U.S. DEMAND FOR FRESH-FRUIT IMPORTS

A Thesis

by

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ABSTRACT

U.S. DEMAND FOR FRESH-FRUIT IMPORTS

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With increasing fresh-fruit import dependence, it is important for the U.S. to analyze trends and future trade scenarios, and develop corresponding strategies to achieve economic efficiency in the international market. Estimation of import demand elasticities is an effective approach for building economic models and predicting possible development scenarios for international trade. This study employs two Source-Differentiated Almost Ideal Demand Systems (SDAIDS) to estimate the elasticities of demand for (1) mangoes and guavas, bananas, avocadoes and papayas imported from NAFTA, CAFTA-DR, and MERCOSUR; and (2) berries, apples, and avocadoes imported from Canada and Mexico. The results of this study suggest that for the study period from 2005 to 2015 all the selected fresh fruits were normal goods, with some of them being luxuries. The expected total impact of a 20% tariff on imports from Mexico was calculated, and the results showed that the U.S. monthly expenditure of fresh-fruit imports is expected to increase, on average, by $10.45 million, and the tariff revenue is expected to be, on average, $17.49 million.

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INTRODUCTION

The U.S. is one of the world's major producers of fresh fruits with diverse climate zones present in the country. At the same time, the U.S. is one of the major importers of fresh fruits with a constantly increasing import trend and 50% average share of imports in domestic consumption from 2014 to 2015 (USDA-ERS, 2016). In the last three decades, U.S. imports[1] of fresh fruits have been increasing at an annual average growth rate of seven percent, making up nine percent of the total U.S. food imports (in dollar terms) in 2015 (USDA-ERS, 2016). According to the USDA, since the 1990s, U.S. demand for fresh fruits has increased more than the domestic production; consequently, the imports have increased to satisfy the country's increased demand (USDA-ERS, 2016). In 2015, seven fresh fruits—bananas and plantains (as one category), nuts, berries, avocadoes, grapes, melons, and pineapples—accounted for 82% ($10.3 billion) of the total value of all fresh-fruit imports ($12.5 billion). Figure 1 shows the percentage change in import values of these fresh fruits from 2005 to 2015, measured in 2015 dollars.

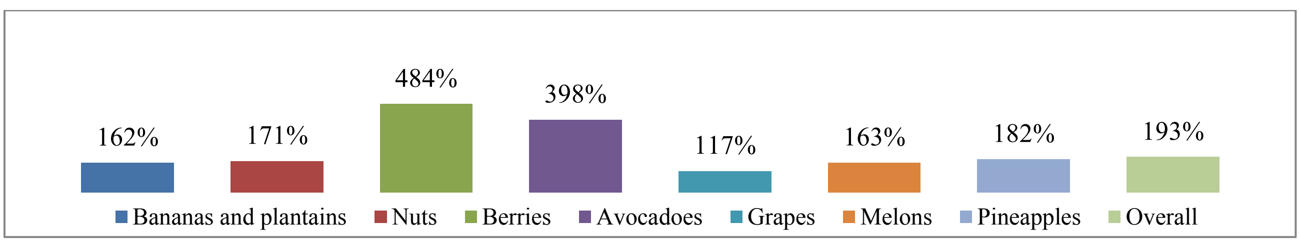

Figure 1. Percentage Change in Import Value of the Top Imported Fresh Fruits, 2005-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade database, 2016.

While imports of berries and avocadoes increased by nearly five and four times, respectively, the other categories less than doubled. Overall, from 2005 to 2015, the real imports

[1] Hereafter, imports refer to the imports for consumption.

of fresh fruits almost doubled. Figure 2 summarizes the structure and overall trend in the U.S. fresh-fruit imports for the period from 2005 to 2015 in 2015 dollars. Although the increasing trends in import values can also be attributed to inflation, these trends are consistent with the equivalent volume trends.

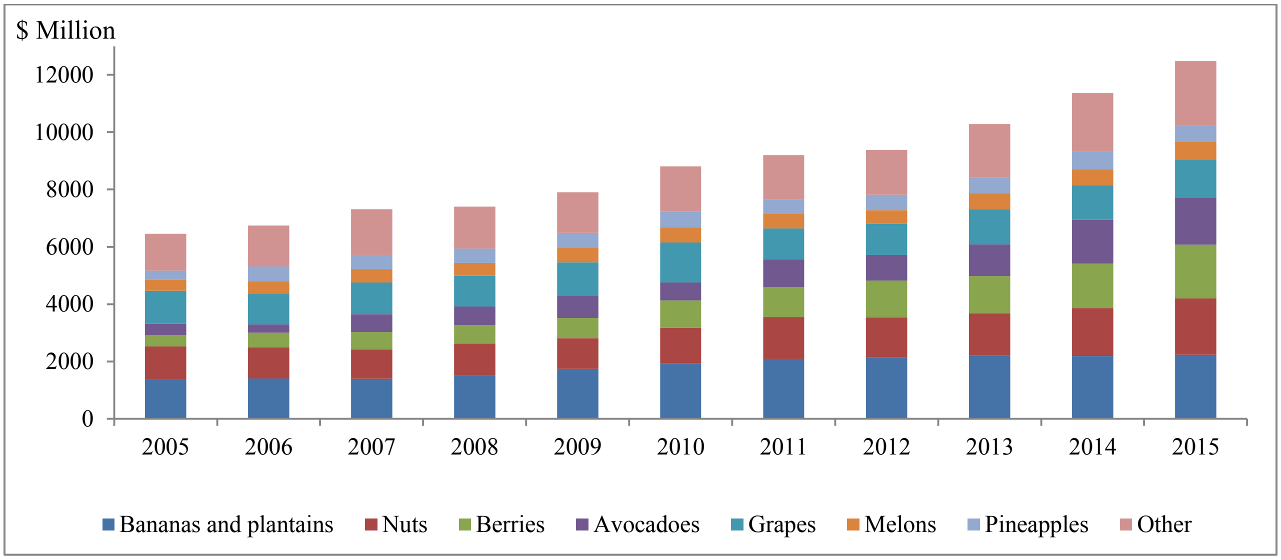

Figure 2. U.S. Fresh-Fruit Imports by Fruits and Years, 2005-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade database, 2016.

The main trading partners of the U.S. are the member countries of North American Free Trade Agreement (NAFTA) countries, the Southern Common Market (or the Common market of Southern Cone—MERCOSUR) and its associate countries, the Dominican Republic-Central America Free Trade Agreement (CAFTA-DR) countries, as well as some countries with bilateral preferential or free trade agreements with the U.S. From 2005 to 2015, Mexico (with an average share of 32% in 2005-2015), Chile (16%), Guatemala (8%), Costa Rica (10%), Vietnam (5%), Ecuador (5%), Peru (3%), Honduras (3%), and Canada (2%) together accounted for 84% of the U.S. imports of fresh fruits (Figure 3).

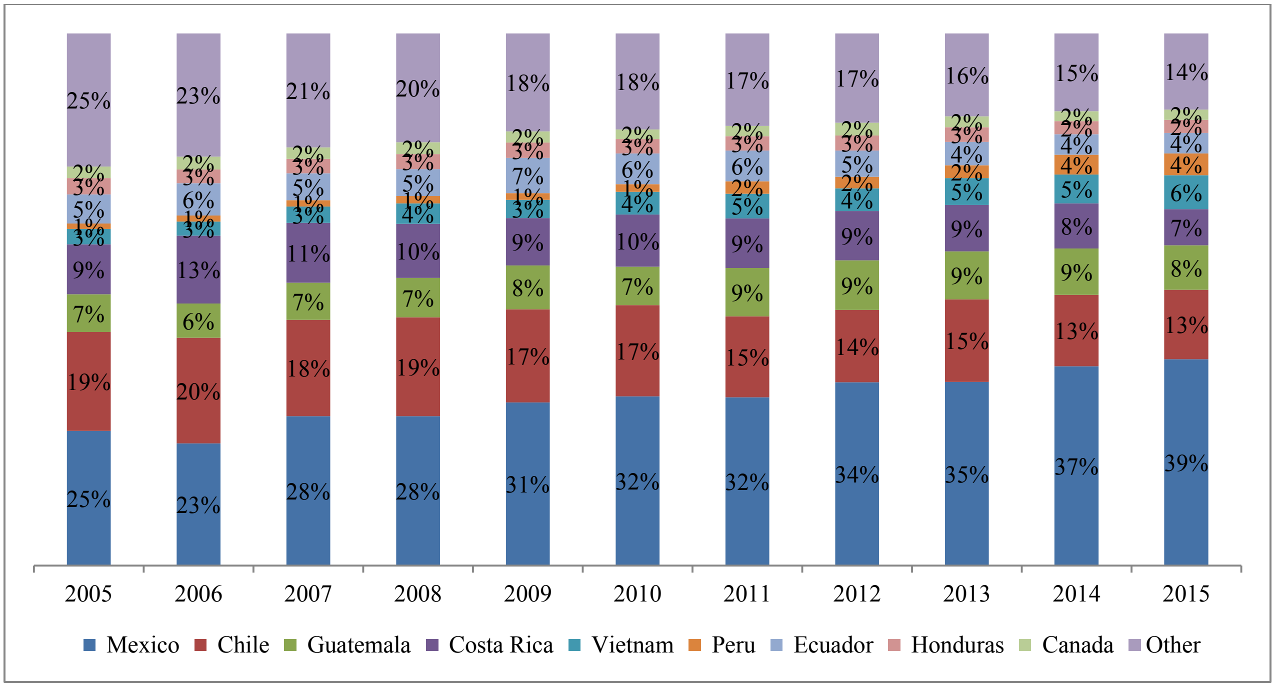

Figure 3. Shares of Fresh-Fruit Imports by Countries and Years, 2005-2015.
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade database, 2016.

The U.S. Fresh-fruit imports from Mexico, Vietnam, and Peru to the U.S. increased while imports from Chile and Costa Rica and the rest of the world (other) decreased. The U.S. imports of fresh fruits from Guatemala, Ecuador, Honduras, and Canada to the U.S. remained stable (U.S. International Trade Commission [USITC] 2016).

Numerous factors can potentially affect the international market conditions and the U.S. trade of fresh fruits. First, relatively open regime of imports in the U.S. and lower-than-average import tariffs create significant import incentives for the preferential trade agreements. Second, opportunities for counter-seasonal supply of fresh fruits supported by year-around demand in the U.S. encourage the importers from the southern and northern hemispheres. Third, non-tariff factors (such as phytosanitary control) negatively affect the U.S. exports to some countries. In addition, other market factors, such as exchange rate fluctuations or changes in domestic and global supply volumes, can affect the U.S. trade of fresh fruits both negatively and positively

(Johnson, 2016). Low import tariffs for the suppliers and high export tariffs on the U.S. exports are partly responsible for the unproportionate development of the U.S. exports and imports of fresh fruits (Johnson, 2016). Globally, the average tariff on fresh-fruit imports is more than 50% of the import value, while in the U.S., nearly 60% of all tariffs are less than 5% of the value of the imported commodities (Johnson, 2016). This study is focused on assessing the U.S. trade relationships with the NAFTA countries, the MERCOSUR and its associate countries[2], and the CAFTA-DR countries.

1.1 CAFTA-DR

Central American Free Trade Agreement (signed in 2004) is an agreement between the U.S. and Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Dominican Republic. According to the Office of U.S. Trade Representative (USTR), this group of countries is 16th largest import source (for all goods and services imported) for the U.S., with $24billion imports in 2015 (USTR, 2016). In 2004, when the agreement was signed, nearly 50% of tariffs on the U.S. agricultural goods were eliminated, while the other 20% was phased out during the next 20 years. The tariffs on the goods from those countries were mainly eliminated by the U.S. before the creation of the CAFTA agreement, within the scope of Caribbean Basin Initiative (USTR, 2016).

[2] The term “associates of MERCOSUR” refers to Chile and Peru primarily.

1.2 MERCOSUR

The Common Market of the Southern Cone (MERCOSUR) is a regional block of countries in Southern America. The member countries are Argentina, Brazil, Paraguay, and Uruguay. Associate countries are Peru, Chile, Bolivia, Ecuador, Suriname, and Colombia. One of the objectives of the agreement is the free trade promotion among the member countries. The agreement has free trade agreements with third parties, such as Egypt, Israel, etc. As of 2017, the four members of MERCOSUR have no free trade agreement (FTA) with the U.S, but some of the associate countries, including Peru and Chile, have a bilateral FTA with the U.S. (USTR, 2016).

1.3 NAFTA

The North American Free Trade Agreement was signed in 1992 and became effective in 1994. The agreed date of finalizing the gradual duty phase-out was 2008. During the period from 2005 to 2015, the NAFTA countries accounted from 25% (in 2005) to 41% (in 2015) of fresh-fruit imports of the U.S., making the agreement the main fresh fruit trade partner for the U.S. (USTR, 2016). In 2015, the real imports of fresh fruits imported from the NAFTA countries amounted to almost $5.1 billion, of which 95% was imported from Mexico and 5% from Canada (USITC, 2016). In 2005-2015, the share of U.S. fresh-fruit imports from Mexico was the largest among all sources. The real imports of fresh fruits imported from Mexico increased from $1.6 billion (25%) in 2005 to almost $5 billion (40%) in 2015. The real imports of fresh fruits from Canada, on the other hand, were $0.15 billion (2%) in 2005 and $0.24 (2%) billion in 2015. As discussed later, the U.S. imports from these countries exhibit highly seasonal patterns, and these sources often substitute each other in the U.S. market.

With the U.S. President Donald Trump considering imposing import tariffs on goods and services coming from Mexico (Flores, 2017), it becomes increasingly important to evaluate the expected impact of these tariffs on the U.S. imports of fresh fruits.

1.4 Statement of the Problem

With an increasing dependence on fresh-fruit imports, it is important for the U.S. to analyze trends and future trade scenarios, and develop corresponding action plans for achieving economic efficiency in the international market. Estimation of import demand elasticities is an effective approach for building economic models and predicting possible development scenarios for international trade. Elasticities estimated for different sources of origin enable interested parties to evaluate the effects of changes in total expenditure and own price on the quantity of a good imported, as well as the economic relationships among various exporters in one particular import market. Considerable research effort has been devoted to the estimation of the U.S. demand for fresh fruits at the retail level (e.g., You, Epperson, and Huang, 1996; Huang, 1993; Brown and Lee, 2002; Durham and Eales, 2006) and import level (e.g., Nzaku, Houston, and Fonsah, 2010). However, to the best of our knowledge, there is no published empirical analysis aimed at estimating import demand elasticities for fresh fruits at the source level, as well as there is no published empirical analysis of the impact of tariffs on the U.S. imports of fresh fruits. This study employs two Source-Differentiated Almost Ideal Demand Systems (SDAIDS) to estimate the elasticities of demand for (1) mangoes and guavas, bananas, avocadoes and papayas imported from NAFTA, CAFTA-DR, and MERCOSUR; and (2) berries, apples, and avocadoes imported from Canada and Mexico. In addition, this study uses the estimated elasticities of demand to evaluate the expected impact of tariffs on Mexican goods and services. The study incorporates the main exporters of fresh fruits to the U.S., and therefore contributes to a better understanding of the economic and trade relationships among these countries or regions.

1.5 Study Objectives

The main objective of this study is to analyze the U.S. demand for the fresh fruits differentiated by sources of origin. The specific objectives include:

1. Discuss the recent U.S. fresh-fruit import trends;
2. Identify the most imported fresh fruits from NAFTA, CAFTA-DR, and MERCOSUR and estimate a system of demand equations for the U.S. fresh-fruit imports from these trade agreements;
3. Identify the most imported fresh fruits among the NAFTA countries and estimate a system of demand equations for the U.S. fresh-fruit imports from these countries;
4. Estimate both uncompensated and compensated own-price and expenditure elasticities of demand for the major fresh fruits and discuss how the quantity demanded for each of them reacts to the changes in own-price and import expenditure;
5. Estimate both uncompensated and compensated cross-price elasticities of demand of selected fruit categories and discuss the economic relationships among them;
6. Develop and analyze a scenario of imposing a 20% tariff on Mexican imports and its impact on the U.S. fresh fruit trade.

1.6 Significance of the Study

The present study differs from the previous studies in that it estimates the demand elasticities considering the source of origin as a specific quality attribute for the selected fresh fruits. With the focus on the major import sources, the study explores U.S. trade relationships with (1) NAFTA, CAFTA-DR, and MERCOSUR trade agreements; and (2) Canada and Mexico. The study also includes the rest of the world (ROW) as an additional import source.

The study will help to better understand the structure of the U.S. fresh-fruit imports, and provide insight into the demand behavior of the U.S. with respect to specific fruits imported from various sources of origin. The findings of this study will provide a solid foundation for scenario analysis in policy-making. Particularly, the estimated elasticities of demand can be useful in terms of measuring the degree of responsiveness of the U.S. consumers to the changes in prices of the imported fresh fruits. Therefore, these elasticities can be used to evaluate the impact of various factors (such as tariffs and phytosanitary regulations) that can influence the prices of the fresh fruits imported to the U.S.

1.7 Limitations

This study has some limitations. First, fresh-fruit imports are highly seasonal, and because of that, for some periods, there are no data available. Therefore, this study uses a common price imputation approach to handle unobserved (or missing) prices. When, for some reason, the U.S. does not import a specific fresh fruit from any of the selected sources of origin, no information on the import quantity and price is observed. Two common approaches to deal with this problem are (1) to discard all missing observations and use the remaining data to estimate the population parameters, or (2) to use simple zero-order methods that are commonly accepted in cross-sectional data analysis (Cox and Wohlgenant, 1986). The second approach assumes finding valid proxies for the missing observations. Because missing prices in trade analysis are often related to seasonal variations (i.e., prices are missing when there are no imports at all), this study uses the weighted average monthly real import prices for the total U.S imports of fresh fruits as proxies for missing prices. Second, not all imported fresh fruits are included in the analysis due to high seasonal patterns or low market shares of some fresh fruits. In addition, exporting countries with less than 5% share were included in the ROW category. Finally, similar to Armington (1969), Winters (1984), and Yang and Koo (1994), this study does not consider domestic production as an additional source of fresh fruits.

Chapter 2

REVIEW OF THE LITERATURE

Significant research effort has been devoted to the estimation of import demand functions. Theoretically consistent models include the Rotterdam model (Barten, 1964), Armington model (Armington, 1969), Traditional Aggregate Import Demand Model (Murray and Ginman, 1976), AIDS model (Deaton and Muellbauer, 1980), and other logarithmically transformed models. With linear Engel curves for all goods, the AIDS model is one of the most popular demand systems. The model estimates a system of budget (or expenditure) share equations that allow for computation of own-price, cross-price, and expenditure elasticities of demand. Various modifications of AIDS have been developed based on the original model, making it rather popular (e.g., Source-Differentiated AIDS, Quadratic AIDS, Linear Approximate AIDS, and Generalized Quadratic AIDS). This section presents recent studies concerned with the estimation of retail- and import-level demand for fresh fruits by estimating some of the foregoing models. The estimated elasticities of demand on the retail level can be different from those estimated at the import level, and this difference can be used to compare the responsiveness of the U.S. to the changes in prices and total expenditure across the two levels.

Huang (1993) estimated a complete system of U.S. demand for 39 food (including apples and bananas) and one non-food categories using constrained maximum likelihood method and annual time-series data for the period of 1953 to 1990. The empirical results suggested that the price had a statistically significant impact on demand for oranges, bananas, grapes, and grapefruits. The own-price elasticity estimate of grapes in absolute terms was found to be greater than one, indicating that U.S. consumers were more sensitive to changes in the price of grapes. Estimated compensated cross-price elasticities suggested a statistically significant complementary relationship between oranges and grapes. Income was found to be an insignificant factor affecting U.S. consumer's demand for fresh fruits. The elasticities of demand obtained by Huang (1993) are presented in Table A. 1 of Appendix A.

You, Epperson, and Huang (1996) estimated a composite demand system to study the U.S. demand for fresh fruits using time-series data from 1960 to 1993. The estimation results included retail-level uncompensated and compensated demand elasticities for eleven fresh-fruit categories. The own-price was found to be a significant factor influencing consumer demand for bananas, grapefruits, grapes, oranges, and watermelons. For oranges and grapefruits, the own-price elasticity estimates in absolute terms were greater than unity, implying that U.S. consumers were more sensitive to changes in own prices of these fruits. Estimated cross-price elasticities indicated statistically significant complementary relationships between lemons and bananas, oranges and grapes, strawberries and bananas, watermelons and peaches, and strawberries and pears. Substitutability was observed between apples and strawberries, lemons and peaches, strawberries and oranges, and strawberries and lemons. The results suggested that income did not significantly affect the consumer-level demand for apples, bananas, cherries, grapefruit, grapes, lemons, oranges, peaches, pears, strawberries, and watermelons. The elasticities of demand obtained by You, Epperson, and Huang (1996) are presented in Table A. 2 of Appendix A.

Brown and Lee (2002) estimated a restricted Rotterdam model using annual time-series data on per-capita fresh fruit consumption and retail-level prices for the period of 1980-1998 in the U.S. Estimated uncompensated own-price elasticities revealed that the demand for apples, bananas, grapes, and oranges was price-inelastic, while the demand for grapefruit was price-elastic. Estimated compensated cross-price elasticities revealed a statistically significant substitutability between bananas and grapefruits. Statistically significant complementary relationships were observed between oranges and grapefruits, oranges and apples/pears, oranges and bananas, grapes and apples/pears, and bananas and apples/pears. The empirical results suggested that income positively affected the demand for fresh fruits. The expenditure elasticities were greater than unity for oranges and grapes, suggesting that these fruits were luxury goods. The elasticities of demand obtained by Brown and Lee (2002) are presented in Table A. 3 of Appendix A.

Durham and Eales (2006) estimated demand elasticities for fresh fruits at the retail level, using Almost Ideal Demand System (AIDS), Linear Approximate Almost Ideal Demand System (LA/AIDS), Quadratic Almost Ideal Demand System (QUAIDS), and double-log models. Weekly data from two retail stores in the Portland, Oregon metropolitan area were used for the study. Based on the root mean squared errors criterion, the QUAIDS model was found to be the best. The elasticity estimates obtained by Durham and Eales (2006) for the Store 1 and Store 2 revealed that the selected fresh-fruit categories were generally price-elastic at the retail level. The empirical results indicated that the own-price was a significant factor influencing the demand for apples, pears, bananas, oranges, grapes, and the aggregated category labeled as "other". The uncompensated price elasticities of apples, pears, oranges and grapes in absolute terms were greater than one, suggesting that the U.S. consumers were more sensitive to the changes in respective own-prices. The estimated compensated cross-price elasticities indicated statistically significant substitutability between pears and apples, pears and bananas, pears and grapes, apples and grapes, bananas and apples, and bananas and grapes. The only statistically significant complementary relationship was observed between bananas and other fruits in case of the Store 1. Estimated income elasticities had the expected positive sign with estimates of greater than unity for grapes and oranges in both stores. In general, estimation results for own and cross-price elasticities were similar for both stores, while some variation in income elasticities was observed.

This variation was explained by demographic differences between the two populations served by those stores. The elasticities of demand obtained by Durham and Eales (2006) are presented in Table A. 4 of Appendix A.

Nzaku, Houston, and Fonsah (2010) estimated an import-level LA/AIDS model for fresh bananas, pineapples, papayas, mangoes (mangoes and guavas), grapes, and avocadoes (without differentiation by sources of origin) using quarterly time-series data from 1989 to 2008. The estimated share equations included trend and trigonometric variables to capture trend and seasonality present in the data. The uncompensated own-price elasticity estimates for bananas, mangoes, and avocadoes in absolute terms were less than unity, suggesting that the demand for these fruits was price-inelastic. Estimated compensated cross-price elasticities indicated statistically significant substitutability between papayas and pineapples, and grapes and papayas. Statistically significant complementary relationships were observed between papayas and bananas, bananas and mangoes, papayas and mangoes, avocadoes, and mangoes. The estimated expenditure elasticities were greater than one for bananas and avocadoes, implying that these fruits were luxury goods. All expenditure elasticities had a positive sign suggesting that as the total expenditure on the selected fresh fruits increased, the quantity demanded of these fruits increased as well, holding all other factors constant. The elasticities of demand obtained by Nzaku, Houston, and Fonsah (2010) are presented in Table A. 5 of Appendix A.

When comparing the retail-level and import-level elasticity estimates, one must be careful with making inferences about the similarity of these estimates due to the fact that one category uses domestic, retail-level prices and the other category uses import-level prices (generally per-unit value). The elasticity estimates obtained by the prior studies are summarized in the table below.

Table 1. Summary of Demand Elasticities Obtained by the Prior Studies

Fruit	Study	Own-price elasticity	Expenditure elasticity
Apples	Huang (1993)	-0.19	-0.36
	You, Epperson, and Huang (1996)	-0.16	-0.19
	Brown and Lee (2002)	-0.52*	1.03*
	Durham and Eales (2006) - 1	-1.13*	0.70
	Durham and Eales (2006) - 2	-1.19	0.82
Avocadoes	Nzaku, Houston, and Fonsah (2010)	-0.88*	1.14*
Bananas	Huang (1993)	-0.50*	0.09
	You, Epperson, and Huang (1996)	-0.42*	0.63
	Brown and Lee (2002)	-0.54*	0.40
	Durham and Eales (2006) - 1	-0.98*	0.74
	Durham and Eales (2006) - 2	-0.90	0.68
	Nzaku, Houston, and Fonsah (2010)	-0.54*	1.11*
Cherries	You, Epperson, and Huang (1996)	-0.03	-1.80
Grapefruits	Huang (1993)	-0.45*	-0.49
	You, Epperson, and Huang (1996)	-1.02*	0.60
	Brown and Lee (2002)	-1.11*	0.42
Grapes	Huang (1993)	-1.18*	0.56
	You, Epperson, and Huang (1996)	-0.91*	0.66
	Brown and Lee (2002)	-0.56*	1.14*
	Durham and Eales (2006) - 1	-1.62*	1.12
	Durham and Eales (2006) - 2	-1.67*	1.28
	Nzaku, Houston, and Fonsah (2010)	-0.38	0.95*
Lemons	You, Epperson, and Huang (1996)	-0.30	0.44
Mangoes/Guavas	Nzaku, Houston, and Fonsah (2010)	-0.61*	0.55*
Oranges	Huang (1993)	-0.85*	-0.16*
	You, Epperson, and Huang (1996)	-1.14*	0.89
	Brown and Lee (2002)	-0.67*	1.75
	Durham and Eales (2006) - 1	-1.37*	1.4
	Durham and Eales (2006) - 2	-1.30*	1.05
Papayas	Nzaku, Houston, and Fonsah (2010)	-0.12	0.84*
Peaches	You, Epperson, and Huang (1996)	-0.96*	-0.08
Pears	You, Epperson, and Huang (1996)	0.29	0.93
	Brown and Lee (2002)	-0.52*	1.03*
	Durham and Eales (2006) - 1	-1.44*	0.77
	Durham and Eales (2006) - 2	-1.68*	0.93
Pineapples	Nzaku, Houston, and Fonsah (2010)	-0.20	0.71*
Strawberries	You, Epperson, and Huang (1996)	-0.28	-0.47
Watermelons	You, Epperson, and Huang (1996)	-0.60*	0.41

* Significant at p=0.05.

In general, own-price elasticity estimates for fresh fruits in previous studies ranged from -0.03 for cherries in You, Epperson, and Huang (1996) to -1.68 for pears in Durham and Eales (2006), except for the own-price elasticity estimate of 0.29 for pears in You, Epperson, and Huang (1996), where they obtained an unexpected positive sign. Expenditure elasticities in previous studies ranged from being negative (inferior goods) for certain fruits to being positive (normal goods) for the majority of these studies. The expenditure elasticities of fresh fruits ranged from 0.09 for bananas in Huang (1993) to 1.75 for oranges in Brown and Lee (2002).

Similar to the reviewed studies, this study analyzes the U.S. demand for fresh fruits and estimates the U.S. consumers' response to changes in prices of the selected fresh fruits. An essential difference arising between the previous research and the present study is the level at which most of the previous studies are conducted. From this prospective, this study is compatible to Nzaku, Houston, and Fonsah (2010), where the U.S. import-level demand of fresh fruits is analyzed. The contribution of this study to the existing literature is the differentiation of fruits by sources of origin that assists in further analyzing the scenario of imposing import tariffs on Mexican goods and services on each of the fresh-fruit categories imported to the U.S.

Chapter 3

THEORETICAL DEVELOPMENT AND SPECIFICATION OF THE MODEL

The Almost Ideal Demand System (AIDS) was first introduced by Deaton and Muellbauer in 1980 (Deaton and Muellbauer, 1980). Since then, the model has gained a wide popularity, and many authors have used its various formulations, making it more flexible and applicable. Derived from the price-independent generalized logarithmic (PIGLOG) model, the AIDS model ideally satisfies the axioms of choice and the conditions for exact aggregation over the consumers. At each level of utility, the AIDS model assumes that consumers minimize expenditure to realize the given utility (Deaton and Muellbauer, 1980). In this study, a Source-Differentiated AIDS (SDAIDS) model was used to estimate the expenditure share equations. The SDAIDS model differentiates the fruits by their sources of origin.

In the AIDS model, the expenditure function, denoted by *c,* has the following form:

$$(1) \qquad \log c(p,u) = (1-u)\log(a(p)) + u\log\big(b(p)\big),$$

where

$$(2) \qquad \log a(p) = \alpha_0 + \sum_k \alpha_k \log(p_k) + 0.5 * \sum_k \sum_j \gamma^*_{kj} \log(p_k) \log\big(p_j\big)$$

and

$$(3) \qquad \log b(p) = \log a(p) + \beta_0 \prod_k p_k^{\beta_k}.$$

where *α*, *β*, and *γ* are parameters; *u* is the utility index taking on values of 0 for the subsistence and 1 for the bliss (with some exceptions), so that *a(p)* can be considered as the cost of subsistence and *b(p)* as the cost of bliss. Then, the AIDS cost function can be written as

$$(4) \qquad \log c(p,u) = \alpha_0 + \sum_k \alpha_k \log(p_k) + 0.5 * \sum_k \sum_j \gamma_{kj}^* \log(p_k)\log(p_j) + u * \beta_0 \prod_k p_k^{\beta_k}$$

Shepard's Lemma (a special case of envelope theorem) can be used to get the quantity demanded, q_i, by taking the derivative of the expenditure function ($\log c(p,u)$) with respect to the p_i.

$$(5) \qquad \frac{\partial c(p,u)}{\partial p_i} = q_i$$

Thus, taking the derivative of $\log c(p,u)$ with respect to $\log(p_i)$ will yield the expenditure share of the good *i* through the following relation[3]

$$(6) \qquad \frac{\partial \log c(p,u)}{\partial \log(p_i)} = \frac{p_i q_i}{c(p,u)} = w_i.$$

Therefore, the logarithmic differentiation of (4) with respect to the $\log(p_i)$ results in budget shares

$$(7) \qquad w_i = \alpha_i + \sum_j \left(0.5 * (\gamma_{ij}^* + \gamma_{ji}^*)\right)\log(p_j) + \beta_i\left(\log\left(\sum_{i=1}^{n} p_i q_i\right) - \log P\right),$$

where

P is a nonlinear price index defined as

$$(8) \qquad \log(P) = \alpha_0 + \sum_k \alpha_k \log(p_k) + 0.5 * \sum_j \sum_k \gamma_{ij} \log(p_k)\log(p_j)$$

[3] $\frac{\partial \log c(p,u)}{\partial \log(p_i)} = \frac{\partial \log c(p,u)}{\partial \log(p_i)} * \frac{\partial(p_i)}{\partial(p_i)} = \frac{\partial \log c(p,u)}{\partial(p_i)} * \frac{\partial(p_i)}{\partial \log(p_i)} = q_i * \frac{1}{c(p,u)} * \frac{1}{\frac{\partial \log(p_i)}{\partial(p_i)}} = \frac{p_i q_i}{c(p,u)} = w_i$

Equation (7) is the AIDS demand function in expenditure share form. The price index shown in equation (8) is applied to deflate the logarithm of expenditure. The following are the restrictions for the parameters of the AIDS model:

(9) *adding up*: $$\sum_{i=1}^{n} \alpha_i = 1, \qquad \sum_{i=1}^{n} \gamma_{ij} = 0, \qquad \sum_{i=1}^{n} \beta_i = 0,$$

(10) *homogeneity*: $$\sum_{j} \gamma_{ij} = 0\text{, and}$$

(11) *summetry*: $$\gamma_{ij} = \gamma_{ji}.$$

The AIDS model estimates a set of parameters that are used in the calculation of demand elasticities. Following Green and Alston (1990), the uncompensated (Marshallian) price elasticities were calculated as

(12) $$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta_i(\alpha_j + \sum_{k=1}^{n} \gamma_{jk} \log(p_k))}{w_i}$$

where δ_{ij} is the Kronecker delta with $\delta_{ij} = 1$ if $i = j$ (own-price elasticity) and $\delta_{ij} = 0$ if $i \neq j$ (cross-price elasticity).

Expenditure elasticities are calculated as

(13) $$\varepsilon_{ix} = 1 + \frac{\beta_i}{w_i}.$$

Using Slutsky equation, compensated (Hicksian) price elasticities are calculated as

(14) $$e_{ij} = \varepsilon_{ij} + w_i * \varepsilon_{ix}.$$

Per the law of demand, uncompensated own-price elasticities of demand are expected to have a negative sign. The expenditure elasticities are expected to have a positive sign. The estimated compensated cross-price elasticities are expected to have either positive or negative signs, depending on the fruit and the source of origin, pointing to corresponding substitutability (for a positive sign) or a complementarity (for a negative sign).

3.1 Adjustments to the Empirical Model

To account for seasonality and trend present in the data, as well as for the potential issues related to serial correlation and endogeneity, specific adjustments were made to the SDAIDS model.

3.1.1 Seasonality and Trend

Seasonality, if present in data, needs to be captured. There are various methods to account for this problem. Two of the most commonly used methods are the use of dummy variables and the harmonic regression. The first method assumes introducing dummies with values of 1 and 0 for each season, where the value of the dummy variable is 1 for the given season and 0 otherwise. Having 10 fruit-source combinations for the first model and 7 fruit-source combinations for the second model, this approach is inappropriate because the imports of fruits from the selected sources have unstable seasonal patterns. Thus, accounting for all the months would mean creating additional 11 variables and losing degrees of freedoms (Arnade, Pick, and Gehlhar, 2005). The method of harmonic regression presumes creating two additional trigonometric variables, sine and cosine, and including them in the model. The sine and cosine variables have the following general forms:

(15) $$sin_i = f(trend, SL) = \sin\left(2\pi \frac{t_i}{12}\right)$$

and

(16) $$cos_i = f(trend, SL) = \cos\left(2\pi \frac{t_i}{12}\right)$$

where:

- t_i is the corresponding trend variable taking up 1 for the first observation and n for the n^{th} observation;
- π is a mathematical constant approximately equal to 3.1416;
- SL is the seasonal length which is equal to 12 for the monthly data.

The estimation of the system of demand equations returns parameter estimates for the sine and cosine variable as well. The presence of statistical significance of those estimates indicates whether the original share equation exhibited statistically significant seasonality or not. In addition to the restrictions of the AIDS model given by the equations (9), (10), and (11), the sums of coefficients of trigonometric variables were also restricted to zero:

(17) $$\sum_i s_i = 0$$

(18) $$\sum_i c_i = 0$$

where *i* is the index of each fruit-source combination; c_i and s_i are the coefficients for the sine and cosine functions measuring their contribution to the model (Arnade, Pick, and Gehlhar, 2005).

Given that the share equations have fairly linear trends, the study accounts for the possible trend by introducing an additional trend variable for each of the budget share equations. The variable takes on the value 1 for the first observation and increases chronologically thereafter. The estimated coefficient of the trend variable was also restricted to sum to zero:

$$\sum_i z_i = 0 \qquad (19)$$

where *i* is the index of each fruit-source combination, and z_i is the coefficient of the trend variable for each of the share equations. As equations (15) and (16) show, the trend variable is also used for the construction of sine and cosine functions.

3.1.2 Endogeneity

Endogeneity of the expenditure is an issue that is encountered in a system of demand equations (Attfield, 1985). In this study, the total expenditure is defined as the sum of expenditures on all selected fruit-source combinations, whereas the expenditure share, w_i, is defined as the ratio of the i^{th} expenditure share to the total expenditure, leading to the endogeneity of the total expenditure. To address this issue, the log of total expenditure was modeled as a function of the real GDP and the real prices used to calculate the total expenditure. That is,

$$\log(X) = a_0 + \sum_i v_i \log(p_i) + glog(GDP) + \varepsilon_i \qquad (20)$$

where:

- *log(X)*is the logarithm of total expenditure,
- p_i is the price of i^{th} fruit-source combination,
- GDP is the real monthly GDP,
- a_0, g, and v_i, are the parameters to be estimated, and
- ε_i is the error term.

3.1.3 Serial Correlation

Because the demand system equations are estimated using time-series data, the issue of serial correlation must be addressed. Following Berndt and Savin (1975), a first-order autoregressive procedure [AR(1)] was used to address this problem (Berndt and Savin, 1975). One common coefficient, ρ, was obtained for each system of equations. For consistency, the estimation of the total expenditure was done with addressing the serial correlation issue.

Chapter 4

DATA

This study uses data on monthly imports in U.S. dollars and quantities (in metric tons) for 11 years from January 2005 to December 2016 for a total of 132 observations, reported by the U.S. International Trade Commission. Prices were adjusted for inflation, using the consumer price index reported by the U.S. Department of Labor (2016). The study also uses the U.S. Gross Domestic Product data reported by the U.S. Department of Commerce (2016) to address the problem of endogeneity. All data used are publicly available.

4.1 Analysis by Preferential Trade Agreements

The first system of demand equations analyzes the monthly imports of:

1. Mangoes and guavas imported from NAFTA (100% imported from Mexico), MERCOSUR (56% imported from Peru and 44% from Brazil), and ROW;
2. Bananas imported from CAFTA-DR (50% imported from Guatemala and 31% from Costa Rica) and ROW (56% imported from Ecuador);
3. Avocadoes imported from NAFTA (100% imported from Mexico) and ROW (60% imported from Chile);
4. Papayas imported from CAFTA-DR (82% imported from Guatemala), NAFTA (100% imported from Mexico), and ROW (64% imported from Belize).

Table 2 exhibits the average real import values, average quantities, and weighted average real prices for the selected fresh fruits.

Table 2. Average Real Prices, Average Monthly Import Quantities and Average Import Values, for the Selected Fresh Fruits, 2005-2015

Category-Source	Average Price $/kg	Average Quantity (1000 kg)	Average Import value ($1000)
Bananas – CAFTA-DR	0.40	221,400	88,560
Avocadoes – NAFTA	2.11	29,797	62,872
Bananas – ROW	0.42	123,740	51,971
Mangoes and guavas – NAFTA	0.82	18,102	14,844
Avocadoes – ROW	1.32	7,958	10,505
Papayas – NAFTA	0.65	8,950	5,818
Mangoes and guavas – MERCOSUR	1.11	4,899	5,438
Mangoes and guavas – ROW	1.01	5,311	5,364
Papayas – ROW	0.66	2,417	1,595
Papayas – CAFTA-DR	0.59	777	458

Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

During the studied period, the average real value of imports was the highest for bananas imported from CAFTA-DR ($88.6 million), followed by avocadoes imported from NAFTA ($62.9 million) and bananas imported from ROW ($52.0 million). In terms of physical weight, bananas imported from CAFTA-DR had the maximum value (221.4 thousand tons), followed by bananas imported from ROW (123.7 thousand tons), and avocadoes imported from NAFTA (29.8 thousand tons). Because of their high price, avocadoes imported from NAFTA rank third in terms of volume but second in terms of the real dollars. The monthly weighted average real prices, quantities and their standard deviations are presented in Table B. 1 of Appendix B.

Figure 4 shows the average real expenditure shares of the selected fruit-source combinations during the period from 2005 to 2015. According to Figure 4, on average, bananas imported from CAFTA-DR maintained 36% share of the total import value of the selected fruit-source combinations, which is approximately $90 million per month. Avocadoes imported from

NAFTA and bananas from ROW had 23% (approximately $61 million) and 22% (approximately $52 million) shares respectively.

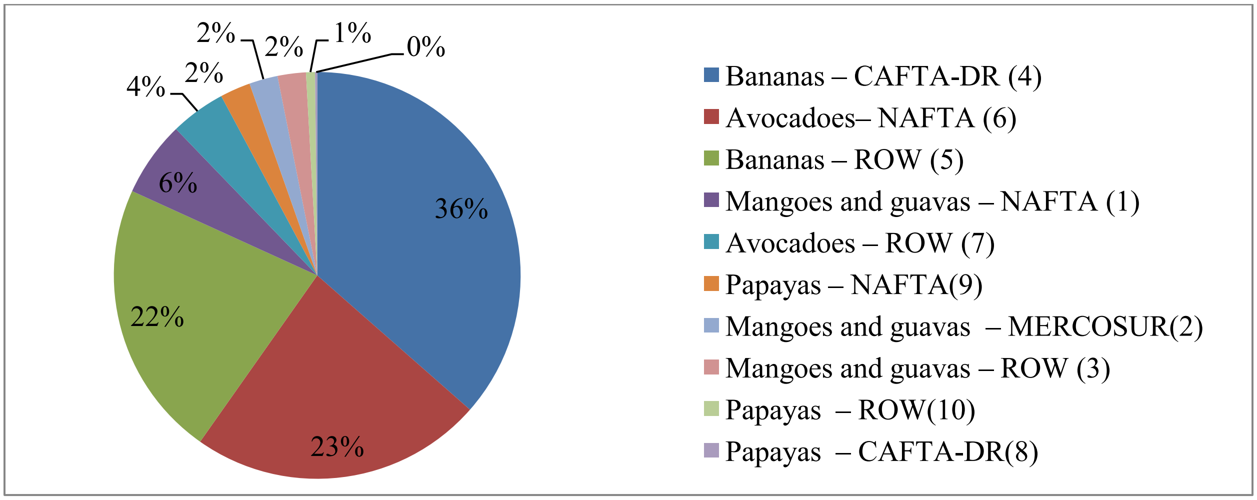

Figure 4. Average Real Expenditure Shares of the Selected Fruits and Sources, 2005-2015.
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

As noted, the imports of fresh fruits normally exhibit seasonal patterns, which are mostly due to diversity in climate conditions of the import sources. In addition, most of the selected fresh fruits imports exhibit increasing or decreasing trends. Figure 5 depicts the imports of mangoes and guavas from NAFTA, MERCOSUR, and ROW. As Figure 5 reveals, on average, mangoes and guavas imported from NAFTA reach their minimum when the imports from MERCOSUR and ROW are at their highest. For some months, those minimums are zero, which means that in these months no mangoes and guavas are imported from the corresponding source. With U.S. being the closest to the other two NAFTA countries, growing seasons in NAFTA countries tend to be more similar relative to the MERCOSUR countries (such as Brazil and Peru) and countries from ROW, which explains the seasonality observed in Figure 5. Therefore, NAFTA and the other sources usually substitute each other in the U.S. market.

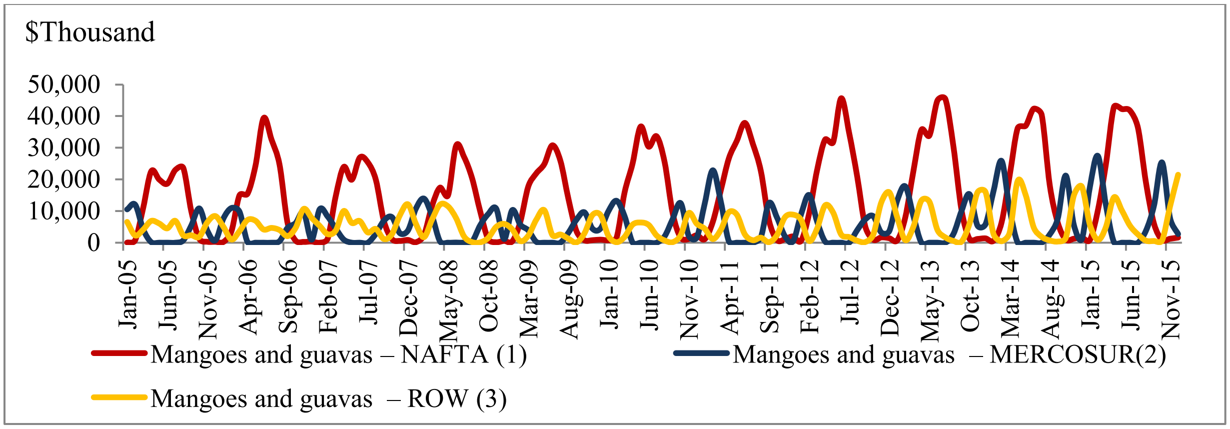

Figure 5. Monthly Real Imports of Mangoes and Guavas from NAFTA, MERCOSUR, and ROW, 2010-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

Seasonal patterns are different in case of imports of fresh bananas (Figure 6), where increasing trends are more visible. For some periods, seasonal substitution of the sources of origin can be observed; there are also some periods when the fresh fruits from these sources enter the U.S. market together. The seasonal trends between bananas from CAFTA-DR and bananas from ROW may be similar because climate conditions in Guatemala, Costa Rica, and Honduras (CAFTA-DR) for growing bananas are similar to those in Ecuador, which accounts for 56% of bananas imported from ROW.

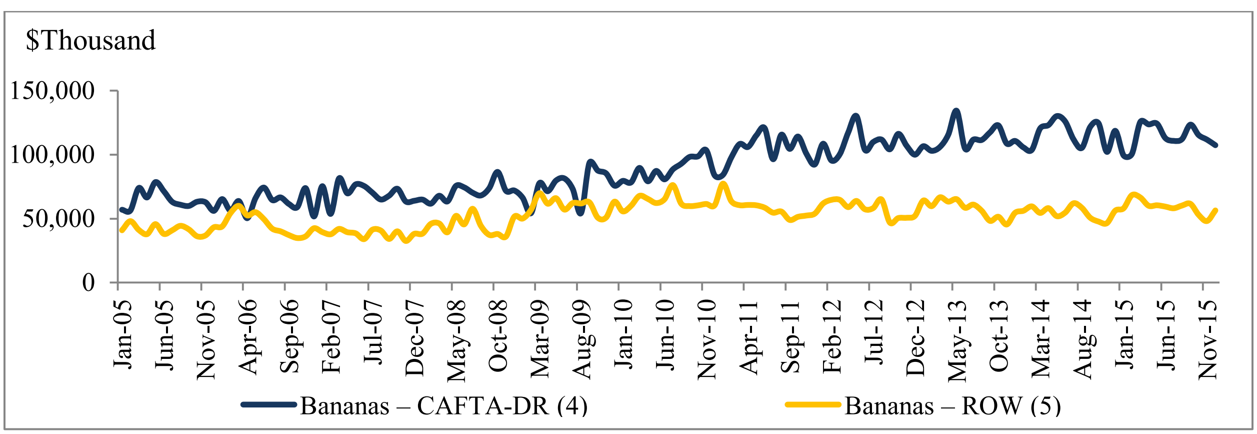

Figure 6. Monthly Real Imports of Bananas from CAFTA-DR and ROW, 2010-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

The U.S. imports of avocadoes have been increasing during the period of 2005-2015. Since 1914, the U.S. Government had a ban placed on the imports of avocadoes to avoid agricultural diseases and pests. The restrictions were completely removed in 2007, which led to the U.S. becoming the world's largest avocado importer (U.S. Agency for International Development, 2014). The main source of avocadoes for the U.S. is Mexico, with average monthly imports of $61 million. The increasing trend of avocado imports from NAFTA and ROW, and the seasonal import patterns can be observed in Figure 7. The imports from NAFTA are substantially higher than the imports from ROW (60% of which is imported from Chile and 27% from Peru). In periods of August-October, the imports from Mexico reach their minimum, and the imports from ROW reach their maximum. Consistent with the observations made before, the climate conditions of the source countries play a significant role in the import patterns of avocadoes.

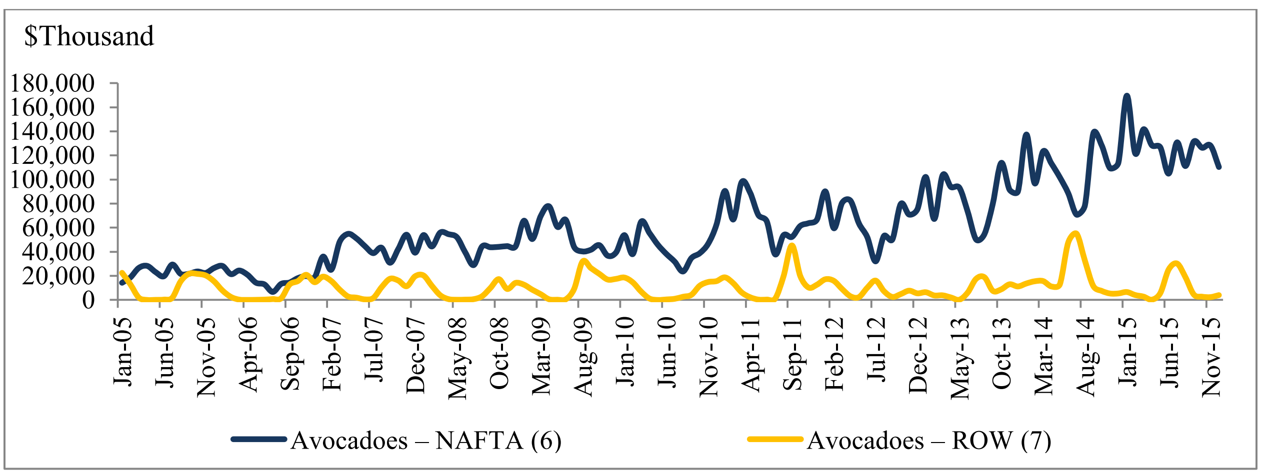

Figure 7. Monthly Real Imports of Avocadoes from NAFTA and ROW, 2010-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

Figure 8 depicts the imports of papayas from CAFTA-DR, NAFTA, and ROW. Interestingly, the imports of papayas from ROW, which are mostly imported from Belize and

Brazil, display a slight decreasing pattern, while the imports from CAFTA-DR display an increasing pattern, and imports from NAFTA exhibit a fairly constant pattern. This is due mainly to the increased imports of papayas from Guatemala and almost a twofold reduction of imports from Belize. In addition, seasonality can be observed in the imports of fresh papayas.

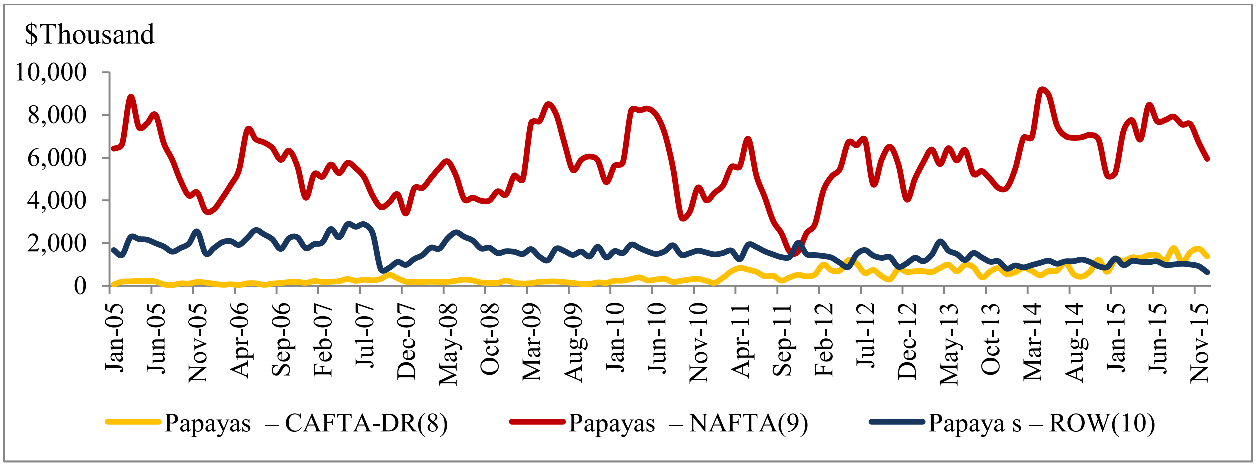

Figure 8. Monthly Real Imports of Papayas from CAFTA- DR and ROW, 2010-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

4.2 Analysis by NAFTA Countries

The second system of demand equations estimates the monthly imports of:

1. Berries imported from Canada, Mexico and ROW (75% imported from Chile),
2. Apples from Canada and ROW (64% imported from Chile),
3. Avocadoes from Mexico and ROW (60% imported from Chile).

Table 3 exhibits the average real import values, average quantities, and weighted average real prices for the selected fresh fruits and sources of origin.

Table 3. Average Real Prices, Average Monthly Import Quantities, and Average Import Values for the Selected Fresh Fruits, 2005-2015

Category-source (Combination number)	Average Price $/kg	Average Quantity (1000 kg)	Average Import value ($1000)
Avocadoes - Mexico (6)	2.1	29,796.8	62,983
Berries - Mexico (1)	3.3	14,171.4	46,534
Berries - ROW (3)	5.3	4,299.9	22,844
Apples - ROW (5)	1.1	12,012.6	12,675
Berries - Canada (2)	2.0	5,978.8	12,043
Avocadoes - ROW (7)	1.3	7,957.6	10,538
Apples - Canada (4)	1.0	2,303.2	2,322

Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade database, 2016.

According to Table 3, during the studied period, the average real imports were the highest for avocadoes imported from Mexico, followed by berries imported from Mexico and berries imported from ROW. In terms of physical weight, avocadoes imported from Mexico were first, followed by berries imported from Mexico and apples imported from ROW (62% imported from Chile and 32% from New Zealand). Due to their relatively higher price, berries from ROW are third in terms of the real import value but sixth in terms of physical weight. Detailed monthly weighted average real prices, quantities, and their standard deviations are presented in Table B. 2 of Appendix B.

Figure 9 shows the average shares of the selected fruit-source combinations in the average real expenditure during the period from 2005 to 2015. As Figure 9 reveals, on average, imports of avocadoes from Mexico maintained 36% share of total import value, which is approximately $61 million. Berries imported from Mexico and ROW (75% imported from Chile) had 24% (approximately $49 million) and 11% (approximately $22 million) shares, respectively.

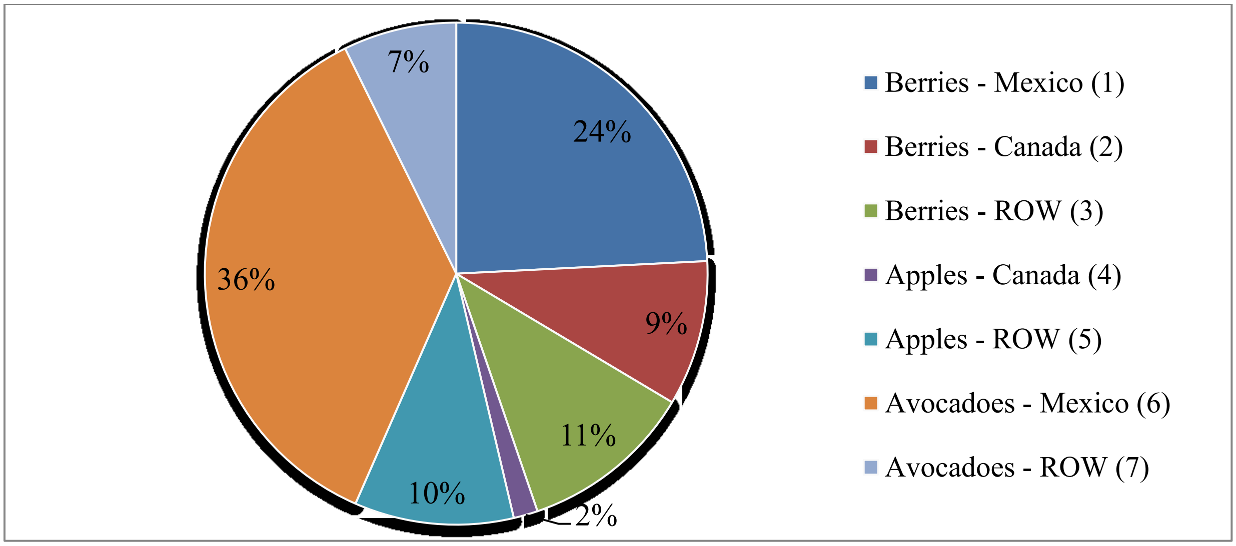

Figure 9. Average Real Expenditure Shares of the Selected Fruits and Sources, 2010-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

Imports of fresh fruits from Canada, Mexico, and ROW also exhibit seasonal patterns, which are mostly due to the climate conditions of the import sources. Imports of most of the selected fresh fruits exhibit linear trends.

Figure 10 exhibits the monthly imports of berries from Mexico, Canada, and ROW. The seasonality of imports of berries from ROW (75% imported from Chile and 20% from Argentina) is similar to that of berries imported from Mexico, despite the different climate conditions in these countries. This can be a result of these countries providing the U.S. with different berry types that are all included in the category labeled "Berries". For instance, Chile provides mainly strawberries, while Mexico and Canada are the major suppliers of raspberries. That is why the weighted average price of berries imported from ROW can be higher than that of berries imported from Mexico and Canada. In addition, when the imports from both Mexico and ROW reach their minimum in September, the imports from Canada reach their maximum. This kind of import patterns, combined with the domestic production, ensure the year-round supply of berries in the U.S. market.

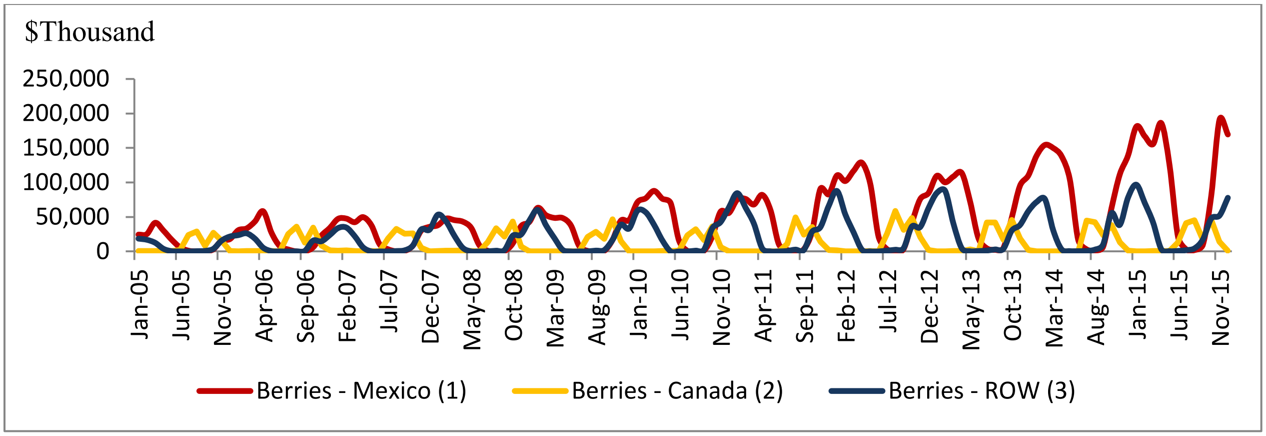

Figure 10 Monthly Real Imports of Berries from Mexico, Canada and ROW, 2010-2015
Note: data are real and include products as reflected in the U.S. Harmonized Tariff Schedule.
Source: U.S. International Trade Commission's Trade Database, 2016.

Figure 11 shows the imports of apples from Canada and ROW. Although the import proportions from these sources are significantly different, the seasonality of imports allows them to have their niches in the U.S. market.

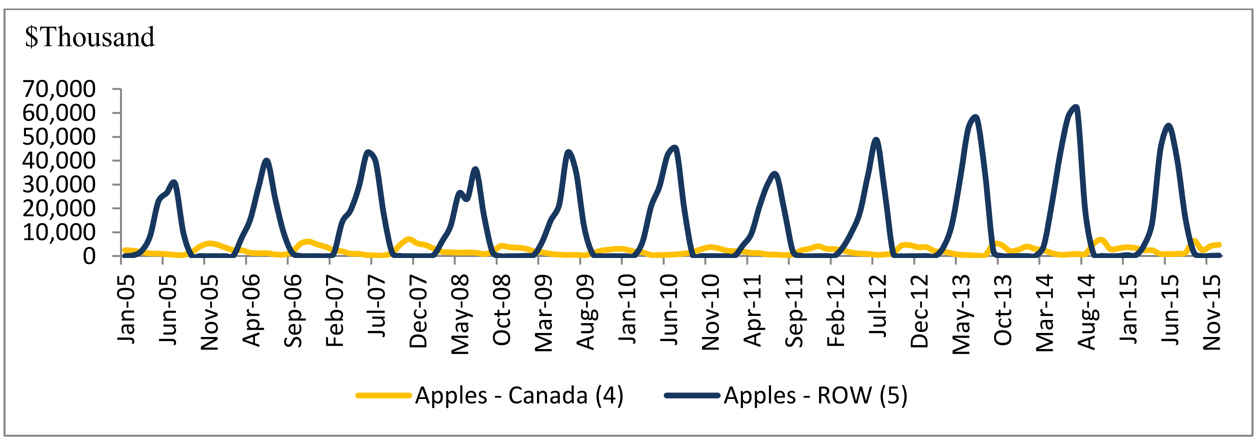

Figure 11 Monthly Real Imports of Apples Imported from Canada and ROW, 2010-2015
Source: U.S. International Trade Commission's Trade Database.
Note: data are real and include products as reflected in U.S. Harmonized Tariff Schedule.

During the period from October to January, the imports of apples from ROW approach zero, while the imports of apples from Canada reach their maximum. Similarly, the imports from Canada approach zero in June-September, when the imports from ROW reach their maximum.

This kind of import pattern can be explained by the geographical location of the source countries—Canada is far to the north compared to Chile and New Zealand—which are the main countries included in the ROW. In addition, due to the climate conditions in these countries, it is likely that the varieties of the apples imported are different, because of which the weighted average prices are different as well.

Chapter 5

ESTIMATION PROCEDURE AND RESULTS

Two systems of demand equations were developed independently following the model discussed in Chapter 3. The first system of demand equations included ten expenditure share equations, and the second system included seven of them. The estimation procedure and results of these systems of demand equations are discussed in the next two sub-sections.

5.1 Demand System by Preferential Trade Agreements

A Source Differentiated Almost Ideal Demand System was estimated for mangoes and guavas imported from NAFTA (i = 1), MERCOSUR (i = 2), and ROW (i = 3), for bananas imported from CAFTA-DR (i = 4) and ROW (i = 5), for avocadoes imported from NAFTA (i = 6) and ROW (i = 7), and for papayas imported from CAFTA-DR (i = 8), NAFTA (i = 9), and ROW (i = 10). The iterated seemingly unrelated regression procedure (ITSUR) was used to estimate the share equations. The analysis was conducted using Statistical Analysis System (SAS) software version 9.3. The expenditure share equations had the following form.

$$(21)\quad w_{i_t} = \alpha_i + \sum_j \gamma_{ij}\log\left(p_{j_t}\right) + \beta_i \log\left(\frac{X}{P}\right)_t + s_i \sin_t + c_i \cos_t + z_i \mathrm{trend}_t + \rho\Big(w_{i_{t-1}} - \Big(\alpha_i + \sum_j \gamma_{ij}\log\left(p_{i_{t-1}}\right) + \beta_i \log\left(\frac{X}{P}\right)_{t-1} + s_i \sin_{t-1} + c_i \cos_{t-1} + z_i \mathrm{trend}_{t-1}\Big)\Big) + \varepsilon_i$$

where, at time period t:

- i and j represent fruit-source combination indices;
- w_i is the import expenditure share for each fruit-source combination;
- p_j is the import price of j^{th} fruit-source combination;

- X is the expenditure on all goods included in the model;
- *trend* represents the linear trend variable;
- α_i, γ_{ij}, β_i, c_i s_i and z_i are the parameters;
- P is the non-linear price index, given by equation (8);
- $Sin_i=f(t_i,SL)$ *and* $cos_i=g(t_i,SL)$ are trigonometric functions capturing seasonality;
- ρ is the first-order autoregressive coefficient;
- ε_i is the error term.

The last equation (w_{10}, papayas imported from ROW) was omitted to avoid the singularity of the variance-covariance matrix of error terms, which occurs due to the budget shares adding up to one. The parameter estimates of the last equation were recovered utilizing the adding up, homogeneity, and symmetry restrictions given by (9), (10), (11), (17), (18), and (19). The coefficient of determination (R^2) for the omitted equation was recovered by squaring the coefficient of correlation between the predicted and actual expenditure shares:

$$R^2 = r^2 = \left(\frac{n(\sum xy) - (\sum x)(\sum x)}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}}\right)^2 \tag{22}$$

where x is the actual w_{10} share and y is the predicted w_{10} share; r is the coefficient of correlation, and R is the coefficient of determination.

The Durbin-Watson statistic was estimated by calculating the ratio of the sum of the squared differences of the residuals ($\hat{e}_t$) and their first lags to the sum of the squared residuals (Durbin and Watson, 1951):

$$d = \frac{\sum(\hat{e}_t - \hat{e}_{t-1})^2}{\sum \hat{e}_t{}^2} \tag{23}$$

The uncompensated elasticities of demand were calculated using the equations (12) and (13); the compensated elasticities of demand were calculated using the equation (14).

Table 4 reports the coefficients of determinations, Durbin-Watson statistics associated with the estimated share equations, and the first-order autoregressive coefficient.

Table 4. R^2's, Durbin-Watson Statistics, and First-Order Autoregressive Coefficient (ρ)

i	R^2	DW
1	0.85	1.82
2	0.39	2.04
3	0.32	1.72
4	0.49	1.92
5	0.78	2.26
6	0.79	1.98
7	0.58	1.35
8	0.67	2.16
9	0.86	1.60
10	0.82	2.05

Parameter	Estimate	p-value
ρ	0.514	0.000

Note: *i* = 1, 2, …, 10; where 1 = mangoes and guavas from NAFTA countries, 2 = mangoes and guavas from MERCOSUR countries or associates, 3 = mangoes and guavas from the rest of the world, 4 = bananas from CAFTA-DR, 5 = bananas from the rest of the world, 6 = avocadoes from NAFTA, 7 = avocadoes from the rest of the world, 8 = papayas from CAFTA-DR, 9 = papayas from NAFTA, and 10 = papayas from the rest of the world.

The statistical significance of the ρ coefficient along with the Durbin-Watson statistics being close to two indicated that the problem of serial correlation was successfully addressed in the model. The highest coefficient of determination was 86%, while the lowest was 32%, suggesting an overall reasonable fit for the system equations.

5.1.1 Demand Elasticities

The uncompensated own-price elasticities and compensated cross-price elasticities of demand calculated at the sample means are reported in Table 5.

Table 5. Uncompensated Own-Price and Compensated Cross-Price Elasticities of Demand

i	1	2	3	4	5
1	**-0.945****	-0.134*	0.168**	0.393**	0.126
2	-0.354*	**-1.088****	0.113	0.342	-0.047
3	0.447**	0.114	**-1.147****	0.699**	0.199
4	0.064**	0.021	0.043**	**-0.677****	0.008
5	0.034	-0.005	0.020	0.013	**-0.155**
6	0.029	0.118**	-0.082**	-0.009	0.014
7	0.113	-0.142	0.223*	0.697*	-0.100
8	0.060	-0.029	0.176*	-0.203	0.611
9	0.060	0.056	-0.013	0.433	-0.289
10	0.195**	0.113	0.189**	0.407	0.265
Continued:	6	7	8	9	10
1	0.111	0.083	0.002	0.024	0.023**
2	1.214**	-0.276	-0.002	0.059	0.035
3	-0.846**	0.435*	0.013*	-0.014	0.060**
4	-0.006	0.084*	-0.001	0.029	0.008
5	0.015	-0.020	0.005	-0.032	0.009
6	**-0.223**	0.012	-0.005	-0.009	-0.001
7	0.064	**-0.958****	-0.002	-0.014	0.028
8	-0.630	-0.062	**-0.241**	0.290	0.024
9	-0.084	-0.025	0.021	**-0.246***	0.083
10	-0.041	0.170	0.006	0.281	**-1.598****

* Significant at p=0.05; ** significant at p=0.01.
Note: *i* = 1, 2, …, 10; where 1 = mangoes and guavas from NAFTA countries, 2 = mangoes and guavas from MERCOSUR countries or associates, 3 = mangoes and guavas from the rest of the world, 4 = bananas from CAFTA-DR, 5 = bananas from the rest of the world, 6 = avocadoes from NAFTA, 7 = avocadoes from the rest of the world, 8 = papayas from CAFTA-DR, 9 = papayas from NAFTA, and 10 = papayas from the rest of the world.

5.1.1.1 Own-Price Elasticities

All uncompensated own-price elasticities (Table 5) had the expected negative sign, which is consistent with the law of demand. Particularly, if the corresponding own-prices increase by

1%, all other factors held fixed, the quantity demanded is expected to decrease, on average, by 0.95% for mangoes and guavas imported from NAFTA, by 1.09% for mangoes and guavas imported from MERCOSUR, by 1.15 % for mangoes and guavas imported from ROW, by 0.68% for bananas imported from CAFTA-DR, by 0.96% for avocadoes imported from ROW, by 0.25% for papayas imported from NAFTA, and by 1.60% for papayas imported from ROW. Demand was found to be price-elastic for mangoes and guavas imported from MERCOSUR and ROW, and for papayas imported from ROW. The obtained elasticity estimates range from -1.59 to -0.25. In general, most of the results of this study are consistent with those obtained by Nzaku, Houston, and Fonsah (2010), as well as by You, Epperson, and Huang (1996), Huang (1993), and Brown and Lee (2002). For example, the own-price elasticity of bananas ranged from -0.98 to -0.42 in previous studies, and the own-price elasticity of bananas imported from CAFTA-DR was found to be -0.67 in this study. However, the latter three studies are at retail level while this study is at country level. As the estimation results suggest, the retail-level demand of U.S. for fresh fruits tends to be more price-elastic than the import-level demand.

The obtained own-price elasticities can be useful in evaluating the impact of various market factors (such as import quotas, tariffs, and other import duties) on the U.S. imports of fresh fruits. For example, the own-price elasticity of mangoes and guavas imported from NAFTA was estimated to be 0.95 meaning that a 20% specific import tariff would reduce the quantity demanded of mangoes and guavas from NAFTA by 19%. This information, if combined with the estimation of the supply function of the domestic producers, can determine the optimal level of import tariff that maximizes the national wealth.

5.1.1.2 Cross-Price Elasticities

The compensated cross-price elasticities reveal the economic relationships between fresh-fruit categories differentiated by sources of origin. The negative (positive) cross-price elasticity implies that when the price of the given fruit from the given source increases by one percent, the quantity demanded of a different fruit category from the same or different source decreases (increases), which in its turn implies that the categories are complements (substitutes).

All other factors held constant, if the average price of mangoes and guavas imported from NAFTA increases by 1%, the quantity demanded is expected to increase by 0.17% for mangoes and guavas imported from ROW, by 0.39% for bananas imported from CAFTA-DR, and by 0.02% for papayas imported from ROW, while the quantity of mangoes and guavas demanded from MERCOSUR is expected to decrease by 0.13%. If the average price of mangoes and guavas imported from MERCOSUR increases by 1%, all other factors held fixed, the quantity demanded is expected to increase by 1.12% for avocadoes from NAFTA and decrease by 0.35% for mangoes and guavas from NAFTA. If the average price of mangoes and guavas imported from ROW increases by 1%, all other factors held fixed, the quantity demanded is expected to increase by 0.45% for mangoes and guavas imported from NAFTA, by 0.70% for bananas imported from CAFTA-DR, by 0.43% for avocadoes imported from ROW, by 0.01% for papayas imported from CAFTA-DR, and by 0.06% for papayas imported from ROW, while the quantity of avocadoes demanded from NAFTA is expected to decrease by 0.85%.

If the average price of bananas imported from CAFTA-DR increases by 1%, all other factors held constant, the quantity demanded is expected to increase by 0.06% for mangoes and guavas imported from NAFTA, by 0.04% for mangoes and guavas imported from ROW, and by 0.08% for avocadoes imported from ROW.

If the average price of avocadoes imported from NAFTA increases by 1%, all other factors held fixed, the quantity of mangoes and guavas demanded from ROW is expected to decrease by 0.82%, while the quantity of mangoes and guavas demanded from MERCOSUR is expected to increase by 0.12%. If the average price of avocadoes imported from ROW increases by 1%, all other factors held fixed, the quantity demanded is expected to increase by 0.22% for mangoes and guavas imported from ROW and by 0.70% for avocadoes imported from ROW.

If the average price of papayas imported from CAFTA-DR increases by 1%, all other factors held constant, the quantity of mangoes and guavas demanded from ROW is expected to increase by 0.18%. If the average price of papayas imported from ROW increases by 1%, all other factors held fixed, the quantity demanded is expected to increase by 0.19% for mangoes and guavas imported from NAFTA, and by 0.19% for mangoes and guavas imported from ROW.

The negative cross-price elasticities showed that there were statistically significant complementary relationships between mangoes and guavas imported from NAFTA and mangoes and guavas imported from MERCOSUR, and between avocadoes imported from NAFTA and mangoes and guavas imported from ROW. The positive cross-price elasticities showed that there was a statistically significant substitutability between mangoes and guavas imported from NAFTA and mangoes and guavas imported from ROW, and bananas imported from CAFTA-DR and papayas imported from ROW. Substitutability was also revealed between mangoes and guavas imported from ROW and bananas imported from CAFTA-DR, avocadoes imported from ROW, papayas imported from CAFTA-DR, and papayas imported from ROW, between avocadoes imported from NAFTA and mangoes and guavas imported from MERCOSUR, and between mangoes and guavas imported from ROW and papayas imported from ROW.

5.1.1.3 Expenditure Elasticities

The expenditure elasticities of demand calculated at the sample means are reported in Table 6.

Table 6. Expenditure Elasticities of Demand

i	Expenditure Elasticity	Standard Error
1	2.482**	0.214
2	0.079	0.641
3	1.767**	0.534
4	1.168**	0.075
5	0.523**	0.099
6	0.663**	0.130
7	2.075**	0.547
8	2.449**	0.350
9	0.221	0.139
10	1.915**	0.195

*Significant at p=0.05; ** significant at p=0.01.
Note: *i* = 1, 2, …, 10; where 1 = mangoes and guavas from NAFTA countries, 2 = mangoes and guavas from MERCOSUR countries or associates, 3 = mangoes and guavas from the rest of the world, 4 = bananas from CAFTA-DR, 5 = bananas from the rest of the world, 6 = avocadoes from NAFTA, 7 = avocadoes from the rest of the world, 8 = papayas from CAFTA-DR, 9 = papayas from NAFTA, and 10 = papayas from the rest of the world.

The expenditure elasticities indicate the relationships between the overall change in expenditure on the selected group of fruit categories and the quantities of those categories demanded. All the estimated statistically significant expenditure elasticities had the expected positive sign, implying that, all other factors held constant, the quantity demanded of all fruit types is expected to increase when the total expenditure increases. Particularly, as the total expenditure increases by 1%, on average, the quantity demanded is expected to increase by 2.48% for mangoes and guavas imported from NAFTA, by 1.77% for mangoes and guavas imported from ROW, by 1.17% for bananas imported from CAFTA-DR, by 0.52% for bananas imported from ROW, by 0.66% for avocadoes imported from NAFTA, by 2.07% for avocadoes imported from ROW, by 2.45% for papayas imported from CAFTA-DR, and by 1.92% for papayas imported from ROW. Interestingly, the estimated expenditure elasticities revealed that, on average, the selected fresh-fruit categories were responsive to the changes in total expenditure. The estimated expenditure elasticities suggested that mangoes and guavas imported from NAFTA and ROW, bananas imported from CAFTA-DR, avocadoes imported from ROW, papayas imported from CAFTA-DR, and papayas imported from ROW were considered as luxury goods, and the U.S. demand for these fruits was rather sensitive to the changes in total expenditure.

5.2 Demand System for Mexico, Canada and ROW

A Source Differentiated Almost Ideal Demand System was estimated for berries imported from Mexico (i = 1), Canada (i = 2), and ROW (i = 3), apples imported from Canada (i = 4) and ROW (i = 5), and avocadoes imported from Mexico (i = 6) and ROW (i = 7). The iterated seemingly unrelated regression procedure (ITSUR) was used to estimate the share equations. The analysis was conducted using Statistical Analysis System (SAS) software version 9.3. The share-equations had the form shown in equation (21). The last equation (w_7, avocadoes imported from ROW) was omitted to avoid the singularity of the variance-covariance matrix of error terms. The parameter estimates of the last equation were recovered using the adding up, homogeneity, and symmetry restrictions given by the equations (9), (10), (11), (17), (18), and (19). The coefficient of determination (R^2) for the omitted equation was recovered using the equation (22). The Durbin-Watson statistic for the omitted equation was calculated as a ratio of the sum of squared differences of the residuals and their first lag to the sum of squared residuals. The uncompensated elasticities of demand were calculated using the equations (12) and (13); the compensated elasticities of demand were calculated using the Slutsky equation given by equation

(14). Table 7 reports the coefficients of determinations, the Durbin-Watson statistics, and the first-order autoregressive coefficient (ρ) associated with the estimated share equations.

Table 7. R^2's, Durbin-Watson Statistics, and First-Order Autoregressive Coefficient (ρ)

i	R^2	DW
1	0.84	1.92
2	0.65	2.07
3	0.89	2.26
4	0.72	1.62
5	0.84	1.62
6	0.57	1.97
7	0.59	1.51
Parameter	Estimate	p-value
ρ	0.490	0.0000

Note: *i* = 1, 2, …, 7; where 1 = berries from Mexico, 2 = berries from Canada, 3 = berries from the rest of the world, 4 = apples from Canada, 5 = apples from the rest of the world, 6 = avocadoes from Mexico, 7 = avocadoes from the rest of the world.

The statistical significance of the ρ along with the Durbin-Watson statistics being close to two indicated that the problem of serial correlation was successfully addressed in the model. The highest coefficient of determination was 89%, while the lowest was 57%. Overall, the estimation results indicate that the demand system provides a good fit.

5.2.1 Demand Elasticities

The uncompensated own-price elasticities and the compensated cross-price elasticities of demand calculated at the sample means are reported in Table 8.

Table 8. Uncompensated Own-Price and Compensated Cross-Price Elasticities of Demand

i	1	2	3	4	5	6	7
1	**-0.558****	0.109	0.091	0.002	-0.136*	-0.083	0.150*
2	0.282	**-0.939****	0.258**	-0.015	0.316**	-0.228	0.233
3	0.197	0.216**	**-0.907****	0.042**	0.263**	0.131	-0.072
4	0.023	-0.090	0.305**	**-0.935****	-0.017	0.802*	-0.099
5	-0.322*	0.289**	0.288**	-0.003	**-0.979****	0.374	0.154
6	-0.056	-0.059	0.041	0.035*	0.106	**-0.130**	-0.044
7	0.499*	0.300	-0.111	-0.021	0.216	-0.220	**-0.699***

* Significant at p=0.05; ** significant at p=0.01.
Note: *i* = 1, 2, …, 7; where 1 = berries from Mexico, 2 = berries from Canada, 3 = berries from the rest of the world, 4 = apples from Canada, 5 = apples from the rest of the world, 6 = avocadoes from Mexico, 7 = avocadoes from the rest of the world; * indicates statistical significance at the 5%.

5.2.1.1 Own-Price Elasticities

All uncompensated own-price elasticities had the expected negative sign, which is consistent with the law of demand. In particular, this study suggests that if the corresponding own-prices increases by 1%, all other factors held fixed, the quantity demanded is expected to decrease on average by 0.56% for berries imported from Mexico, by 0.94% for berries imported from Canada, by 0.91% for berries imported from ROW, by 0.94% for apples imported from Canada, by 0.98% for apples imported from ROW, and by 0.70% for avocadoes imported from ROW. The obtained elasticity estimates range from -0.98 to -0.56. The estimation results are consistent with those of the first system of demand equations. In the second system of demand equations, all the fresh fruits were price-inelastic, and, in the first system, three out of seven statistically significant estimates were price-inelastic. The implication of the estimated own-price elasticities is similar to that described in sub-section 5.1.1.1. In particular, the elasticities of demand estimated foe Mexico and Canada could be used to evaluate the impact of various market factors affecting the fresh-fruit trade among NAFTA countries.

5.2.1.2 Cross-Price Elasticities

The compensated cross-price elasticities reveal the economic relationships between fresh-fruit categories differentiated by sources of origin. The negative (positive) cross-price elasticity implies that when the price of a given fruit from a given source increases by one percent, the quantity demanded of a different fruit category from the same or different source decreases (increases), which in its turn implies that the categories are complements (substitutes).

All other factors held constant, if the average price of berries imported from Mexico increases by 1%, the quantities demanded are expected to increase by 0.15% for avocadoes imported from ROW and decrease by 0.14% for apples imported from ROW. If the average price of berries imported from Canada increases by 1%, all other factors held constant, the quantity demanded is expected to increase by 0.26% for berries imported from ROW and by 0.32% for apples imported from ROW. If the average price of berries imported from ROW increases by 1%, all other factors held constant, the quantity demanded is expected to increase by 0.22% for berries imported from Canada, 0.04% for apples imported from Canada, and 0.26% for apples imported from ROW.

All other factors held constant, if the average price of apples imported from Canada increases by 1%, the quantity demanded is expected to increase by 0.31% for berries imported from ROW and by 0.80% for avocadoes imported from Mexico. If the average price of apples imported from ROW increases by 1%, all other factors held constant, the quantity demanded is expected to increase by 0.29% for berries imported from Canada and by 0.29% for berries imported from ROW, while the quantity of berries demanded from Mexico is expected to decrease by 0.32%.

If the average price of avocadoes imported from Mexico increases by 1%, the quantity of apples demanded from Canada is expected to increase by 0.04%, and if the price of avocadoes imported from ROW increases by 1%, the quantity of berries demanded from Mexico is expected to increase by 0.50%.

The estimated cross-price elasticities indicated that there was statistically significant substitutability between berries imported from Mexico and avocadoes imported from ROW, berries imported from Canada and berries imported from ROW, berries imported from Canada and apples imported from ROW, berries imported from ROW and apples imported from Canada, berries imported from ROW and apples imported from ROW, and apples imported from Canada and avocadoes imported from Mexico. The only statistically significant complementary relationship was revealed between berries imported from Mexico and apples imported from ROW.

5.2.1.3 Expenditure Elasticities

The expenditure elasticities of demand calculated at the sample means are reported in Table 9 below.

Table 9. Expenditure Elasticities of Demand

i	Expenditure Elasticity	Standard Error
1	1.760**	0.0883
2	0.988**	0.2464
3	1.159**	0.1305
4	0.554*	0.2198
5	1.942**	0.1793
6	0.299**	0.0873
7	0.496	0.3284

* Significant at p=0.05; ** significant at p=0.01.
Note: *i* = 1, 2, …, 7; where 1 = berries from Mexico, 2 = berries from Canada, 3 = berries from the rest of the world, 4 = apples from Canada, 5 = apples from the rest of the world, 6 = avocadoes from Mexico, 7 = avocadoes from the rest of the world; * indicates statistical significance at the 5%.

The expenditure elasticities indicate the relationships between the overall change in expenditure on the selected group of fruit categories and the quantities of those categories demanded. All the estimated statistically significant expenditure elasticities had the expected positive sign, implying that all other factors held constant, the quantity demanded of all fruit categories is expected to increase when the total expenditure increases. Particularly, as the total expenditure increases by 1%, on average, the quantity demanded increases by 21.76% for berries imported from Mexico, 0.99% for berries imported from Canada, 1.16% for berries imported from ROW, 0.55% for apples imported from Canada, 1.94 % for apples imported from ROW, and 0.30% for avocadoes imported from Mexico. Berries imported from Mexico and ROW, and apples imported from ROW were found to be luxury goods. The obtained results suggested that U.S. demand for berries imported from Canada, apples imported from Canada, and avocadoes imported from Mexico is less responsive to the changes in the total expenditure.

Chapter 6

THE DIRECT AND INDIRECT IMPACT OF IMPOSING TARIFFS ON MEXICAN IMPORTS ON THE U.S. FRESH FRUIT TRADE

On the 26th of January, 2017, the U.S. White House spokesman Sean Spicer informed the U.S. public that President D. Trump is considering imposing up to 20% tariff on fruits and services imported from Mexico. The purpose of such a tariff was to finance the construction of President Trump's proposed wall along the U.S. border with Mexico (Flores, 2017). Having estimated the responses of different import sources to changes in prices of fresh fruits imported from Mexico, it is possible to evaluate the expected changes in the U.S. imports in the wake of this tariff. In this study, the impact of 20% tariff imposed on Mexico was calculated based solely on the estimated elasticities of demand and assuming that the tariff will not force Mexican producers to reduce their prices.

The direct impact of the tariff on the U.S. imports of mangoes and guavas, papayas, and berries imported from Mexico was obtained using the estimated own-price elasticities of demand. First, the corresponding own-price elasticities were multiplied by 20, and the products were further multiplied by to the monthly average quantities, thus the new average monthly quantities were obtained. Second, the average monthly prices were increased by 20% and the after-tariff prices were obtained. Third, the after-tariff quantities and prices were multiplied, yielding the after-tariff average monthly imports. Finally, the 20% of the total value of the new average monthly imports were calculated to estimate the generated tariff revenues for each of the fruits (Dharmasena and Capps, 2012).

Table 10. Direct Impacts of 20% Tariff on Imports from Mexico

	Mangoes and Guavas from Mexico	Papayas from Mexico	Berries from Mexico
Pre-Tariff Total Value of Average Monthly Imports (million $)	28.98	5.79	49.36
Pre-Tariff Total Quantity of Average Monthly Imports (1000 tons)	18.10	8.95	14.17
Pre-Tariff Average Price	1.60	0.65	3.48
Own-Price Elasticity	-0.95	-0.25	-0.56
Change in Total Quantity of Average Monthly Imports (%)	-19%	-5%	-11%
Change in Total Quantity of Average Monthly Imports (1000 tons)	-3.42	-0.44	-1.58
Post-Tariff Total Quantity of Average Monthly Imports (1000 tons)	14.68	8.51	12.59
Post-Tariff Average Price	1.92	0.78	4.18
Post-Tariff Total Value of Average Monthly Imports (million $)	28.20	6.61	52.62
Change in Total Value of Average Monthly imports (million $)	-0.78	0.82	3.26
Change in Total Value of Average Monthly imports (%)	-3%	14%	7%
Expected Tariff Revenue (million $)	5.64	1.32	10.52

As Table 10 suggests, because of 20% tariff, the average monthly imports from Mexico are expected to decline by 3,42 thousand tons for mangoes and guavas, by 0.44 thousand tons for papayas, and by 1.58 thousand tons for berries. Given the inelastic demand of the U.S. for these fruits, it is expected that 20% tariff on imports from Mexico will on average increase the value of total imports (measured in 2015 dollars) of these fruits, despite the reduction of the physical weight of these fresh fruits imported. Therefore, assuming that the imposed tariff does not affect the original producers' prices, the collected tariff revenues are expected to be $5.64 million for mangoes and guavas, $1.32 million for papayas, and $10.52 million for berries. The total direct impact, therefore, is expected to be an increase of the import expenditure by $3.3 million, which is the sum of the changes in average monthly imports. The average tariff revenue is expected to be $17.49 million, which is the sum of the individual tariff revenues for each of the fresh-fruits categories imported from Mexico.

The indirect impact of 20% tariff was estimated using the statistically significant cross-price elasticities of fresh fruits imported from Mexico along with the fruits imported from all other sources. First, the relevant cross-price elasticities were summed up to obtain the net impact of a one percent change in the prices of fruits imported from Mexico on the quantity of the corresponding fresh-fruit category demanded. Next, the obtained values were multiplied by 20, and the resulting products were further multiplied by the average monthly quantities of the fruits imported to the U.S to obtain the after-tariff quantities demanded. Finally, these quantities were multiplied by the average prices, and the after-tariff average monthly imports were calculated. Because the tariff does not affect the prices of these fruits directly, there will be no tariff revenue for them. Table 11 shows the expected indirect impact of 20% tariff imposed on imports from Mexico.

Table 11. Indirect Impact of 20% Tariff on the U.S. Fresh-Fruit Imports

	Mangoes and Guavas from MERCOSUR	Mangoes and Guavas from ROW	Bananas from CAFTA-DR	Papayas from ROW	Apples from Canada	Apples from ROW	Avocadoes from ROW
Pre-Tariff Total Value of Average Monthly Imports (million $)	5.53	8.00	89.58	1.62	2.36	13.84	11.26
Pre-Tariff Total Quantity of Average Monthly Imports (1000 tons)	4.90	5.31	221.40	2.42	2.30	12.01	7.96
Average Price	1.13	1.51	0.40	0.67	1.02	1.15	1.41
Coefficient of Net Cross-Price Effect	-0.02	0.09	0.39	0.02	0.04	-0.14	0.15
Change in Total Quantity of Average Monthly Imports (1000 tons)	-0.02	0.09	17.40	0.01	0.02	-0.33	0.24
Change in Total Quantity of Average Monthly Imports (%)	-0.3%	1.7%	7.9%	0.5%	0.7%	-2.7%	3.0%
Post-Tariff Total Quantity of Average Monthly Imports (1000 tons)	4.88	5.40	238.80	2.43	2.32	11.69	8.20
Post-Tariff Total Value of Average Monthly Imports (million $)	5.51	8.14	96.62	1.62	2.37	13.46	11.60
Change in Total Value of Average Monthly imports (million $)	-0.02	0.14	7.04	0.01	0.02	-0.38	0.34
Change in Total Value of Average Monthly imports (%)	-0.3%	1.7%	7.9%	0.5%	0.7%	-2.7%	3.0%

As Table 11 suggests, in case if the U.S. Government imposes 20% tariff on imports from Mexico, the average monthly imports are expected to decrease by 0.02 thousand tons for mangoes and guavas imported from MERCOSUR (44% is imported from Brazil and 56% from Peru), and by 0.33 thousand tons for apples imported from ROW (64% imported from Chile and 32% from New Zealand). On the other hand, the average monthly imports are expected to increase by 0.09 thousand tons for mangoes and guavas imported from ROW (44% imported from Ecuador and 17% from Guatemala), by 17 thousand tons for bananas imported from CAFTA-DR (50% imported from Guatemala, 31% from Costa Rica), by 0.01 thousand tons for papayas imported from ROW (64% imported from Belize), by 0.02 thousand tons for apples imported from Canada, and by 0.24 thousand tons for avocadoes imported from ROW (60% imported from Chile). Because of these changes in import quantities, the total value of average monthly imports are expected to decrease by $0.02 million for mangoes and guavas imported from MERCOSUR, and by $0.38 million for apples imported from ROW. On the other hand, the average monthly imports are expected to increase by $0.14 million for mangoes and guavas imported from ROW, by $7.04 million for bananas imported from CAFTA-DR, by $0.01 million for papayas imported from ROW, by $0.02 million for apples imported from Canada, and by $0.34 million for avocadoes imported from ROW.

The total indirect impact of 20% tariff on Mexican goods and services on the U.S. imports of fresh fruits was obtained by summing up the individual changes in total value of average monthly imports of the selected sources and was estimated to be $7.15 million.

Combining the estimated direct and indirect impacts, the total impact of 20% tariff on imports from Mexico was calculated, suggesting that the U.S. monthly expenditure on fresh-fruit imports is expected to increase, on average, by $10.45 million, and the tariff revenue is expected to be, on average, $17.49 million.

Chapter 7

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

The U.S. is one of the major importers of fresh fruits with constantly increasing imports and 50% average share of imports in domestic consumption in 2014-2015 (USDA-ERS 2016). The main trading partners of the U.S. are the member countries of the NAFTA, MERCOSUR and its associate countries, CAFTA-DR countries, as well as some countries with bilateral free trade agreements (FTA) with the U.S. However, to the best of our knowledge, the U.S. demand for individual fresh fruits at source level has not been studied in the previous research. In This study, two Source-Differentiated Almost Ideal Demand Systems were estimated using time-series data, with NAFTA, CAFTA-DR, MERCOSUR, and ROW as import sources for the first model, and Mexico, Canada and ROW as import sources for the second model. One hundred and thirty-two monthly observations used in this study were obtained from the U.S. International Trade Commission's data ranging from the 1st of January of 2005 to 31st of December of 2016. These data contained information on total quantities imported and total nominal import values.

In this study, the uncompensated and compensated elasticities of demand were estimated. The estimated statistically significant elasticities of demand revealed that the demand for all fresh fruits was price-inelastic except for the demand for mangoes and guavas imported from MERCOSUR, mangoes and guavas imported from ROW, and papayas imported from ROW. In the first system of demand equations, most of the statistically significant cross-price elasticities had positive sign indicating that the fruits imported from those sources were substitutes. Some of the estimated cross-price elasticities of demand had negative sign indicating that the corresponding fruits were complements for each other. All the estimated expenditure elasticities were positive implying that the quantity demanded of all fruits increased as real expenditure for those fruits rose with all other factors held constant. In the second system of demand equations, most of the statistically significant cross-price elasticities had positive sign indicating that the corresponding fresh fruits were substitutes, and only one elasticity estimate indicated a complementary relationship.

The findings of this study are useful in terms of formulating trade policies and conducting scenario analysis in policy decision-making. Particularly, the estimated elasticities of demand can be used to evaluate the impact of various economic factors (such as tariffs and phytosanitary regulations) that can influence the price of the fresh fruits imported to the U.S. These elasticities are useful in terms of measuring the degree of responsiveness of the U.S. consumers to the changes in prices of the imported fresh fruits. For instance, the demand for fresh fruits that were found to be price-inelastic is expected to be less impacted by the price changes than those with a higher magnitude for own-price elasticity of demand in absolute value. The last section of the study estimated the changes in the U.S. imports of fresh fruits in case if the U.S. Government imposes import tariffs on goods and services imported from Mexico. The analysis revealed that the combined direct and indirect impacts of 20% tariff is expected to be an increase of the U.S. import expenditure by $10.45 million, and the expected tariff revenue is expected to be $17.49 million.

A few recommendations for the future research need to be noted. First, additional data including other sources can be added to make the findings more representative. Second, the selected preferential trade agreements can be analyzed one by one with a specific dummy variable representing the start of the agreement. The findings of such study can be useful in considering formation of a new trade agreement (such as an agreement with MERCOSUR countries). Third, further analysis can focus on estimating the supply function of the U.S. fresh fruit producers, which, if combined with the findings of this study, can be used to estimate optimal tariff levels for each of the sources analyzed in this study. Finally, future research can focus on estimating the supply flexibilities of the Mexican fresh fruit producers, which will allow the estimation of the expected response of these producers to the imposition of a tariff on goods and services imported from Mexico.

Irrespective of the foregoing recommendations, this study is a solid contribution to exploring the insights into the U.S. demand for fresh fruits.

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APPENDICES

APPENDIX A

THE ELASTICITY ESTIMATES FROM THE PREVIOUS STUDIES

Table A. 1. Elasticity Estimates Obtained by Huang (1993)

	Apple	Orange	Banana	Grape	Grapefruit	Income
Apple	-0.19	0.12	0.10	0.06	0.07	-0.36
Orange	0.12	-0.85*	-0.06	0.00	-0.10*	-0.16
Banana	0.14	-0.09	-0.50*	-0.02	-0.05	0.09
Grape	0.18	-0.01	-0.04	-1.18*	-0.15	0.56
Grapefruit	0.18	-0.28*	-0.11	-0.12	-0.45*	-0.49

Table A. 2. Elasticity Estimates Obtained by You, Epperson, and Huang (1996)

Fruits	Apples	Bananas	Cherries	Grapefruits	Grapes	Lemons
Apples	-0.16	0.08	-0.03	-0.03	0.14	-0.02
Bananas	0.12	-0.42*	0.02	0.06	-0.05	-0.14*
Cherries	-0.61	0.35	-0.03	-0.22	-0.05	-0.23
Grapefruits	-0.13	0.15	-0.04	-1.02*	0.20	-0.02
Grapes	0.34	-0.09	-0.01	0.14	-0.91*	-0.04
Lemons	-0.10	-0.57*	-0.06	-0.03	-0.10	-0.30
Oranges	0.06	-0.04	-0.01	0.13	-0.21*	0.03
Peaches	0.31	0.40	0.06	0.06	0.31	0.23*
Pears	-0.26	-0.04	-0.06	0.07	-0.23	-0.15
Strawberries	0.45*	-0.50*	-0.07	0.05	0.03	-0.22
Watermelons	0.03	-0.28	0.05	-0.10	0.22	0.15*
Continued:	Oranges	Peaches	Pears	Strawberries	Watermelons	Expenditure
Apples	0.03	-0.09	-0.04	0.08*	0.01	-0.19
Bananas	-0.03	0.16	-0.01	-0.14*	-0.15	0.63
Cherries	0.07	0.38	-0.19	-0.27	0.39	-1.80
Grapefruits	0.25	0.06	0.04	0.04	-0.14	0.60
Grapes	-0.28*	0.22	-0.09	0.01	0.21	0.66
Lemons	0.08	0.40*	-0.15	-0.26	0.34*	0.44
Oranges	-1.14*	0.15	0.01	0.10*	0.05	0.89
Peaches	0.27	-0.96*	0.04	0.09	-0.34*	-0.08
Pears	0.04	0.06	0.29	-0.40*	0.31	0.93
Strawberries	0.27*	0.14	-0.34	-0.28	0.16	-0.47
Watermelons	0.07	-0.26*	0.14	0.08	-0.6*	0.41

Table A. 3. Elasticity Estimates Obtained by Brown and Lee (2002)

	Oranges	Grapefruits	Apples/pears	Bananas	Grapes	Income
Oranges	-0.67*	-0.14*	-0.48*	-0.37*	-0.01	1.75*
Grapefruits	-0.14	-1.11*	0.20	0.64*	-0.01	0.42
Apples/pears	-0.12*	-0.002	-0.52*	-0.17*	-0.2*	1.031*
Bananas	-0.05	-0.19*	-0.05	-0.54*	0.05	0.40
Grapes	0.02	-0.05	-0.45*	-0.11	-0.56*	1.14*

Table A. 4. Elasticity Estimates Obtained by Durham and Eales (2006)

Store1	Apples	Pears	Bananas	Oranges	Grapes	Other	Expenditure
Apples	-1.13*	0.04	0.03	0.08	0.18*	0.11	0.70
Pears	0.18*	-1.44*	0.10	0.07	0.25*	0.07	0.77
Bananas	0.02	0.01	-0.98*	0.08*	0.11*	0.02	0.74
Oranges	0.01	0.01	0.00	-1.37*	0.25	-0.30*	1.40
Grapes	0.11	0.07	0.04	0.27	-1.62*	0.01	1.12
Other	-0.01	0.00	-0.10	-0.14	-0.07	-0.99*	1.30
Store2	Apples	Pears	Bananas	Oranges	Grapes	Other	Expenditure
Apples	-1.19*	0.06	0.07*	0.06	0.16*	0.03	0.82
Pears	0.19*	-1.68*	0.13*	0.02	0.25*	0.16	0.93
Bananas	0.10*	0.05	-0.9*	0.02	0.12*	-0.07	0.68
Oranges	0.07	0.01	-0.02	-1.30*	0.27	-0.08	1.05
Grapes	0.12	0.08	0.02	0.15	-1.67*	0.02	1.28
Other	-0.07	0.03	-0.20	-0.06	0.02	-0.99*	1.29

Table A. 5. Elasticity Estimates Obtained by Nzaku, Houston, and Fonsah (2010)

	Bananas	Pineapples	Papayas	Mangoes/guavas	Grapes	Avocadoes	Expenditure
Bananas	−0.54*	−0.06	−0.08*	−0.08*	−0.23	−0.02	1.11*
Pineapples	−0.47	−0.23	0.09*	0.04	−0.35	0.16	0.71*
Papayas	−3.12*	0.35*	−0.12	−0.27*	1.89*	0.01	0.84*
Mangoes/guavas	−0.57	0.04	−0.06	−0.61*	0.17	−0.17*	0.55*
Grapes	−0.65	−0.12	0.14*	0.01	−0.38	0.01	0.95*
Avocadoes	−0.30	0.21	0.00	−0.26	0.44	−0.88*	1.14*

APPENDIX B

THE DESCRIPTIVE STATISTICS FOR TWO MODELS

Table B. 1. Weighted Average Monthly Real Prices, Average Monthly Quantities, and Standard Deviations by Years For NAFTA, CAFTA-DR, MERCOSUR, and ROW, 2005-2015.

Fruit - Source	Variable	2005	2006	2007	2008	2009	2010
Mangoes and guavas – NAFTA	Price ($/kg)	0.8	0.9	0.8	0.7	0.8	0.8
	St. deviation	2.6	3.5	3.1	2.1	0.6	0.5
	Quantity (tons)	13295.9	15096.9	15440.0	15175.3	15492.4	18368.5
	St. deviation	12628.9	15359.2	14824.3	14019.8	14658.9	17546.1
Mangoes and guavas – MERCOSUR	Price ($/kg)	0.9	0.9	0.9	0.9	1.2	1.0
	St. deviation	0.1	0.1	2.6	0.1	0.3	0.1
	Quantity (tons)	4666.3	4725.3	4489.3	5339.2	3374.8	4711.1
	St. deviation	5082.2	4783.9	3965.7	5592.2	2952.1	4941.6
Mangoes and guavas – ROW	Price ($/kg)	1.1	1.0	1.0	1.1	0.8	0.9
	St. deviation	1.1	1.0	1.0	1.9	0.4	1.1
	Quantity (tons)	4289.3	5018.4	5368.0	4649.7	5310.2	4079.5
	St. deviation	3380.3	3784.1	4727.4	3774.6	4563.9	3638.5
Bananas – CAFTA-DR	Price ($/kg)	0.3	0.3	0.3	0.3	0.4	0.4
	St. deviation	0.0	0.0	0.0	0.0	0.1	0.0
	Quantity (tons)	195626.4	191654.3	220627.4	216517.7	172721.9	204896.8
	St. deviation	17636.9	22090.7	22152.7	17819.6	42717.7	13304.2
Bananas – ROW	Price ($/kg)	0.3	0.4	0.3	0.4	0.5	0.5
	St. deviation	0.0	0.0	0.0	0.0	0.1	0.0
	Quantity (tons)	123073.6	128302.0	113022.7	114827.8	125608.8	136282.4
	St. deviation	8969.0	13870.5	10661.3	16596.9	20701.0	10828.8
Avocadoes – NAFTA	Price ($/kg)	2.1	2.0	2.3	2.3	2.1	2.0
	St. deviation	0.3	0.2	0.3	0.4	0.5	0.2
	Quantity (tons)	11195.8	9081.3	18280.3	19542.3	25050.7	22220.5
	St. deviation	1896.5	3225.8	3622.5	4266.0	7052.8	7523.0
Avocadoes – ROW	Price ($/kg)	1.0	0.9	1.0	1.1	1.2	1.2
	St. deviation	0.5	0.5	0.1	0.5	0.4	0.3
	Quantity (tons)	10821.3	6979.1	10791.2	6692.3	10928.6	6530.2
	St. deviation	9277.9	8571.8	7557.9	6283.4	8673.3	6310.7
Papayas – CAFTA-DR	Price ($/kg)	0.8	0.6	0.5	0.4	0.5	0.5
	St. deviation	0.1	0.2	0.0	0.0	0.1	0.1
	Quantity (tons)	196.0	177.1	560.7	487.2	326.6	511.6
	St. deviation	74.2	54.8	150.9	101.4	63.0	124.8
Papayas – NAFTA	Price ($/kg)	0.9	0.7	0.6	0.7	0.6	0.6
	St. deviation	0.1	0.1	0.0	0.0	0.0	0.1
	Quantity (tons)	6681.8	7595.0	7720.4	7073.5	10396.8	9601.2
	St. deviation	1480.4	1781.3	1182.8	911.0	1751.4	2667.5
Papayas – ROW	Price ($/kg)	0.7	0.6	0.6	0.7	0.7	0.6
	St. deviation	0.1	0.1	0.1	0.1	0.1	0.0
	Quantity (tons)	2792.8	3242.7	3228.4	2800.1	2312.5	2711.5
	St. deviation	447.0	503.9	1531.4	732.7	430.1	322.8

Continued:

Fruit - Source	Variable	2011	2012	2013	2014	2015	Average
Mangoes and guavas – NAFTA	Price ($/kg)	0.8	0.8	0.8	0.9	0.9	0.8
	St. deviation	0.5	0.4	0.4	0.3	0.3	2.1
	Quantity (tons)	19966.6	20811.7	23625.8	20187.2	21659.0	15478.2
	St. deviation	18557.6	19686.7	21839.7	19932.1	21274.5	14839.5
Mangoes and guavas – MERCOSUR	Price ($/kg)	1.1	1.1	1.2	1.4	1.7	1.0
	St. deviation	0.1	0.2	0.3	0.4	0.4	0.6
	Quantity (tons)	5832.6	4263.9	5432.1	5586.4	5472.6	4551.0
	St. deviation	6798.0	3740.5	5384.8	6842.4	5421.0	4552.9
Mangoes and guavas – ROW	Price ($/kg)	0.8	1.0	1.1	1.2	1.1	1.0
	St. deviation	0.4	2.2	0.9	0.6	0.8	1.1
	Quantity (tons)	5231.0	5816.8	6704.2	5997.2	5956.9	4785.8
	St. deviation	4342.7	5437.7	5854.0	6399.3	6199.8	3978.1
Bananas – CAFTA-DR	Price ($/kg)	0.5	0.5	0.4	0.4	0.4	0.4
	St. deviation	0.0	0.0	0.0	0.0	0.0	0.0
	Quantity (tons)	221628.3	240120.7	254595.2	260370.0	256636.3	200340.8
	St. deviation	20191.3	21325.4	19060.4	22178.8	19667.2	22620.3
Bananas – ROW	Price ($/kg)	0.5	0.5	0.5	0.5	0.5	0.4
	St. deviation	0.0	0.0	0.0	0.0	0.0	0.0
	Quantity (tons)	121928.5	122355.5	125134.4	121483.7	129119.6	123519.5
	St. deviation	14920.0	12259.1	10690.7	12025.9	11364.3	13604.6
Avocadoes – NAFTA	Price ($/kg)	2.6	1.8	2.0	2.2	1.9	2.1
	St. deviation	0.7	0.3	0.4	0.2	0.3	0.3
	Quantity (tons)	26578.1	35943.3	42480.9	50387.9	67004.1	17561.8
	St. deviation	8687.8	10665.6	14282.2	12108.9	9840.3	4597.7
Avocadoes – ROW	Price ($/kg)	1.6	1.4	1.6	1.9	1.7	1.1
	St. deviation	0.4	0.4	0.4	0.5	0.4	0.4
	Quantity (tons)	8030.8	5937.2	5171.3	10375.6	5276.1	8790.4
	St. deviation	6267.9	3984.5	3084.1	5954.3	5265.9	7779.2
Papayas – CAFTA-DR	Price ($/kg)	0.7	0.7	0.5	0.6	0.7	0.5
	St. deviation	0.1	0.1	0.0	0.1	0.0	0.1
	Quantity (tons)	698.3	1103.7	1365.3	1148.4	1972.9	376.5
	St. deviation	177.1	296.3	286.5	297.6	279.0	94.8
Papayas – NAFTA	Price ($/kg)	0.5	0.6	0.6	0.7	0.6	0.7
	St. deviation	0.1	0.1	0.0	0.1	0.1	0.0
	Quantity (tons)	8407.9	8946.6	9330.5	10616.0	12077.9	8178.1
	St. deviation	3467.1	1270.7	1380.8	1401.6	1867.6	1629.1
Papayas – ROW	Price ($/kg)	0.6	0.7	0.6	0.7	0.7	0.6
	St. deviation	0.0	0.1	0.0	0.1	0.1	0.1
	Quantity (tons)	2544.7	1802.8	2230.1	1505.2	1414.1	2848.0
	St. deviation	450.4	391.5	568.5	266.8	353.4	661.3

Source: USITC, 2016.

Table B. 2. Weighted Average Monthly Real Prices, Average Monthly Quantities, and Standard Deviations by Years for Mexico, Canada, and ROW, 2005-2015.

Fruit - Source	Variable	2005	2006	2007	2008	2009	2010
Berries - Mexico	Price ($/kg)	2.7	3.0	3.1	3.0	2.8	3.6
	St. deviation	1.3	1.6	1.7	1.4	1.3	1.5
	Quantity (tons)	5718.8	7383.0	8413.9	8480.8	11077.6	12307.3
	St. deviation	4826.5	6137.9	6798.9	6641.3	8771.1	9346.3
Berries - Canada	Price ($/kg)	1.9	1.9	1.9	2.2	2.1	2.2
	St. deviation	0.9	1.2	1.5	1.3	0.7	1.2
	Quantity (tons)	4841.2	5377.6	4857.3	4798.0	5085.0	4478.1
	St. deviation	6450.3	8168.8	6884.1	8161.4	8264.6	7131.5
Berries - ROW	Price ($/kg)	5.7	6.0	6.1	5.7	4.8	5.3
	St. deviation	2.1	2.4	2.1	1.9	2.3	2.3
	Quantity (tons)	1386.8	1805.7	2335.0	3214.8	3719.9	4972.6
	St. deviation	1386.9	1752.4	2296.1	3355.4	4361.8	4965.8
Apples - Canada	Price ($/kg)	0.8	0.9	1.0	0.8	0.9	1.0
	St. deviation	0.1	0.2	0.2	0.2	0.3	0.3
	Quantity (tons)	2815.8	2904.7	2591.6	3002.8	1758.2	1743.5
	St. deviation	1791.9	1288.9	2375.9	1529.6	714.7	998.0
Apples - ROW	Price ($/kg)	1.1	1.1	0.9	1.0	1.0	1.0
	St. deviation	0.3	0.5	0.3	0.1	1.0	0.2
	Quantity (tons)	7413.8	10149.5	14625.0	10770.6	11223.1	14221.3
	St. deviation	9522.7	12324.7	16097.2	12744.5	13728.9	17522.0
Avocadoes - Mexico	Price ($/kg)	2.1	2.0	2.3	2.3	2.1	2.0
	St. deviation	0.3	0.2	0.3	0.4	0.5	0.2
	Quantity (tons)	11195.8	9081.3	18280.3	19542.3	25050.7	22220.5
	St. deviation	1896.5	3225.8	3622.5	4266.0	7052.8	7523.0
Avocadoes - ROW	Price ($/kg)	1.0	0.9	1.0	1.1	1.2	1.2
	St. deviation	0.4	0.4	0.1	0.2	0.2	0.5
	Quantity (tons)	10821.3	6979.1	10791.2	6692.3	10928.6	6530.2
	St. deviation	9277.9	8571.8	7557.9	6283.4	8673.3	6310.7

Continued:

Fruit - Source	Variable	2011	2012	2013	2014	2015	Average
Berries - Mexico	Price ($/kg)	2.7	3.0	3.1	3.0	2.8	3.6
	St. deviation	1.3	1.6	1.7	1.4	1.3	1.5
	Quantity (tons)	5718.8	7383.0	8413.9	8480.8	11077.6	12307.3
	St. deviation	4826.5	6137.9	6798.9	6641.3	8771.1	9346.3
Berries - Canada	Price ($/kg)	1.9	1.9	1.9	2.2	2.1	2.2
	St. deviation	0.9	1.2	1.5	1.3	0.7	1.2
	Quantity (tons)	4841.2	5377.6	4857.3	4798.0	5085.0	4478.1
	St. deviation	6450.3	8168.8	6884.1	8161.4	8264.6	7131.5
Berries - ROW	Price ($/kg)	5.7	6.0	6.1	5.7	4.8	5.3
	St. deviation	2.1	2.4	2.1	1.9	2.3	2.3
	Quantity (tons)	1386.8	1805.7	2335.0	3214.8	3719.9	4972.6
	St. deviation	1386.9	1752.4	2296.1	3355.4	4361.8	4965.8
Apples - Canada	Price ($/kg)	0.8	0.9	1.0	0.8	0.9	1.0
	St. deviation	0.1	0.2	0.2	0.2	0.3	0.3
	Quantity (tons)	2815.8	2904.7	2591.6	3002.8	1758.2	1743.5
	St. deviation	1791.9	1288.9	2375.9	1529.6	714.7	998.0
Apples - ROW	Price ($/kg)	1.1	1.1	0.9	1.0	1.0	1.0
	St. deviation	0.3	0.5	0.3	0.1	1.0	0.2
	Quantity (tons)	7413.8	10149.5	14625.0	10770.6	11223.1	14221.3
	St. deviation	9522.7	12324.7	16097.2	12744.5	13728.9	17522.0
Avocadoes - Mexico	Price ($/kg)	2.1	2.0	2.3	2.3	2.1	2.0
	St. deviation	0.3	0.2	0.3	0.4	0.5	0.2
	Quantity (tons)	11195.8	9081.3	18280.3	19542.3	25050.7	22220.5
	St. deviation	1896.5	3225.8	3622.5	4266.0	7052.8	7523.0
Avocadoes - ROW	Price ($/kg)	1.0	0.9	1.0	1.1	1.2	1.2
	St. deviation	0.4	0.4	0.1	0.2	0.2	0.5
	Quantity (tons)	10821.3	6979.1	10791.2	6692.3	10928.6	6530.2
	St. deviation	9277.9	8571.8	7557.9	6283.4	8673.3	6310.7

Source: USITC, 2016.

APPENDIX C

PARAMETER ESTIMATES, UNCOMPENSATED AND COMPENSATED ELASTICITIES OF DEMAND, AND CORRESPONDING STANDARD ERRORS, P-VALUES, AND T-STATISTICS FOR THE FIRST SYSTEM OF DEMAND EQUATIONS

Table C. 1. Estimates of the First Demand System

Parameter	Estimate	Standard Error	t-statistic	p-value
g1_1	-0.096	0.032	-2.990	0.003
g1_2	0.015	0.018	0.870	0.388
g1_3	-0.012	0.014	-0.810	0.421
g1_4	-0.071	0.033	-2.160	0.033
g1_5	0.118	0.036	3.310	0.001
g1_6	0.085	0.039	2.210	0.029
g1_7	-0.053	0.029	-1.840	0.069
g1_8	-0.003	0.001	-3.360	0.001
g1_9	0.022	0.006	3.830	0.000
g1_10	-0.007	0.002	-3.030	0.003
g2_2	-0.008	0.008	-0.980	0.329
g2_3	0.007	0.006	1.210	0.229
g2_4	0.016	0.014	1.180	0.241
g2_5	-0.035	0.020	-1.780	0.078
g2_6	0.000	0.017	0.020	0.981
g2_7	0.006	0.011	0.520	0.606
g2_8	0.001	0.001	1.210	0.230
g2_9	-0.005	0.004	-1.250	0.214
g2_10	0.002	0.001	1.890	0.061
g3_3	-0.007	0.005	-1.290	0.198
g3_4	-0.007	0.012	-0.550	0.582
g3_5	0.024	0.018	1.310	0.194
g3_6	-0.006	0.014	-0.440	0.658
g3_7	-0.002	0.009	-0.230	0.819
g3_8	0.000	0.000	-0.750	0.458
g3_9	0.003	0.003	1.130	0.260
g3_10	0.000	0.001	-0.290	0.770
g4_4	0.090	0.051	1.760	0.081
g4_5	0.008	0.054	0.150	0.881
g4_6	-0.023	0.041	-0.560	0.576
g4_7	-0.024	0.022	-1.090	0.278
g4_8	-0.003	0.001	-2.080	0.040
g4_9	0.017	0.008	2.150	0.033
g4_10	-0.005	0.004	-1.410	0.160
g5_5	0.016	0.076	0.210	0.831
g5_6	-0.158	0.040	-3.920	0.000
g5_7	0.052	0.038	1.380	0.171
g5_8	0.004	0.002	2.380	0.019
g5_9	-0.039	0.009	-4.250	0.000
g5_10	0.009	0.004	2.220	0.028
g6_6	0.081	0.060	1.350	0.179

g6_7	0.042	0.035	1.190	0.238
g6_8	0.001	0.001	0.970	0.335
g6_9	-0.027	0.008	-3.530	0.001
g6_10	0.005	0.003	1.720	0.088
g7_7	-0.026	0.032	-0.810	0.421
g7_8	-0.002	0.001	-1.900	0.060
g7_9	0.010	0.007	1.540	0.125
g7_10	-0.003	0.002	-1.480	0.141
g8_8	0.001	0.000	3.840	0.000
g8_9	0.001	0.001	2.050	0.042
g8_10	0.000	0.000	-0.420	0.677
g9_9	0.013	0.003	4.810	0.000
g9_10	0.003	0.001	2.980	0.004
g10_10	-0.005	0.001	-3.830	0.000

Note: in g_{ij}, i=1,2,…10, where:

1 = mangoes and guavas imported from NAFTA

2 = mangoes and guavas imported from MERCOSUR

3 = mangoes and guavas imported from ROW

4 = bananas imported from CAFTA-DR

5 = bananas imported from ROW

6 = avocadoes imported from NAFTA

7 = avocadoes imported from ROW

8 = papayas imported from CAFTA-D

9 = papayas imported from NAFTA

10 = papayas imported from ROW

Table C. 2. Estimated Uncompensated Elasticities of Demand

Parameter	Estimate	Standard Error	t-statistic	p-value
e_1_1	-0.945	0.098	-9.690	0.000
e_1_2	-0.190	0.061	-3.130	0.002
e_1_3	0.112	0.045	2.530	0.013
e_1_4	-0.513	0.146	-3.510	0.001
e_1_5	-0.420	0.089	-4.730	0.000
e_1_6	-0.467	0.146	-3.210	0.002
e_1_7	-0.026	0.092	-0.280	0.779
e_1_8	-0.003	0.003	-0.850	0.394
e_1_9	-0.036	0.014	-2.500	0.014
e_1_10	0.006	0.008	0.730	0.468
e_2_1	-0.359	0.156	-2.300	0.023
e_2_2	-1.088	0.221	-4.910	0.000
e_2_3	0.111	0.128	0.870	0.387
e_2_4	0.313	0.365	0.860	0.393
e_2_5	-0.064	0.356	-0.180	0.858
e_2_6	1.196	0.444	2.700	0.008
e_2_7	-0.279	0.242	-1.150	0.251
e_2_8	-0.002	0.009	-0.270	0.791
e_2_9	0.058	0.054	1.070	0.287
e_2_10	0.035	0.021	1.700	0.093
e_3_1	0.341	0.119	2.870	0.005
e_3_2	0.074	0.136	0.540	0.589
e_3_3	-1.147	0.123	-9.320	0.000
e_3_4	0.055	0.290	0.190	0.851
e_3_5	-0.190	0.232	-0.820	0.412
e_3_6	-1.257	0.331	-3.790	0.000
e_3_7	0.357	0.186	1.920	0.057
e_3_8	0.010	0.006	1.700	0.092
e_3_9	-0.057	0.035	-1.650	0.102
e_3_10	0.047	0.014	3.270	0.001
e_4_1	-0.005	0.019	-0.290	0.772
e_4_2	-0.005	0.023	-0.230	0.819
e_4_3	0.017	0.015	1.140	0.258
e_4_4	-0.677	0.106	-6.400	0.000
e_4_5	-0.249	0.091	-2.750	0.007
e_4_6	-0.277	0.075	-3.710	0.000
e_4_7	0.033	0.036	0.900	0.368
e_4_8	-0.003	0.003	-0.940	0.348
e_4_9	0.000	0.015	0.030	0.974
e_4_10	0.000	0.007	-0.050	0.958
e_5_1	0.034	0.027	1.280	0.202

e_5_2	-0.017	0.031	-0.540	0.589
e_5_3	0.009	0.019	0.450	0.655
e_5_4	-0.177	0.148	-1.200	0.234
e_5_5	-0.155	0.161	-0.960	0.337
e_5_6	-0.107	0.094	-1.140	0.258
e_5_7	-0.043	0.045	-0.960	0.341
e_5_8	0.004	0.005	0.710	0.477
e_5_9	-0.044	0.026	-1.750	0.084
e_5_10	0.005	0.012	0.390	0.696
e_6_1	-0.011	0.036	-0.310	0.756
e_6_2	0.103	0.038	2.700	0.008
e_6_3	-0.097	0.027	-3.610	0.000
e_6_4	-0.250	0.105	-2.380	0.019
e_6_5	-0.132	0.084	-1.560	0.121
e_6_6	-0.223	0.148	-1.510	0.134
e_6_7	-0.017	0.062	-0.280	0.784
e_6_8	-0.006	0.002	-2.330	0.021
e_6_9	-0.025	0.013	-1.870	0.064
e_6_10	-0.006	0.006	-1.060	0.292
e_7_1	-0.011	0.123	-0.090	0.930
e_7_2	-0.189	0.128	-1.480	0.142
e_7_3	0.176	0.092	1.910	0.058
e_7_4	-0.060	0.326	-0.180	0.855
e_7_5	-0.557	0.267	-2.090	0.039
e_7_6	-0.419	0.378	-1.110	0.270
e_7_7	-0.958	0.283	-3.390	0.001
e_7_8	-0.006	0.007	-0.820	0.415
e_7_9	-0.064	0.042	-1.540	0.127
e_7_10	0.013	0.017	0.740	0.463
e_8_1	-0.087	0.101	-0.860	0.391
e_8_2	-0.085	0.120	-0.710	0.482
e_8_3	0.121	0.078	1.560	0.123
e_8_4	-1.096	0.667	-1.640	0.103
e_8_5	0.072	0.690	0.100	0.918
e_8_6	-1.200	0.367	-3.270	0.001
e_8_7	-0.170	0.189	-0.900	0.370
e_8_8	-0.241	0.183	-1.310	0.192
e_8_9	0.231	0.307	0.750	0.453
e_8_10	0.006	0.255	0.020	0.980
e_9_1	0.047	0.040	1.180	0.240
e_9_2	0.051	0.044	1.160	0.250
e_9_3	-0.018	0.028	-0.670	0.505
e_9_4	0.352	0.219	1.610	0.111
e_9_5	-0.337	0.225	-1.500	0.137

e_9_6	-0.135	0.134	-1.010	0.313
e_9_7	-0.035	0.066	-0.530	0.600
e_9_8	0.020	0.022	0.940	0.352
e_9_9	-0.246	0.110	-2.230	0.027
e_9_10	0.081	0.047	1.730	0.086
e_10_1	0.080	0.060	1.340	0.183
e_10_2	0.069	0.068	1.030	0.307
e_10_3	0.145	0.043	3.350	0.001
e_10_4	-0.292	0.362	-0.810	0.421
e_10_5	-0.157	0.378	-0.410	0.679
e_10_6	-0.487	0.199	-2.440	0.016
e_10_7	0.086	0.107	0.800	0.424
e_10_8	0.002	0.061	0.040	0.968
e_10_9	0.235	0.160	1.470	0.145
e_10_10	-1.598	0.168	-9.540	0.000

Note: in g_{ij}, i=1,2,…10, where:

1 = mangoes and guavas imported from NAFTA

2 = mangoes and guavas imported from MERCOSUR

3 = mangoes and guavas imported from ROW

4 = bananas imported from CAFTA-DR

5 = bananas imported from ROW

6 = avocadoes imported from NAFTA

7 = avocadoes imported from ROW

8 = papayas imported from CAFTA-D

9 = papayas imported from NAFTA

10 = papayas imported from ROW

Table C. 3. Estimated Compensated Elasticities of Demand

Parameter	Estimate	Standard Error	t-statistic	p-value
ec_1_1	-0.797	0.093	-8.540	0.000
ec_1_2	-0.134	0.060	-2.230	0.028
ec_1_3	0.168	0.045	3.750	0.000
ec_1_4	0.393	0.114	3.460	0.001
ec_1_5	0.126	0.099	1.280	0.202
ec_1_6	0.111	0.138	0.810	0.422
ec_1_7	0.083	0.090	0.920	0.358
ec_1_8	0.002	0.003	0.600	0.549
ec_1_9	0.024	0.016	1.540	0.126
ec_1_10	0.023	0.007	3.340	0.001
ec_2_1	-0.354	0.159	-2.230	0.028
ec_2_2	-1.086	0.218	-4.990	0.000
ec_2_3	0.113	0.132	0.860	0.394
ec_2_4	0.342	0.360	0.950	0.344
ec_2_5	-0.047	0.296	-0.160	0.875
ec_2_6	1.214	0.388	3.130	0.002
ec_2_7	-0.276	0.243	-1.130	0.260
ec_2_8	-0.002	0.009	-0.250	0.806
ec_2_9	0.059	0.046	1.290	0.201
ec_2_10	0.035	0.021	1.680	0.096
ec_3_1	0.447	0.119	3.750	0.000
ec_3_2	0.114	0.133	0.860	0.394
ec_3_3	-1.107	0.127	-8.750	0.000
ec_3_4	0.699	0.247	2.830	0.005
ec_3_5	0.199	0.192	1.030	0.303
ec_3_6	-0.846	0.284	-2.980	0.004
ec_3_7	0.435	0.185	2.350	0.020
ec_3_8	0.013	0.006	2.200	0.030
ec_3_9	-0.014	0.031	-0.470	0.640
ec_3_10	0.060	0.014	4.220	0.000
ec_4_1	0.064	0.019	3.460	0.001
ec_4_2	0.021	0.022	0.950	0.344
ec_4_3	0.043	0.015	2.830	0.005
ec_4_4	-0.251	0.109	-2.310	0.023
ec_4_5	0.008	0.089	0.090	0.927
ec_4_6	-0.006	0.068	-0.080	0.935
ec_4_7	0.084	0.036	2.350	0.021
ec_4_8	-0.001	0.003	-0.300	0.762
ec_4_9	0.029	0.015	1.970	0.051
ec_4_10	0.008	0.007	1.130	0.263
ec_5_1	-0.823	0.247	-3.330	0.001

ec_5_2	-0.005	0.030	-0.160	0.875
ec_5_3	0.020	0.020	1.030	0.303
ec_5_4	0.013	0.147	0.090	0.927
ec_5_5	-0.040	0.162	-0.250	0.805
ec_5_6	0.015	0.085	0.180	0.859
ec_5_7	-0.020	0.045	-0.450	0.657
ec_5_8	0.005	0.005	0.880	0.381
ec_5_9	-0.032	0.025	-1.270	0.207
ec_5_10	0.009	0.012	0.690	0.489
ec_6_1	0.029	0.036	0.810	0.422
ec_6_2	0.118	0.038	3.130	0.002
ec_6_3	-0.082	0.027	-2.980	0.004
ec_6_4	-0.009	0.106	-0.080	0.935
ec_6_5	0.014	0.080	0.180	0.859
ec_6_6	-0.068	0.136	-0.500	0.617
ec_6_7	0.012	0.062	0.200	0.845
ec_6_8	-0.005	0.002	-1.870	0.064
ec_6_9	-0.009	0.013	-0.700	0.485
ec_6_10	-0.001	0.006	-0.220	0.824
ec_7_1	0.113	0.123	0.920	0.358
ec_7_2	-0.142	0.126	-1.130	0.260
ec_7_3	0.223	0.095	2.350	0.020
ec_7_4	0.697	0.297	2.350	0.021
ec_7_5	-0.100	0.224	-0.450	0.657
ec_7_6	0.064	0.328	0.200	0.845
ec_7_7	-0.866	0.284	-3.050	0.003
ec_7_8	-0.002	0.007	-0.330	0.743
ec_7_9	-0.014	0.037	-0.380	0.706
ec_7_10	0.028	0.017	1.590	0.115
ec_8_1	0.060	0.099	0.600	0.549
ec_8_2	-0.029	0.119	-0.250	0.806
ec_8_3	0.176	0.080	2.200	0.030
ec_8_4	-0.203	0.668	-0.300	0.762
ec_8_5	0.611	0.695	0.880	0.381
ec_8_6	-0.630	0.336	-1.870	0.064
ec_8_7	-0.062	0.190	-0.330	0.743
ec_8_8	-0.236	0.183	-1.290	0.200
ec_8_9	0.290	0.305	0.950	0.343
ec_8_10	0.024	0.255	0.090	0.926
ec_9_1	0.060	0.039	1.540	0.126
ec_9_2	0.056	0.043	1.290	0.201
ec_9_3	-0.013	0.029	-0.470	0.640
ec_9_4	0.433	0.220	1.970	0.051
ec_9_5	-0.289	0.228	-1.270	0.207

ec_9_6	-0.084	0.120	-0.700	0.485
ec_9_7	-0.025	0.067	-0.380	0.706
ec_9_8	0.021	0.022	0.950	0.343
ec_9_9	-0.241	0.109	-2.210	0.029
ec_9_10	0.083	0.047	1.770	0.080
ec_10_1	0.195	0.058	3.340	0.001
ec_10_2	0.113	0.067	1.680	0.096
ec_10_3	0.189	0.045	4.220	0.000
ec_10_4	0.407	0.361	1.130	0.263
ec_10_5	0.265	0.382	0.690	0.489
ec_10_6	-0.041	0.183	-0.220	0.824
ec_10_7	0.170	0.107	1.590	0.115
ec_10_8	0.006	0.061	0.090	0.926
ec_10_9	0.281	0.159	1.770	0.080
ec_10_10	-1.584	0.167	-9.470	0.000

Note: in g_{ij}, i=1,2,…10, where:

1 = mangoes and guavas imported from NAFTA

2 = mangoes and guavas imported from MERCOSUR

3 = mangoes and guavas imported from ROW

4 = bananas imported from CAFTA-DR

5 = bananas imported from ROW

6 = avocadoes imported from NAFTA

7 = avocadoes imported from ROW

8 = papayas imported from CAFTA-D

9 = papayas imported from NAFTA

10 = papayas imported from ROW

APPENDIX D

PARAMETER ESTIMATES, UNCOMPENSATED AND COMPENSATED ELASTICITIES OF DEMAND, AND CORRESPONDING STANDARD ERRORS, P-VALUES, AND T-STATISTICS FOR THE SECOND SYSTEM OF DEMAND EQUATIONS

Table D. 1. Estimates of the Second Demand System

Parameter	Estimate	Standard Error	t-statistic	p-value
g1_1	-0.244	0.075	-3.250	0.002
g1_2	0.006	0.044	0.140	0.890
g1_3	-0.043	0.024	-1.840	0.068
g1_4	0.012	0.006	1.940	0.055
g1_5	-0.265	0.033	-8.140	0.000
g1_6	0.438	0.080	5.500	0.000
g1_7	0.098	0.043	2.250	0.026
g2_2	0.006	0.015	0.380	0.707
g2_3	0.014	0.008	1.640	0.103
g2_4	-0.003	0.002	-1.250	0.215
g2_5	0.021	0.027	0.780	0.438
g2_6	-0.058	0.061	-0.950	0.342
g2_7	0.015	0.014	1.050	0.298
g3_3	0.009	0.011	0.840	0.405
g3_4	0.004	0.002	2.110	0.037
g3_5	-0.002	0.019	-0.110	0.913
g3_6	0.027	0.040	0.680	0.499
g3_7	-0.009	0.014	-0.620	0.536
g4_4	0.000	0.002	0.160	0.872
g4_5	0.006	0.005	1.250	0.215
g4_6	-0.014	0.010	-1.420	0.160
g4_7	-0.043	0.004	-1.540	0.127
g5_5	-0.097	0.046	-2.110	0.037
g5_6	0.287	0.068	4.210	0.000
g5_7	0.050	0.033	1.530	0.129
g6_6	-0.529	0.160	-3.310	0.001
g6_7	-0.151	0.060	-2.510	0.014
g7_7	0.003	0.031	0.110	0.911

Note: in g_{ij}, i=1,2,…7, where:

1 = Berries imported from Mexico

2 = Berries imported from Canada

3 = Berries imported from ROW

4 = Apples imported from Canada

5 = Apples imported from ROW

6 = Avocadoes imported from Mexico

7 = Avocadoes imported from ROW

Table D. 2. Estimated Uncompensated Elasticities of Demand

Parameter	Estimate	Standard error	t-statistic	p-value
e_1_1	-0.558	0.098	-5.710	0.000
e_1_2	-0.939	0.155	-6.050	0.000
e_1_3	-0.907	0.076	-11.970	0.000
e_1_4	-0.935	0.136	-6.880	0.000
e_1_5	-0.978	0.155	-6.300	0.000
e_1_6	-0.130	0.173	-0.750	0.453
e_1_7	-0.699	0.333	-2.100	0.038
e_2_1	-0.056	0.056	-0.990	0.322
e_2_2	-0.106	0.050	-2.140	0.035
e_2_3	-0.026	0.011	-2.350	0.020
e_2_4	-0.317	0.053	-5.930	0.000
e_2_5	-0.719	0.141	-5.100	0.000
e_2_6	0.022	0.076	0.290	0.775
e_2_7	0.043	0.127	0.340	0.736
e_3_1	0.147	0.079	1.860	0.066
e_3_2	-0.030	0.020	-1.560	0.123
e_3_3	0.215	0.112	1.920	0.057
e_3_4	-0.585	0.269	-2.180	0.031
e_3_5	0.161	0.123	1.310	0.191
e_3_6	-0.084	0.080	-1.050	0.295
e_3_7	0.107	0.060	1.790	0.077
e_4_1	0.024	0.016	1.510	0.134
e_4_2	0.145	0.072	2.010	0.046
e_4_3	-0.288	0.185	-1.550	0.123
e_4_4	-0.156	0.094	-1.670	0.097
e_4_5	-0.111	0.129	-0.860	0.394
e_4_6	0.243	0.116	2.090	0.039
e_4_7	-0.142	0.103	-1.370	0.173
e_5_1	-0.073	0.129	-0.570	0.570
e_5_2	0.602	0.356	1.690	0.094
e_5_3	-0.139	0.194	-0.720	0.476
e_5_4	1.911	0.346	5.520	0.000
e_5_5	0.070	0.083	0.840	0.401
e_5_6	-0.033	0.019	-1.710	0.090
e_5_7	0.107	0.100	1.060	0.289
e_6_1	-0.328	0.210	-1.570	0.120
e_6_2	0.012	0.125	0.100	0.922
e_6_3	-0.128	0.069	-1.850	0.066
e_6_4	0.007	0.049	0.150	0.885
e_6_5	0.030	0.014	2.190	0.031

e_6_6	0.075	0.055	1.380	0.170
e_6_7	-0.087	0.052	-1.670	0.097
e_7_1	-0.066	0.078	-0.850	0.398
e_7_2	0.379	0.193	1.960	0.052
e_7_3	-0.166	0.152	-1.090	0.277
e_7_4	-0.029	0.043	-0.680	0.501
e_7_5	0.165	0.180	0.920	0.359
e_7_6	-0.399	0.459	-0.870	0.386
e_7_7	0.253	0.142	1.780	0.077

Note: in g_{ij}, i=1,2,…7, where:

1 = Berries imported from Mexico

2 = Berries imported from Canada

3 = Berries imported from ROW

4 = Apples imported from Canada

5 = Apples imported from ROW

6 = Avocadoes imported from Mexico

7 = Avocadoes imported from ROW

Table D. 3. Estimated Compensated Elasticities of Demand

Parameter	Estimate	Standard error	t-statistic	p-value
ec_1_1	-0.132	0.115	-1.150	0.251
ec_1_2	0.109	0.057	1.910	0.058
ec_1_3	0.091	0.046	1.970	0.051
ec_1_4	0.002	0.011	0.140	0.887
ec_1_5	-0.136	0.052	-2.610	0.010
ec_1_6	-0.083	0.120	-0.690	0.491
ec_1_7	0.150	0.074	2.020	0.046
ec_2_1	0.282	0.148	1.910	0.058
ec_2_2	-0.846	0.158	-5.350	0.000
ec_2_3	0.258	0.075	3.460	0.001
ec_2_4	-0.015	0.019	-0.800	0.423
ec_2_5	0.316	0.111	2.850	0.005
ec_2_6	-0.228	0.215	-1.060	0.291
ec_2_7	0.233	0.119	1.960	0.052
ec_3_1	0.197	0.100	1.970	0.051
ec_3_2	0.216	0.062	3.460	0.001
ec_3_3	-0.777	0.074	-10.530	0.000
ec_3_4	0.042	0.016	2.720	0.007
ec_3_5	0.263	0.071	3.690	0.000
ec_3_6	0.131	0.156	0.840	0.402
ec_3_7	-0.072	0.093	-0.780	0.438
ec_4_1	0.023	0.165	0.140	0.887
ec_4_2	-0.090	0.112	-0.800	0.423
ec_4_3	0.305	0.112	2.720	0.007
ec_4_4	-0.926	0.136	-6.840	0.000
ec_4_5	-0.017	0.124	-0.130	0.895
ec_4_6	0.802	0.310	2.580	0.011
ec_4_7	-0.099	0.194	-0.510	0.613
ec_5_1	-0.322	0.123	-2.610	0.010
ec_5_2	0.289	0.101	2.850	0.005
ec_5_3	0.288	0.078	3.690	0.000
ec_5_4	-0.003	0.019	-0.130	0.895
ec_5_5	-0.780	0.151	-5.180	0.000
ec_5_6	0.374	0.189	1.970	0.051
ec_5_7	0.154	0.123	1.250	0.215
ec_6_1	-0.056	0.081	-0.690	0.491
ec_6_2	-0.059	0.056	-1.060	0.291
ec_6_3	0.041	0.048	0.840	0.402
ec_6_4	0.035	0.013	2.580	0.011
ec_6_5	0.106	0.054	1.970	0.051
ec_6_6	-0.022	0.153	-0.140	0.885

ec_6_7	-0.044	0.079	-0.560	0.574
ec_7_1	0.499	0.247	2.020	0.046
ec_7_2	0.300	0.153	1.960	0.052
ec_7_3	-0.111	0.142	-0.780	0.438
ec_7_4	-0.021	0.042	-0.510	0.613
ec_7_5	0.216	0.173	1.250	0.215
ec_7_6	-0.220	0.390	-0.560	0.574
ec_7_7	-0.663	0.330	-2.010	0.047

Note: in g_{ij}, i=1,2,…7, where:

1 = Berries imported from Mexico

2 = Berries imported from Canada

3 = Berries imported from ROW

4 = Apples imported from Canada

5 = Apples imported from ROW

6 = Avocadoes imported from Mexico

7 = Avocadoes imported from ROW

VITA

Hovhannes Mnatsakanyan attended Yerevan State University where he received his Bachelors of Art in Cross-Cultural Communications. He then attended the Agribusiness Teaching Center at Armenian National Agrarian University where he received his Bachelors of Science in Agribusiness and Marketing. During this time, he worked with Energy Saving Foundation and participated in development of many strategic documents for the Republic of Armenia. Hovhannes received his MS in Agricultural Sciences (with emphasize on Agricultural Economics) in August 2017 at Texas A&M University-Commerce. During his studies at TAMU-C, he was a Graduate Research Assistant.

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