensated inverse demands as,

$$[5] \quad \frac{\partial \ln D(u, q)}{\partial \ln q_i} = w_i = \alpha_i + \sum_j \gamma_{ij}^* \ln q_j - \beta_i u \beta_0 \prod_j q_j^{-\beta_j},$$

where $\gamma_{ij}^* = 0.5(\gamma_{ij}^* + \gamma_{ji}^*)$.

Following Eales and Unnevehr (1993) we can uncompensate the inverse demands by inverting the distance function at the optimal quantity.

$$[6] \quad U(q) = -\ln a(q) / \{\ln b(q) - \ln a(q)\}$$

Substituting [6] into [5] yields what Eales and Unnevehr call the inverse almost ideal demand system (IAIDS).

$$[7] \quad w_i = \alpha_i + \sum_j \gamma_{ij} \ln q_j + \beta_i \ln Q,$$

where,

$$[8] \quad \ln Q = \alpha_0 + \sum_j \ln q_j + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln q_i \ln q_j$$

As it stands, equation (7) does not control for the timing of imports of fresh tomatoes from Canada or Mexico during the months May through August and January

through April respectively (see figure 1). To extend the IAIDS model, two sets of dummy variables are added to equation (7). Furthermore, it is nice to work with a model that is linear in the parameters. Due to the nonlinearity in $\ln Q$, equation [7] must be estimated using a custom nonlinear system of equations program. Eales and Unnevehr (1993) use Stone's quantity index which is akin to Stone's price index in the AIDS model to develop a linear approximate inverse almost ideal demand system (LA/IAIDS). The expanded system of (n) equations is:

$$[9] \quad w^{U.S.} = \alpha_0 + \gamma_{11} \ln q^{U.S.} + \gamma_{12} \ln q^{CAN} + \gamma_{13} \ln q^{MEX} + \beta_1 \ln Q^* \\ + \delta_{11} D^{MEX} + \delta_{12} D^{CAN} + \varepsilon_1,$$

$$[10] \quad w^{MEX} = \alpha_1 + \gamma_{21} \ln q^{U.S.} + \gamma_{22} \ln q^{CAN} + \gamma_{23} \ln q^{MEX} + \beta_2 \ln Q^* \\ + \delta_{21} D^{MEX} + \delta_{22} D^{CAN} + \varepsilon_2,$$

$$[11] \quad w^{CAN} = \alpha_3 + \gamma_{31} \ln q^{U.S.} + \gamma_{32} \ln q^{CAN} + \gamma_{33} \ln q^{MEX} + \beta_3 \ln Q^* \\ + \delta_{31} D^{CAN} + \delta_{32} D^{MEX} + \varepsilon_3.$$

Where,

$$D^{MEX} = 1 \text{ if the month is January through April} \\ = 0 \text{ otherwise}$$

$$D^{CAN} = 1 \text{ if the month is April through August} \\ = 0 \text{ otherwise,}$$

and,

$$Q^* = \sum_i w_i^h \ln p_j^h, \text{ for } h = \text{U.S., CAN or MEX.}$$

Finally, the theoretical restrictions of symmetry, adding up and homogeneity are imposed as, $\sum_i \alpha_i = 1$; $\sum_i \gamma_{ij} = 0$; $\sum_i \beta_i = 0$ for adding up, $\sum_j \gamma_{ij} = 0$ for homogeneity; and

$\gamma_{ij} = \gamma_{ji}$ for symmetry. Note that we can drop one of the three estimating equations and recover the estimates through the theoretical restrictions above.

The seasonal dummies (D^{CAN} , D^{MEX}) are included in the estimating equations to control for the seasonality and timing of Mexican and Canadian fresh tomatoes in the U.S. market. For example, if the coefficient on the Mexican (Canadian) dummy variable is negative and statistically significant in the U.S. share equation [9], then there is evidence that the mean retail share of U.S. fresh tomatoes decreased significantly during the winter months January through April (summer months April through August).⁶ The Mexican and Canadian seasonal dummies are defined analogously for equations [10] and [11].

We push the envelope a step further by calculating the percentage increase in the mean tomato share that occurred during the months January through April (for Mexico) and April through August (for Canada). Consider a simplified semi-logarithmic regression equation of the form

$$[12] \quad \ln Y_i = \alpha + \sum_i \beta_i \ln X_i + \sum_j \gamma_j D_j + \varepsilon_i$$

where X_i represent continuous explanatory variables and D_j is a set of dummy variables.

The coefficient of a continuous variable is

$$[13] \quad \beta_i = \frac{\partial \ln Y_i}{\partial \ln X_i} = \frac{\partial Y_i}{\partial X_i} \frac{X_i}{Y_i}.$$

Thus the coefficient of a continuous variable is the elasticity of Y for a small change in the explanatory variable X_i . However, a dummy variable is a discontinuous variable and

⁶ At this point it is not clear what the magnitude of the increase in imports is. For example if equation (7) were a double logarithmic specification then an additional $\exp\{\delta_{ij} - 1\} * 100$ percent more imports occurred during these months.

the derivative of Y with respect to a small change in D_i does not exist. Instead, we can calculate the percentage change in Y going from Y_0 to Y_1 for a discrete change in D_i from 0 to 1 as,⁷

$$\left[\frac{Y_0 - Y_1}{Y_1} \right] * 100 = \left[\frac{\exp(\alpha + \sum_i \beta_i \ln X_i + \gamma \cdot 1 + \varepsilon_i) - \exp(\alpha + \sum_i \beta_i \ln X_i + \gamma \cdot 0 + \varepsilon_i)}{\exp(\alpha + \sum_i \beta_i \ln X_i + \gamma \cdot 0 + \varepsilon_i)} \right] * 100$$

$$[14] \quad = (\exp(\gamma) - 1) * 100$$

Flexibilities

Eales and Unnevehr (1993) provide the relevant formulas for the flexibilities when estimating the LA/AIDS model.

$$[15] \quad f_{ij} = -\delta_{ij} + \{\gamma_{ij} - \beta_i w_j\} / w_i \text{ and,}$$

$$[16] \quad f_i = -1 + \beta_i / w_i .$$

Equation [15] is defined for all own and cross flexibilities where δ_{ij} is the Kronecker delta that equals one if $i = j$. Interpreting own and cross flexibility estimates is more difficult because these estimates are less commonly employed in explaining econometric results. However based on previous studies we employ the following interpretation (Eales and Unnevehr 1993; Schroeter and Foster 2004; Park and Thurman 1999). Own price flexibilities describe the percentage change in the price of the i^{th} good, when the quantity demanded of that good increases by one percent. The demand for the i^{th} commodity is flexible (inflexible) if a one percent increase in the consumption of that

⁷ Note that the OLS properties of the variance estimates when using a nonlinear transformation no longer hold. Equation [14] is a continuous and differentiable function. Let $g = (\exp(\gamma) - 1) * 100$ and let $\text{var}(\hat{\gamma})$ be the OLS variance from equation [12]. Then using the multivariate Delta method, the asymptotic

variance of a nonlinear transformation such as [14] is: $\text{var}(g) = \frac{\partial g}{\partial \gamma} \text{Var}(\hat{\gamma}) \frac{\partial g}{\partial \gamma}'$.

commodity leads to a greater (less) than one percent decrease in the marginal consumption value (its normalized price).⁸ Similarly, the cross-price flexibility is defined as the percentage change in the price of a good, where the quantity demanded of a competing good increases by one percent. Goods are gross quantity-substitutes (q-substitutes) if their cross-price flexibility is negative and gross quantity-complements (q-complements) if their cross-price flexibility is positive.

Equation [16] is the analog to the expenditure elasticity of the AIDS model. It is interpreted as a scale flexibility that measures the percentage change in the price of a good brought about by a proportional change in the aggregate quantity or scale consumption. Scale flexibilities that are greater (less) than 1 in absolute value are necessity (luxury) goods (Eales and Unnevehr 1993).

Data

The dependent variables in equations (9) through (11) are the monthly share of U.S. expenditure on U.S. tomatoes, the monthly share of U.S. expenditure on Mexican tomatoes and the monthly share of U.S. expenditure on Canadian tomatoes respectively ($w^{U.S.}$, w^{MEX} and w^{CAN}). Due to trade data limitations on some varieties of fresh market tomatoes, we define fresh tomatoes in this study as the Cherry, Roma or Nesoï type. In the U.S. inverse demand equation [9] the share of U.S. fresh tomatoes is constructed using monthly retail prices for U.S. fresh tomatoes taken from the Bureau of Labor Statistics (U.S. Dept. of Labor). In the Mexican and Canadian equations [10 and 11], the share of U.S. consumption of Mexican and Canadian tomatoes is constructed using unit value import prices by dividing the value of Mexican (Canadian) fresh tomato imports by

⁸ This is more intuitive if we think of the dependent variable as a marginal consumption value rather than the traditional consumption share.

the quantity of fresh tomato imports. Monthly imports are taken from the U.S. Department of Commerce at the SITC-10 digit product level. Table 1 in the appendix shows the mean expenditure shares for all three NAFTA members. It is clear that the majority of U.S. demand for fresh tomatoes at the retail level is satisfied domestically (76%). Mexico and Canada make up the remainder at 20 and 4 percent respectively.

The natural logarithm of quantities ($\ln q$) for the three NAFTA members respectively are, U.S. domestic shipments, Canadian imports and Mexican imports of fresh tomatoes on a monthly basis. All quantities are in volumes (as opposed to values) in millions of pounds. Domestic shipment data of fresh tomatoes produced in the U.S. are taken from the U.S. Tomato Statistics (ERS/USDA). U.S. domestic shipment data is used as a proxy for the quantity available for retail demand. It is assumed however that U.S. domestic shipments destined for the export market are not available to retail outlets. Thus, to get a pure domestic component that is available at the retail demand level, exports were subtracted from total domestic production. Equations [9] through [11] are estimated using the linear approximate seemingly unrelated regression of the IAIDS model on a monthly basis for the period January 1990 through December 1999. There are 120 observations and 14 parameters to be estimated after imposing the theoretical restrictions.

Results

Table 1 presents the econometric results from the system of seemingly unrelated regression equations of the LA/IAIDS model, and table 2 presents the own and cross flexibility estimates as well as the scale (expenditure) elasticities. Standard errors on all flexibility estimates are obtained by bootstrapping the flexibility formulas over 1000

replications. Figures 3 through 6 graph the own and cross flexibilities over the sample period.

Seasonal Dummy Variables

The first thing to note is the explanatory power of the model (table 1). Almost all regression coefficients are significant at the one percent level and R-squared values range from 0.86 to 0.98. Thus, most of the U.S. demand for fresh tomatoes can be explained in terms of the three NAFTA countries. The significance of the dummy variables is mixed. In the U.S. equation (equation 9), the dummy variable for Mexican tomatoes (Jan.-Apr), is negative a statistically significant (-0.78). This means that the marginal consumption value of U.S. demand for domestic fresh tomatoes decreases by 54 percent $((\exp(-0.78)-1)*100)$ in the months January through April which is when Mexican tomatoes flood the U.S. market. The marginal consumption value of U.S. demand for U.S. fresh tomatoes in the months April through August is insignificant (D^{CAN}).

In the U.S. inverse demand equation for Mexican tomatoes (equation 10), the seasonal dummy variable is positive and significant at the 10 percent level with respect to Canadian quantities. We might expect the marginal consumption value (its price) for Mexican tomatoes by U.S. retail outlets to decrease when Mexican fresh tomatoes are abundant (January through April). Although the Mexcian dummy has the correct sign, the coefficient is insignificant. The marginal consumption value in the U.S. equation for Mexican tomatoes increases by 6.2 percent $((\exp(-.14)-1)*100)$ when the Canadian tomatoes are in peak supply in the U.S. market (i.e. when Mexican imports are at their lowest levels during the summer months April through August).

Finally, in the retail demand equation for Canadian greenhouse tomatoes in the U.S. (equation 11), the Canadian (Mexican) dummy variables are negative (positive) and statistically significant. This suggests that the U.S. price for Canadian tomatoes increased during the winter months when Canadian (Mexican) tomatoes are in short (abundant) supply but by only 11 percent. The reverse is true for the Canadian inverse demand equation during the summer months (table 1).

Own Price Flexibilities

Table 2 presents the flexibility results calculated at the means of the retail demand shares. Note that all own and cross quantity flexibilities are negative and significant at the one percent level.⁹ In terms of the own quantity flexibilities at the retail level, the U.S. own price for Canadian tomatoes with respect to the quantity of Canadian tomatoes appears to be the most flexible (-21.1).¹⁰ Based on this estimate, a one percent increase in the quantity of Canadian tomatoes results in a 21.2 percent decrease in the retail price of Canadian tomatoes in the U.S. market. This is an important result in terms of the NAFTA trade conflict over tomatoes. Because the U.S. market price is extremely sensitive to increased tomato quantities from Canada, it may appear that Canadian tomatoes are being dumped onto the U.S. market when in fact; it is just the adjustment of local demand conditions that leads to low prices during certain times of the year. On the other hand, the own flexibility of the U.S. retail price with respect to the quantity of U.S. tomatoes is the most inflexible at -0.6 percent. The own flexibility with respect to Mexican quantities lies in between these at -1.5%.

⁹ Note that we bootstrapped all quantity flexibilities using 10,000 replications instead of 1000. The significance of the results in table 2 remained the same.

¹⁰ Again recall that a large and negative own price flexibility estimate implies that the tomato price (or marginal consumption value) is flexible because the price change is much more than the quantity change.

The above results are even more evident in figure 3 which plots the point estimates of the own quantity flexibilities for all three countries over the sample period. Notice the systematic variation in the price flexibilities throughout any given year. In the winter months January through April, the U.S. own quantity flexibility for Mexican tomatoes with respect to Mexican quantities ($F_{mex,mex}$) is relatively inflexible because there are fewer tomato varieties to choose from relative to some of the other months of the year (i.e. when Mexican supplies slightly lower). In the summer months when Canadian varieties enter the U.S. market and Mexican supplies are lower, the Mexican own price flexibility ($F_{mex,mex}$) is much higher (more flexible) in absolute terms because there are both Canadian and Mexican tomato varieties available. This result is even more pronounced in the case of the U.S. price for Canadian tomatoes with respect to Canadian quantities ($F_{can,can}$). The own quantity flexibility (around -4.0%) for Canadian tomato prices during the summer months is much more inflexible when Canadian supplies are abundant and Mexican and U.S. supplies are relatively low. However, when Canadian tomatoes are out of season, the own price flexibility for Canadian tomatoes in the U.S. market is remarkably flexible (around -60%).¹¹ The U.S. own price flexibility with respect to U.S. quantities is much more stable because the U.S. is typically a year round supplier.¹² Thus, in the flexibility formula, the denominator does not fluctuate much.

Cross Price Flexibilities

¹¹ In fact, we had to cut off part of the variation in the graph of the own Canadian flexibilities in order to highlight the variation and seasonality of these estimates as noted in the footnote to figure 3. The variation is due to the variation in the expenditure share in the flexibility formula.

¹² Also, recall that our estimation is in terms of the U.S. market. Thus there may be a home bias in retail consumption that is underlying the relatively stable U.S. quantity flexibilities.

The mean cross price flexibilities are shown as the off diagonal elements in table 2. Figures 4 through 6 show the variation and seasonality of these estimates over any given year in the sample period. In terms of the U.S. inverse demand equation with respect to the quantities of Mexican and Canadian fresh market tomatoes (first row in table 2), the results indicate that both Mexican and Canadian tomatoes are q-substitutes (flexibilities < 0) of similar magnitude. However, the point estimates should be interpreted with care. A one percent increase in the quantity of Mexican (Canadian) tomatoes results in a -0.5 (-0.4) percent decrease in the price of domestic tomatoes. Figure 4 illustrates that the decrease in the retail price in the U.S. demand equation with respect to Mexican (Canadian) quantities is greatest in the winter months when there is a limited amount of tomato varieties.

In the inverse demand equation for Mexican tomatoes, both U.S. and Canadian quantities appear to be q-substitutes with Mexican tomatoes at -1.0 and -1.5 percent respectively. Interestingly, in the winter months the cross price relationship between Mexican and U.S. tomatoes as well as Mexican and Canadian tomatoes is small (-0.2 to -0.4 percent). This suggests that in the winter months, Mexican and U.S. (as well as Mexican and Canadian) tomato varieties are not strong substitutes. In the IAIDS, we say that goods with very large cross price flexibilities are close to perfect substitutes. The results suggest that only in the winter months when Mexican supplies are abundant are U.S. and Mexican fresh tomatoes very closely related. On the other hand, the cross price flexibility of Mexican tomatoes with respect to Canadian greenhouse tomatoes shows the highest degree of substitution in the summer months (a larger negative number) around -4.0 percent in the later 1990's. However, Mexican and Canadian fresh tomatoes appear

to be more substitutable in the later 1990's compared to the early 1990's (note the smaller negative numbers in the later 1990's in the summer months).

Figure 6 shows clearly how the degree of substitutability between tomato varieties that differ by country of origin depends critically on the season. In the inverse demand equation for Canadian tomatoes with respect to the quantity of U.S. tomatoes (Canada/U.S. in figure 6), Canadian and U.S. tomatoes are almost independent goods in the summer months (a small negative number) but very substitutable in the remaining months of the year.¹³ A similar pattern emerges in the cross price flexibilities in the Canadian price equation with respect to Mexican quantities (Canada/Mexico, figure 6). In the mid and later 1990's (after NAFTA), Canadian and Mexican tomatoes in the U.S. market are only moderately substitutable in the summer months where we see small and negative flexibilities. However, in the winter months, Canadian and Mexican tomatoes are almost perfect substitutes.

Conclusions

In the North American market, fresh tomato consumption has increased significantly over the last three decades. After the signing of NAFTA, a much larger share of this consumption has come from Mexico and Canada during specific months of the year. However, very little is known about the demand side of this market in the U.S. not to mention the relationship between fresh tomato varieties that are differentiated by country of origin.

We used the LA/IAIDS model developed by Eales and Unnevehr (1993) to serve two purposes. First, we believe that estimating the relationship between U.S. fresh

¹³ Note that Canada still supplies the U.S. market in the non-summer months but the volume of shipments is much less.

tomatoes and Mexican and Canadian tomatoes using price as the dependent is a better specification given that tomatoes are highly perishable and it is the price (not quantities) that clears the market. From the perspective of the U.S. market this is an important step toward understanding local and seasonal demand conditions. As expected, results vary dramatically depending on the season. Own-quantity effects are relatively inflexible (flexible) in the U.S (Mexican) equation so that a one percent increase in the quantity of tomatoes induces a less than (more than) one percent fall in the own-price. In the case of Canadian greenhouse tomatoes in the U.S. market, the results suggest that the retail price of Canadian tomatoes is extremely sensitive to own quantity changes (-21%). In term of the cross quantity effects, U.S. prices with respect to Mexican and Canadian tomato quantities (row one, table 2) are q-substitutes throughout the year but the relationship is much weaker during the winter months for Mexico and the summer months for Canada. In terms of the U.S. demand for Mexican tomatoes (row 2, table 2), domestic U.S. tomatoes are highly q-substitutable in the summer months April through August but show low substitutability in the winter months when Mexican tomatoes are in season. Mexican prices in the U.S. market decrease by much more than one percent when relatively higher amounts of Canadian tomatoes enter the market in the summer months. Finally, Canadian prices in the U.S. market show the highest degree of variation with respect to changes in Mexican and U.S. quantities (figure 6). The results suggest that Canadian and U.S. and Mexican tomatoes are highly q-substitutable (and very price flexible) in the winter months but are nearly independent goods (price inflexible) in the summer months when Canadian tomatoes are in season.

The second purpose of using the LA/AIDS model is to provide a better understanding of the recent dumping investigations brought by the U.S. on Mexican and Canadian fresh tomatoes.¹⁴ Dumping occurs by an exporter if a “like product” is being introduced into the commerce of another country at less than its normal value. Thus, there are two preconditions that must be met before a country can establish an antidumping duty. One is proving material injury to domestic industries and the other is the “likeness” of the product(s) being investigated. Proving material injury requires the calculation of dumping margins – a supply side concept. While we have not modeled the supply side of this market, the price dependent specification can serve as a rough proxy as to when price changes are relatively flexible and inflexible. On the other hand, our results can play a pivotal roll in determining the likeness of fresh tomato varieties. Article 2.6 of the Agreement on Implementation of Article VI of the General Agreement on Tariffs and Trade (1994), states that a "like product" is a product which is identical or in other words alike in all respects to the product under consideration.

Our results suggest that the “likeness” of a product and the changes in prices that might suggest dumping depend critically on the *time of year*. Figure 6 shows that U.S. cross price flexibility for Canadian tomatoes with respect to U.S. tomato quantity is not as responsive in the summer months but increases rapidly in the fall and winter months when the price of Canadian tomatoes in the U.S. market drops as Canadian greenhouse

¹⁴ In 1996 the U.S. and Mexico temporarily settled a previous antidumping dispute by establishing two seasonal price floors or minimum reference prices. The antidumping dispute was based on claims by Florida and California tomato producers that the price of Mexican imports was undercutting domestic fresh market tomato prices. In April of 2001, U.S. producers initiated another antidumping suit against Canada arguing that Canadian greenhouse producers were dumping fresh tomatoes into the U.S. market at prices below the cost of production. While the Commerce Department determined that Canadian tomatoes were being dumped, the International Trade Commission held that the U.S. industry had suffered no injury, temporarily putting an end to the case. While Mexico and the U.S. settled on a reference price system, bilateral negotiations on fresh tomatoes between these two countries, is still ongoing.

owners try to market their perishable excess supplies in a market with an abundance of domestically grown tomatoes from California and the southeastern U.S. The U.S. may have been successful in meeting the “likeness” of product criterion but not in the summer months when these varieties are not very q-substitutable. More work is needed on the supply side to determine dumping margins; however our results suggest that after the peak summer season, Canadian greenhouse producers may not be dumping fresh tomatoes more than they are trying to sell excess tomatoes when U.S. market prices are more flexible. A similar story emerges between Mexican and U.S. tomatoes in the winter months.

References

- Acosta, G. "The Effects of NAFTA on Trade and Welfare in the U.S. Fresh Tomato Industry." Master's Thesis, Purdue University. (2002)
- Acosta, G, K. Foster, and G. Sullivan. (2004). "The Effects of NAFTA on Trade and Welfare in the U.S. Fresh Tomato Industry." *Journal of International Food & Agribusiness Marketing*. 16(2004): 115-139.
- Armington, P.S. "A Theory of Demand for Products Distinguished by Place of Production," *IMF Staff Papers*, International Monetary Fund, 16: pp159-178.
- Barten, A.P. and L.J. Bettendorf. "Price Formation of Fish: An Application of an Inverse Demand System." *European Economic Review* 33(October 1989): 1509-1525
- Cook, R. and L. Calvin. "Greenhouse Tomatoes Change the Dynamics of the North American Fresh Tomato Industry," *United States Department of Agriculture*, Economic Research Report No. 2, April 2005.
- Deaton, A. and J. Muellbauer. "Economics and Consumer Behavior." Cambridge University Press. 1980.
- Deaton, A. and J. Muellbauer. "An Almost Ideal Demand System." *American Economic Review* 70(1990): 312-326
- Eales, J.S. and L.J. Unnevehr. "Simultaneity and Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 75(May 1993): 259-268.
- ERS/USDA. "Tomato Trade," *Economic Research Service, United States Department of Agriculture*, Briefing Room, July, 2004.
- . U.S. Tomato Statistics (902010), *Economic Research Service, United States Department of Agriculture*, March, 2003..
- Huang, K.S. "An Inverse Demand System for U.S. Composite Foods." *American Journal of Agricultural Economics*. 70(November 1988): 902-909.
- Moschini, G. and A. Vissa. "A Linear Inverse Demand System." *Journal of Agricultural and Resource Economics*. 17(1992):292-302.
- Padilla-Bernal, L., D.D. Thilmany and M.L. Loureiro. 2003. "An Empirical Analysis of Market Integration and Efficiency for U.S. Fresh Tomato Markets," *Journal of Agricultural and Resource Economics*, vol. 28(3):pp. 435-450.

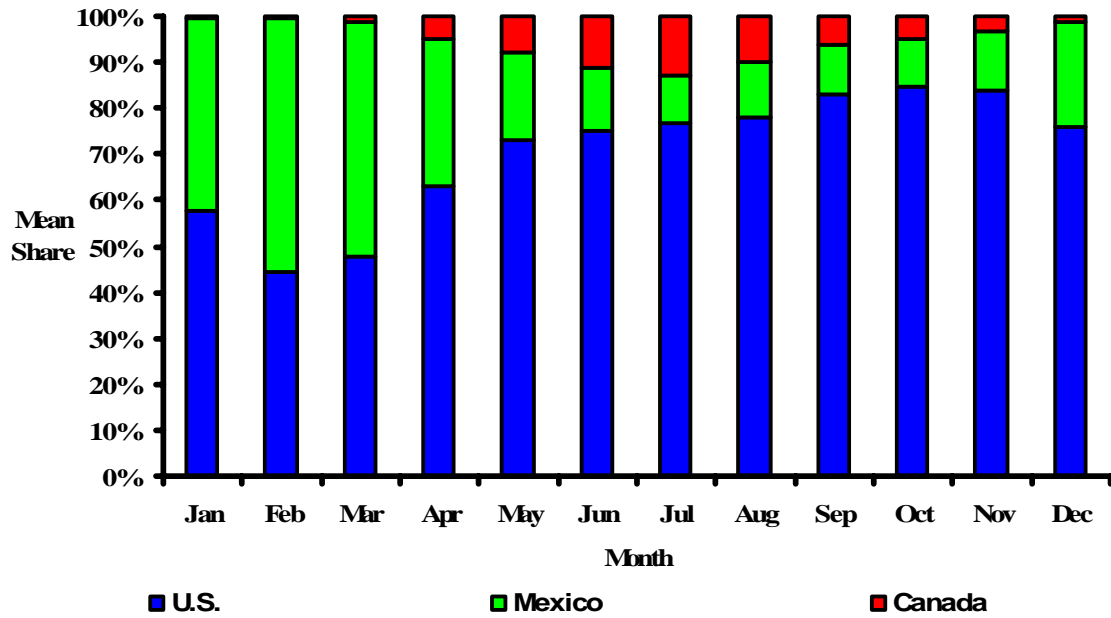
Roth, E., M. Meilson, H. Pickering, S. Jaffry, D. Whitemarsh, P. Wattage, and J. Frere. "The Value of Fish Quality," available online at: www.oregonstate.edu/Dept/IIFET/2000/papers/roth.pdf.

Schroeter, C. And K. Foster. "The Impact of Health Information and Demographic Changes on Aggregate meat Demand." Selected Paper Presented at the American Agricultural Economics Association Meetings. 2004. Denver Colorado

U.S. Department of Commerce. U.S. Imports of Merchandise (1990-2000). Economics and Statistics Administration. U.S. Census Bureau, Washington, D.C.

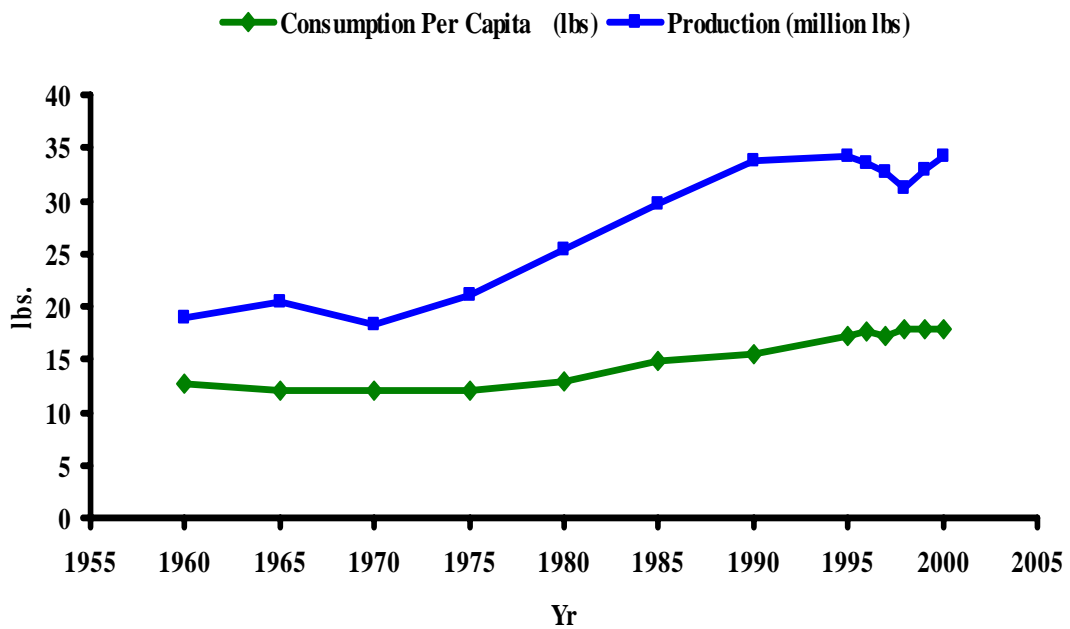
—. U.S. Exports of Merchandise (1990-2000). Economics and Statistics Administration. U.S. Census Bureau, Washington, D.C.

Figure 1: Monthly U.S. market shares of fresh tomatoes among NAFTA members



Source: Economic Research Service, USDA and Bureau of Labor Statistics

Figure 2: U.S. fresh tomatoes, per capita use and production



Source: Economic Research Service, USDA

Table 1. Linear approximate SUR estimates of the AIDS model^a

Equation	AIDS	SUR Estimates							R ²	mean share
		U.S.	Mexico	Canada	Scale	Dmex	Dcan	Intercept		
[9]	U.S.	0.654** (0.019)	-0.348*** (0.022)	-0.306*** (0.008)	-0.156** (0.064)	-0.078* (0.042)	0.020 (0.028)	2.401*** (0.766)	0.912	0.757
[10]	Mexico	-0.348*** (0.022)	0.663*** (0.027)	-0.314*** (0.011)	0.180** (0.084)	-0.031 (0.056)	0.064* (0.038)	-2.244** (1.008)	0.861	0.205
[11]	Canada	-0.306*** (0.008)	-0.314*** (0.011)	0.620*** (0.01)	-0.024 (0.064)	0.108*** (0.039)	-0.083** (0.033)	0.843 (0.782)	0.981	0.038

^a Asymptotic standard errors are shown in parentheses

*, ** and *** indicate significance at the 10, 5 and 1 percent levels respectively.

Table 2. AIDS tomato flexibilities^a

	U.S.		Mexico		Canada	
	Flexibility	Standard error ^b	Flexibility	Standard error ^b	Flexibility	Standard error ^b
U.S.	-0.601	(0.089)	-0.489	(0.105)	-0.397	(0.095)
Mexico	-1.1019	(0.133)	-1.467	(0.202)	-1.517	(0.104)
Canada	-17.986	(0.542)	-17.689	(0.858)	-21.072	(0.596)
Exp/Scale^c	-1.201***	(0.125)	-0.124	(0.445)	-2.315	(4.57)

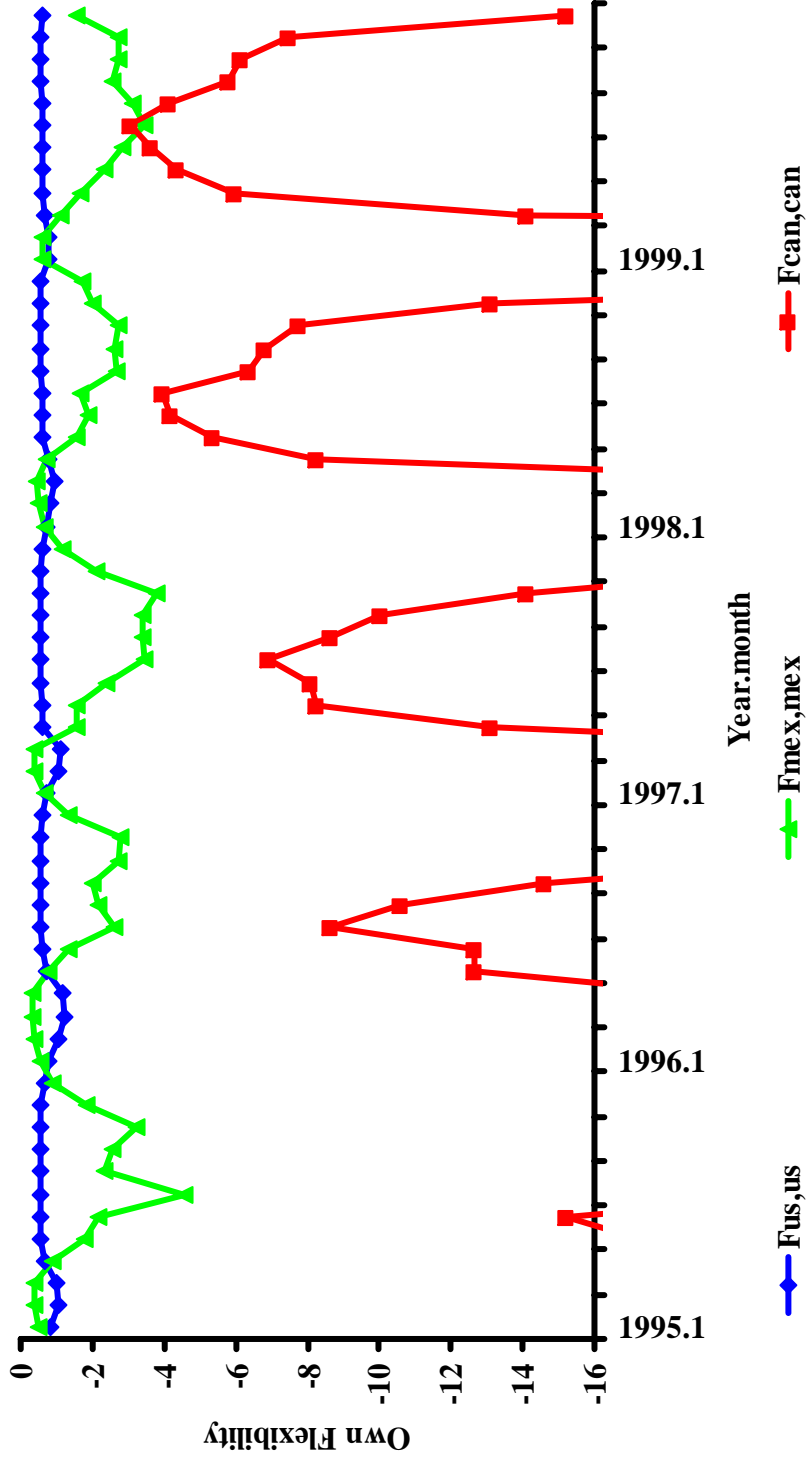
^a All own, cross and scale flexibilities are calculated at the mean share.

^b Standard errors are approximated using the bootstrap technique over 1000 drawings with replacement.

^c The scale flexibility associated with Stone's quantity index (Q^{*}).

*, ** and *** indicate significance at the 10, 5 and 1 percent levels respectively.

Figure 3. Own quantity flexibilities in the U.S. market.^{a,b}



^a Fus,us is the own quantity flexibility in the U.S for U.S. tomatoes; Fmex,mex is the own quantity flexibility for Mexican tomatoes in the U.S. market; and Fcan,can is the own quantity flexibility for Canadian tomatoes in the U.S. market.

^b Own flexibilities for Canada (Fcan,can) are truncated at -16 to help compress the scale in the figure.

Figure 4. U.S. cross quantity flexibilities in the U.S. market.

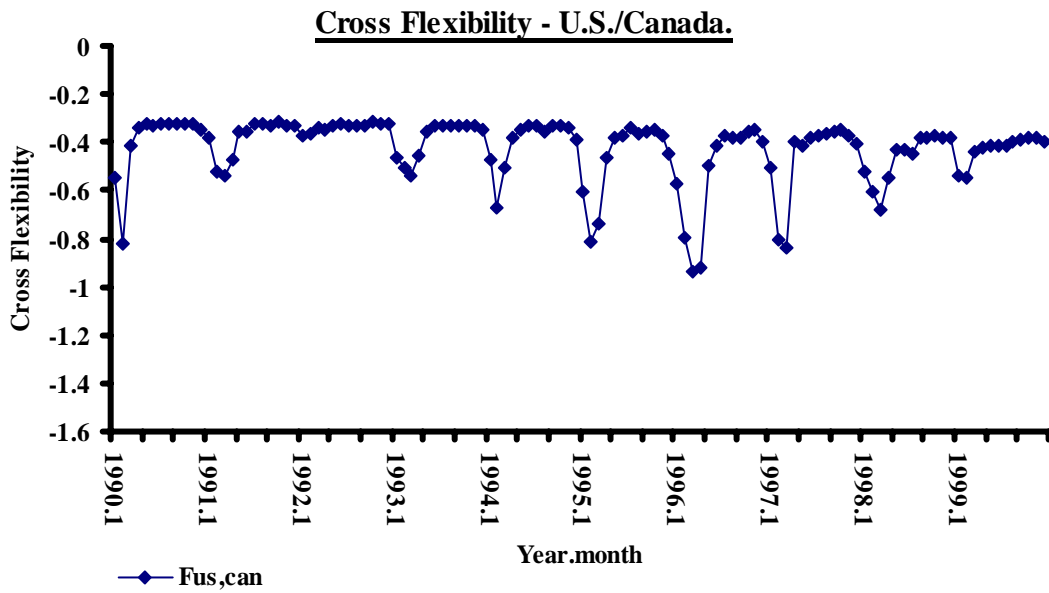
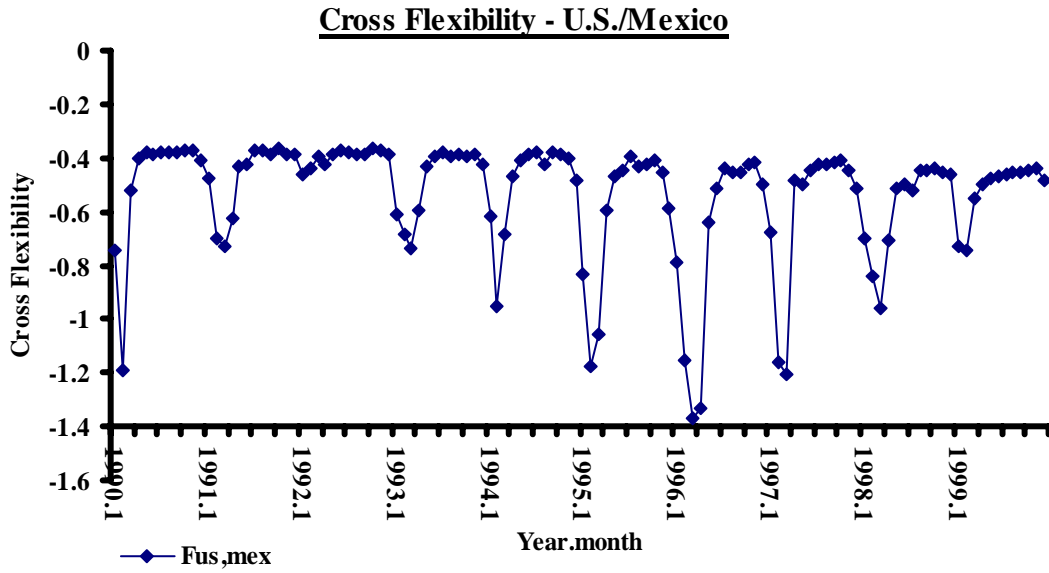


Figure 5. Mexico cross quantity flexibilities in the U.S. market.

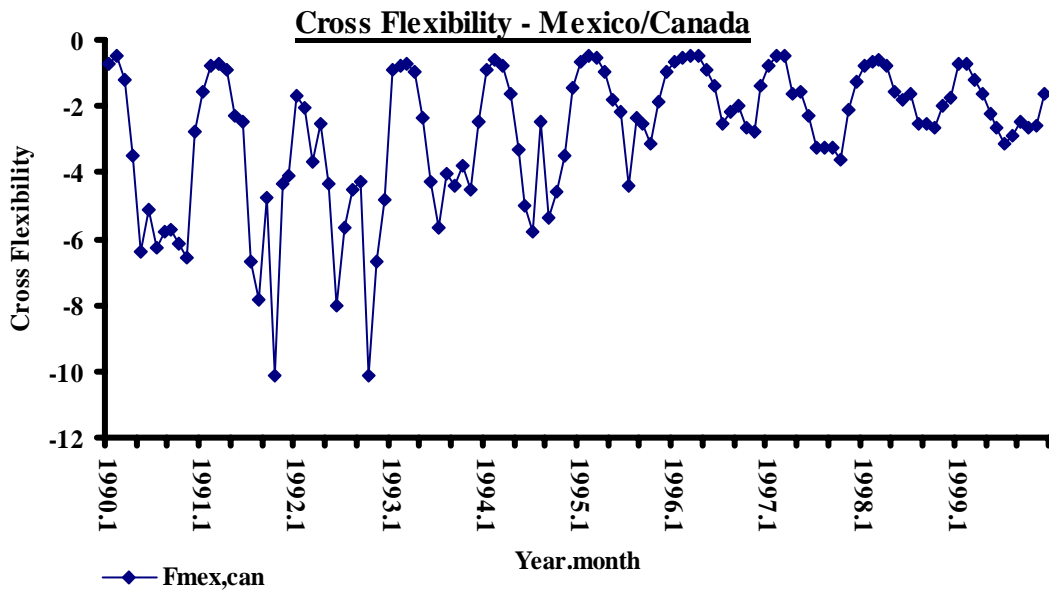
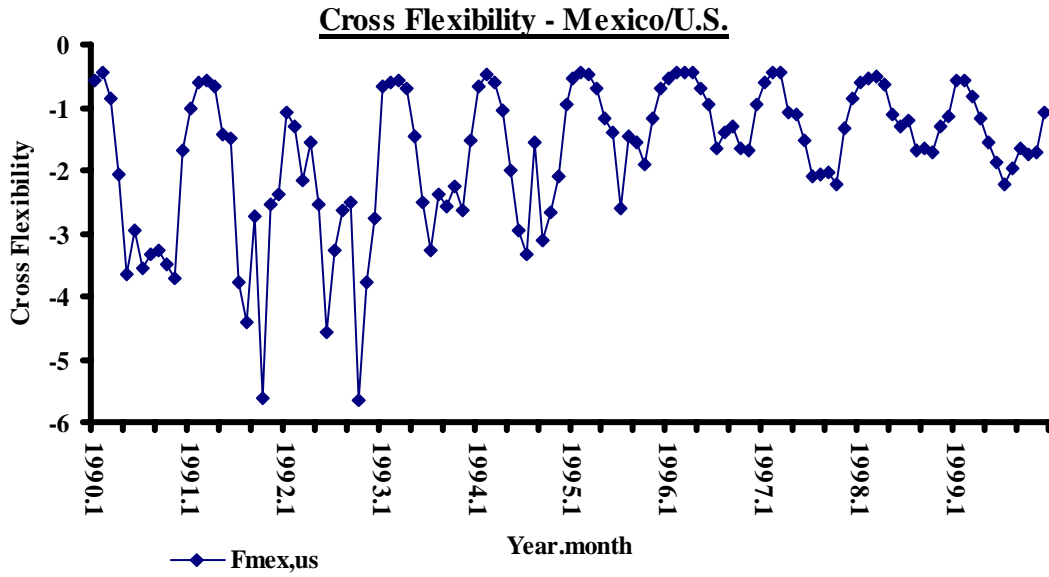


Figure 6. Canadian cross quantity flexibilities in the U.S. market.

