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A Case Study of Avocado, Berry, and Apple Trade through NAFTA

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ABSTRACT

A Source-Differentiated Almost Ideal Demand System (SDAIDS) model was estimated for berries, apples, and avocadoes imported through NAFTA prior to the new USMCA. Elasticity estimates are useful for measuring consumers' responsiveness to changes in fresh-fruit prices or expenditures. This study found the demands for berries, apples, and avocadoes were price inelastic; and that cases of substitute fresh-fruit imports were more frequent than complements. The study also assessed expected changes in US fresh-fruit imports through NAFTA in the wake of a tariff on Mexican fresh fruits as frequently propagated by politicians in the news. The combined direct and indirect impacts from the imposition of a 20% tariff on berries imported from Mexico suggested that US monthly expenditures on berries, apples, and avocadoes would increase by $6.25 million and the tariff revenue would be close to $10 million.

KEYWORDS: elasticities, fresh fruits, imports, NAFTA, SDAIDS, tariff, USMCA

INTRODUCTION

The North American Free Trade Agreement (NAFTA), signed in 1992 and effective in 1994, agreed to a final phase out of duties in 2008. President Donald Trump announced his dislike of NAFTA early in the 2016 presidential debates (Gandel 2016) and urged for its replacement. Soon after President Trump took office on January 20, 2017, discussions on imposing tariffs on imports from Mexico periodically appeared in media, including as an option to pay for a border wall to stifle undocumented immigration through Mexico into the United States (Abdullah and Gamboa 2017) and even as a warning to Mexico to stop the flow of illegal drugs into the United States (Egan 2019). On August 27, 2019, after months of negotiations, President Trump announced the United States and Mexico had agreed on revisions to key parts of NAFTA (Zaru, Faulders, and McGraw 2018).

The new US-Mexico-Canada agreement (USMCA), signed on November 30, 2018, was sent to Congress for revision around September 1, 2019 (Tausche 2019) and voted on and passed both houses of Congress by the end of 2019 (Tausche 2019; Kushner 2020). The US House of Representatives ratified the agreement in mid-December 2019 and the US Senate followed in mid-January 2020 (Domel 2020b). The Mexican Senate approved the changes to the trade treaty on December 12, 2019 (Domel 2020a) while the

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Canadian Parliament was the last to ratify on March 3, 2020 after taking a few weeks' break to help stop the spread of the coronavirus (Ljunggren 2020).

President Trump signed the implementation bill associated with the USMCA on January 29, 2020. According to Kushner (2020), the USMCA has been rightly hailed as one of President Trump's most historic achievements and a big win for America's farmers, businesses, and workers. The agreement "is expected to increase US agricultural exports by $2 billion and result in a $65 billion increase in gross domestic product," said Texas Farm Bureau President Russell Boening (Domel 2020b, pp. 9). "The combined effect of USMCA is expected to increase total annual US agricultural and food exports by $2.2 billion," said Texas Farm Bureau Vice President Mark Chamblee (Tomascik and Dorsett 2019, pp. 21). According to US Senator Ted Cruz, "[nationally, USMCA supports more than 11 million jobs, and here at home, around one million Texas families rely on USMCA-related jobs" (Tomascik and Dorsett 2019, pp. 21). According to Tomascik and Dorsett (2019, pp. 21) and Domel (2020b, pp. 9), more than 950,000 Texas jobs are supported by trade with North American countries.

According to Texas Senator John Cornyn, Texas exported more than $137 billion worth of goods and services in 2018 to its North American partners (Domel 2020b), accounting for 43% of Texas' total exports to the world (Tomascik and Dorsett 2019). Senator Cornyn said "[t]his trade supports an estimated 950,000 jobs in Texas and has helped make [the] state's economy the tenth-largest in the world" (Domel 2020b, pp. 9).

During the period from 2005 to 2015, NAFTA countries accounted for 25% in 2005 to 41% in 2015 of US fresh-fruit imports, making the agreement the main fresh fruit trade partner for the United States (USTR 2016). In 2015, the real fresh-fruits imports from 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 US 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. US imports from these countries exhibit highly seasonal patterns, and these sources often substitute each other in the US market.

This study, in the context of fresh-fruit imports through NAFTA countries, quantifies and assesses the implications of imposing tariffs on imports from Mexico as repeatedly propagated by political leaders as an option to pay for a border wall (Abdullah and Gamboa 2017), perhaps as a way to negotiate the new USMCA or, most recently, as a warning to Mexico to stop the flow of illegal drugs to the United States (Egan 2019).

This study employs a Source-Differentiated Almost Ideal Demand System (SDAIDS) to estimate the elasticities of demand for berries, apples, and avocadoes imported from Mexico and Canada. The study focuses on important fruits that are imported from Mexico and Canada, and uses the estimated elasticities of demand to evaluate the expected impact of a 20% tariff on US fresh-fruit imports from Mexico. The study incorporates the main exporters of fresh fruits to the United States, and therefore contributes to a better understanding of the economic and trade relationships among these countries. In addition, former President Trump repeatedly made comments about the possibility of imposing import tariffs on goods and services coming from Mexico (Flores 2017); therefore, it is important to evaluate the expected impact of these tariffs on the US fresh-fruit imports from Mexico.

The study focused on the major fresh fruits that are traded through the United States' NAFTA partners, Mexico and Canada. The study analyzes berries from Mexico and Canada, apples from Canada, and avocados from Mexico but, unfortunately, was unsuccessful incorporating additional fresh fruits from Mexico such as bananas, papayas, mangos, and guavas. In the case of bananas, for the period 2005-2015, only 4% came from Mexico while about 62% came from Central America. Although about 74% of papayas, and about 60% of mangos and guavas came from Mexico, the study obtained better results for the North American region (in terms of convergence of the model, meaningful results, statistical significance, etc.) when papayas, mangos, and guavas were excluded from the analysis. In general, one issue is that not all countries export fruits on a monthly basis to the United States. This basically makes the AIDS model estimation not feasible, unless the analysis is conducted at a lower import frequency (such as quarterly, semiannual, or annual basis as opposed to a monthly basis). Another issue is that when there are many equations, it is harder for the model to fit the data and get meaningful results. For example, Mekonnen, Fonsah and Borgotti (2011) were able to analyze only one fresh fruit from three country sources. Similarly, Muhammad, Zahniser and Fonsah (2015) only analyzed one fresh fruit but from five exporting countries. Last, Tshikala and Fonsah (2012) analyzed the aggregate import demand for three import types of melons, with no country level differentiation. Other studies, such as Mnatsakanyan and Lopez (2019), have been able to analyze slightly more fresh fruits by considering trade-agreement blocs as opposed to countries.

Objectives. The main objective of this study is to analyze the US demand for berries, apples, and avocadoes through NAFTA countries. The specific objectives include:

1. Identify the most imported fresh fruits among the NAFTA countries and estimate a system of demand equations for the US fresh-fruit imports from these countries;
2. 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;
3. Estimate both uncompensated and compensated cross-price elasticities of demand of selected fruit categories and discuss the economic relationships among them; and
4. Develop and analyze a scenario of imposing a 20% tariff on US fresh-fruit imports from Mexico.

LITERATURE REVIEW

Huang (1993) estimated a complete US demand system for 39 food (including apples) and one non-food categories using constrained maximum likelihood and annual time-series data for the period 1953-1990. Income was found to be an insignificant factor affecting US consumers' demand for fresh fruits. Similarly, You, Epperson and Huang (1996) estimated a composite demand system to study the US demand for fresh fruits using time-series data from 1960 to 1993. The estimation results included retail-level uncompensated and compensated demand elasticities for 11 fresh-fruit categories. Substitutability was observed between apples and strawberries, strawberries and oranges, and strawberries and lemons. The results suggested that income did not significantly affect the consumer-level demand for apples, cherries, and strawberries.

Brown and Lee (2002) estimated a restricted Rotterdam model using annual time-series data on per-capita US fresh fruit consumption and retail-level prices for the period 1980-1998. Estimated uncompensated own-price elasticities revealed that the demand for apples was price-inelastic. The empirical results suggested that income positively affected the demand for fresh fruits.

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 metropolitan area of Portland, Oregon were used in the study. Based on the root mean squared errors criterion, the QUAIDS model was found to be a better fit. The elasticity estimates obtained by Durham and Eales (2006) from the two stores 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. The uncompensated price elasticities of apples in absolute terms were greater than one, suggesting that the US consumers were more sensitive to the changes in respective own-prices. 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.

Mnatsakanyan and Lopez (2019) used a SDAIDS model to estimate elasticities of demand for mangos, guavas, bananas, avocadoes, and papayas with preferential trade blocs as import sources. Mnatsakanyan and Lopez (2019) found the demands for all fresh fruits were price-inelastic except for the demand for mangoes and guavas imported through MERCOSUR, mangoes and guavas imported from the rest of the world (ROW), and papayas imported from ROW. In addition, most cross-price elasticities had positive signs, indicating that the fruits imported from various sources were substitutes.

Elasticity estimates from prior studies are summarized in Table 1. When comparing the retail-level and import-level elasticity estimates, one must be cautious about making inferences on these estimates since one category uses domestic, retail-level prices and the other category uses import-level prices (generally per-unit value).

Table 1. Demand Elasticities in Prior Studies.

Fruit	Study	Own-price elasticity	Expenditure elasticity
Apples	Huang (1993)	-0.19	-0.36[a]
	You, Epperson and Huang (1996)	-0.16	-0.19
	Brown and Lee (2002)	-0.52*	1.03[a]*
	Durham and Eales (2006) - Store1	-1.13*	0.70
	Durham and Eales (2006) - Store2	-1.19	0.82
Avocadoes	Nzaku, Houston and Fonsah (2010)	-0.88*	1.14*
	Mnatsakanyan and Lopez (2019)	-0.22	0.66*
Cherries	You, Epperson and Huang (1996)	-0.03	-1.80
Strawberries	You, Epperson and Huang (1996)	-0.28	-0.47

Note: Superscript ([a]) indicates income elasticity estimates. Asterisk (*) denotes statistical significant at $p = 0.05$.

DATA AND PROCEDURES

Data on monthly imports in US dollars and quantities (in metric tons) from January 2005 to December 2015 were obtained from the US International Trade Commission (USITC) (2016). The consumer price index reported by the US Department of Labor (2016) was also used to adjust prices for inflation. US Gross Domestic Product data were also obtained from the US Department of Commerce (2016).

Table 2 reports average import values in 2015 dollars, average quantities, and weighted average real prices for the selected fresh fruits and sources of origin used in this study.

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)
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: Prices and import values are in 2015 dollars and include products as reflected in the US Harmonized Tariff Schedule. Berries imported from ROW are on average 75% from Chile and 20% from Argentina. Apples imported from ROW are on average 64% from Chile and 32% from New Zealand. Avocados imported from ROW are on average 60% imported from Chile and 13% from Dominican Republic.
Source: USITC (2016).

During the period 2005-2015, average imports in 2015 dollars ranked highest for avocadoes imported from Mexico, followed by berries imported from Mexico, and berries imported from ROW (75% imported from Chile and 20% imported from Argentina) (Table 2). In terms of quantity in kg, avocadoes imported from Mexico ranked first, followed by berries imported from Mexico, and apples imported from ROW (64% imported from Chile and 32% from New Zealand). Due to their relatively higher price, berries from ROW are third in terms of the import value in 2015 dollars but sixth in terms of quantity in kg.

Figure 1 reports the average real expenditure shares of the selected fruit-source combinations for the period 2005-2015. On average, avocadoes imports from Mexico maintained 36% share of total import value, which is approximately $61 million, while berries imported from Mexico and ROW (75% imported from Chile and 20% from Argentina) had 24% (approximately $49 million) and 11% (approximately $22 million), respectively.

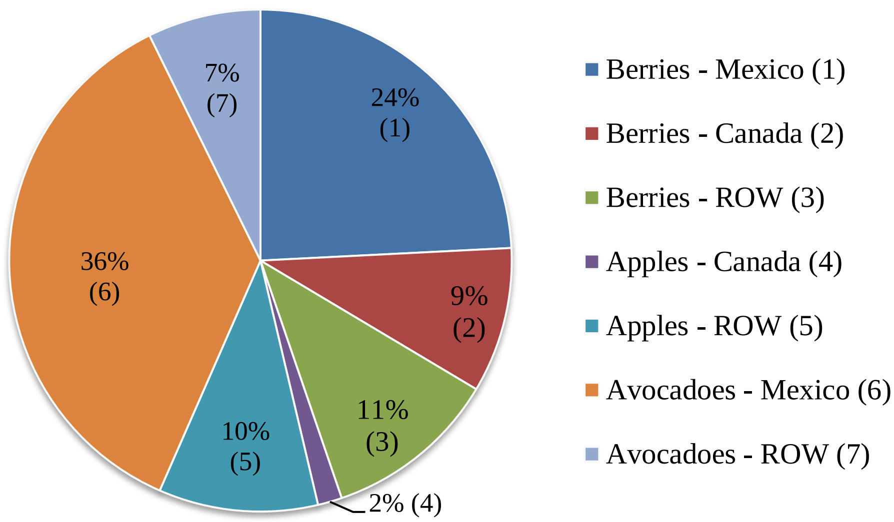

Figure 1. Average Real Expenditure Shares of the Selected Fruits and Sources, 2010-2015
Note: Expenditure shares calculated using 2015 dollars and included products as reflected in the US Harmonized Tariff Schedule.
Source: USITC (2016)

Fresh-fruit imports 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 2 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 may be attributed in part to the different berry types that these countries export. For instance, Chile mainly exports strawberries to the United States, while Mexico and Canada are the major suppliers of raspberries. This is why the weighted average price of berries imported from ROW is higher than that of berries imported from Mexico and Canada (Table 2). In addition, when the imports from both Mexico and ROW reach their minimum in September, the imports from Canada reach their maximum (Figure 2). This kind of import patterns, combined with the domestic production, ensure the year-round supply of berries in the US market.

Figure 3 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 US market. 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; for instance, Canada is further 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.

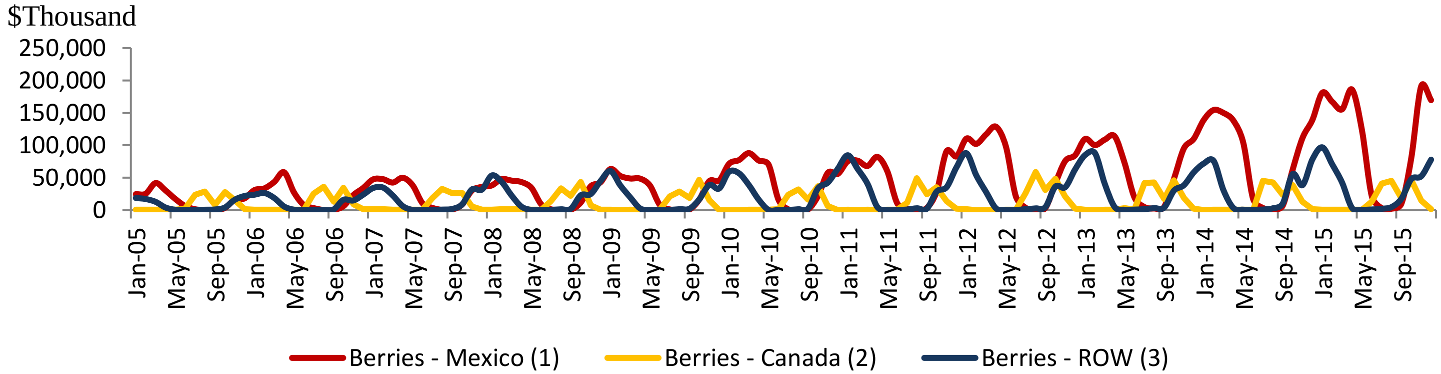

Figure 2. Monthly Real Imports of Berries from Mexico, Canada, and ROW, 2010-2015
Note: Import are in 2015 dollars and include products as reflected in the US Harmonized Tariff Schedule. Berries imported from ROW are on average 75% from Chile and 20% from Argentina.
Source: USITC (2016)

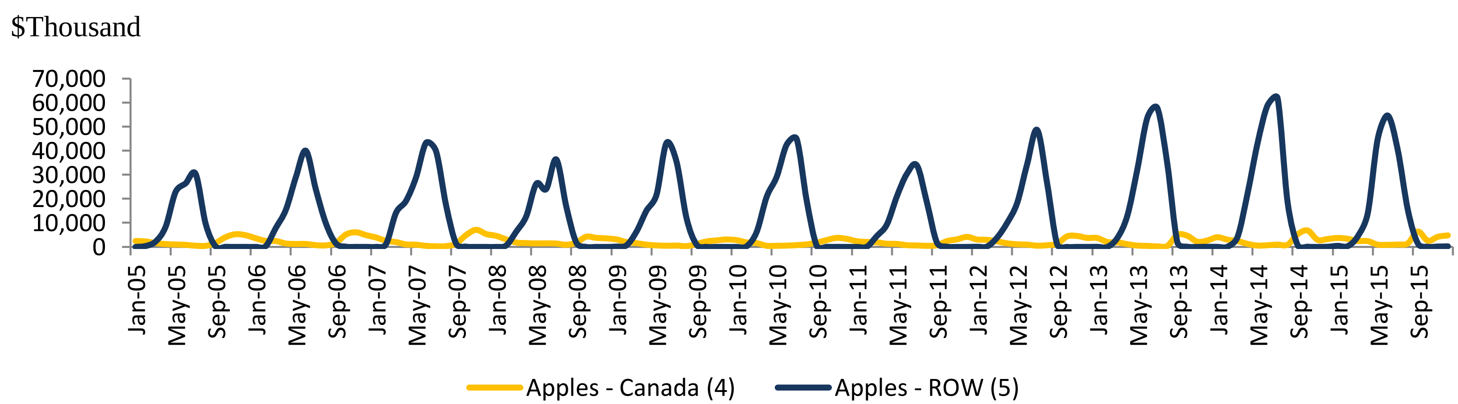

Figure 3. Monthly Real Imports of Apples Imported from Canada and ROW, 2010-2015
Note: Imports are in 2015 dollars and include products as reflected in US Harmonized Tariff Schedule. Apples imported from ROW are on average 64% from Chile and 32% from New Zealand.
Source: USITC (2016)

MODEL

The system of demand equations estimates the monthly imports of:

1. Berries imported from Canada, Mexico, and ROW (75% imported from Chile and 20% from Argentina),
2. Apples from Canada and ROW (64% imported from Chile and 32% from New Zealand), and
3. Avocadoes from Mexico and ROW (60% imported from Chile and 13% from Dominican Republic).

A SDAIDS 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 (ITSUR) procedure was used to estimate the share equations. The analysis was conducted using Statistical Analysis System (SAS) software version 9.3. The SDAIDS model is an extension of Deaton and Muellbauer's (1980) AIDS model.

The expenditure share equation for the i^{th} fruit-source combination at time period *t* is:

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

where the subscript *t* denotes the 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 fresh fruits included in the model; *trend* is a linear trend variable; $\alpha_i, \gamma_{ij}, \beta_i, c_i$ s_i and z_i are population parameters; $Sin_i=f(t_i,SL)$ and $cos_i=g(t_i,SL)$ are trigonometric functions capturing seasonality (Arnade, Pick, and Gehlhar 2005); ρ is the first-order autoregressive coefficient; ε_i is an error term; and *P* is a non-linear price index defined as:

$$(2)\quad \log(P) = \alpha_0 + \textstyle\sum_k \alpha_k \log(p_k) + 0.5 \sum_j \sum_k \gamma_{ij} \log(p_k) \log(p_j).$$

The last equation (w_7) 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:

$$(3)\quad \text{adding up:}\quad \sum_{i=1}^{n} \alpha_i = 1, \quad \sum_{i=1}^{n} \gamma_{ij} = 0, \quad \sum_{i=1}^{n} \beta_i = 0,$$

$$(4)\quad \text{homogeneity:}\quad \sum_j \gamma_{ij} = 0\,, \text{and}$$

(5) symmetry: $\gamma_{ij} = \gamma_{ji}$.

In addition to the usual parameter restrictions of the AIDS model given by the equations (3), (4), and (5), the sums of coefficients of trigonometric variables were also restricted to zero (Arnade, Pick, and Gehlhar 2005):

$$(6) \quad \sum_i s_i = 0,$$

$$(7) \quad \sum_i c_i = 0,$$

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.

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 trend 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:

$$(8) \quad \sum_i z_i = 0,$$

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. The trend variable is also used for the construction of sine and cosine functions, which had the following forms (Arnade, Pick, and Gehlhar 2005):

$$(9) \quad sin_i = f(trend, SL) = \sin\left(2\pi \frac{t_i}{12}\right),$$

and

$$(10) \quad cos_i = f(trend, SL) = \cos\left(2\pi \frac{t_i}{12}\right),$$

where π is a mathematical constant approximately equal to 3.1416, and *SL* stands for seasonal length which is equal to 12 for our monthly data.

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 an endogeneity issue. To address this, following Attfield (1985), 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:

$$(11) \quad \log(X) = v_0 + \sum_i v_i \log(p_i) + g \log(GDP) + \varepsilon_i,$$

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 gross domestic product, v_0, g, and v_i, are the parameters to be estimated, and ε_i is the error term.

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.

The coefficient of determination (R^2) for the omitted equation (w_7) was recovered by squaring the coefficient of correlation between the predicted and actual expenditure shares:

$$(12) \quad R^2 = r^2 = \left(\frac{n(\sum w_7 \widehat{w}_7) - (\sum w_7)(\sum \widehat{w}_7)}{\sqrt{(n \sum w_7^2 - (\sum w_7)^2)(n \sum \widehat{w}_7^2 - (\sum \widehat{w}_7)^2)}} \right)^2$$

where w_7 is the actual share values, $\widehat{w}_7$ is the predicted share values, and r is the coefficient of correlation.

The Durbin-Watson (DW) statistic was calculated as a ratio of the sum of squared differences of the residuals ($\hat{\varepsilon}_t$) and their first lag to the sum of squared residuals ($\hat{\varepsilon}_{t-1}$). That is:

$$(13) \quad DW = \frac{\sum(\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2}{\sum \hat{\varepsilon}_t^2}.$$

Following Green and Alston (1990), the uncompensated (Marshallian) price elasticities were calculated as:

$$(14) \quad \varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta_i(\alpha_j + \sum_{k=1}^{n} \gamma_{jk} \log(p_k))}{w_i}$$

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 were calculated as:

$$(15) \quad \varepsilon_{ix} = 1 + \frac{\beta_i}{w_i}.$$

The compensated elasticities of demand were calculated using the following Slutsky equation:

$$(16) \quad e_{ij} = \varepsilon_{ij} + w_i \, \varepsilon_{ix}.$$

RESULTS

Parameter Estimates. The SDAIDS parameters estimates are reported in Table 3. Of the 74 parameters estimated, 26 were significant at the 0.01 probability level and an additional 10 and four parameter estimates were significant at the 0.05 and 0.10 probability levels, respectively. Several of the parameter estimates corresponding the trigonometric variables were statistically significant, which suggest a presence of seasonal patterns in the data. Similarly, trending patterns were evidenced by most of the parameter estimates associated with the trend variable being statistically significant at the 0.01 probability level. In addition, following Attfield (1985), the statistical significance of the parameter estimates from equation (11) is evidence towards allowing for the assumption of endogeneity in the model.

Table 3. SDAIDS Parameter Estimates

Parameter Estimates from Equation (1):

			γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}
α_1	-1.819*	γ_{1j}	-0.244*	0.006	-0.043†	0.012†	-0.265*	0.438*	0.098‡
α_2	0.168	γ_{2j}		0.006	0.014	-0.003	0.021	-0.058	0.015
α_3	-0.062	γ_{3j}			0.009	0.004‡	-0.002	0.027	-0.009
α_4	0.095‡	γ_{4j}				0.000	0.006	-0.014	-0.006
α_5	-0.885*	γ_{5j}					-0.097‡	0.287*	0.050
α_6	2.994*	γ_{6j}						-0.529*	-0.151‡
α_7	0.509‡	γ_{7j}							0.003

		i	s_i	c_i	z_i
β_1	0.184*	1	0.176*	0.011	-0.001*
β_2	-0.001	2	-0.166*	-0.068*	-0.001†
β_3	0.018	3	0.040*	0.123*	0.000
β_4	-0.007‡	4	-0.002	0.012*	0.000
β_5	0.097*	5	-0.031‡	-0.119*	-0.001*
β_6	-0.253*	6	0.025	0.022	0.004*
β_7	-0.037	7	-0.042*	0.019	0.000

Additional Parameter Estimates from Equation (11):

Par.	v_0	v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8
Par. Est.	0.704*	-0.069	-0.099‡	0.079	0.105†	0.125‡	-0.201	-0.038	8.423*

Note: Daggers (†), double daggers (‡) and asterisks (*) denote statistical significant at $p = 0.10$, $p = 0.05$, and $p = 0.01$ respectively.

Table 4 reports the coefficient of determinations (R^2), the Durbin Watson (*DW*) statistics, and the first order autoregressive coefficient (ρ). 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. In addition, several coefficient of determinations were above 70%, ranging from 57% to 89%. Overall, the estimation results indicate that the SDAID model provided a good fit.

Table 4. Coefficients of Determination (R^2), Durbin-Watson Statistics (*DW*), and First-Order Autoregressive Coefficient (ρ).

i	R^2	DW
Berries from Mexico (1)	0.84	1.92
Berries from Canada (2)	0.65	2.07
Berries from ROW (3)	0.89	2.26
Apples from Canada (4)	0.72	1.62
Apples from ROW (5)	0.84	1.62
Avocadoes from Mexico (6)	0.57	1.97
Avocadoes from ROW (7)	0.59	1.51
Parameter	Estimate	p-value
ρ	0.490	0.0001

Note: Berries imported from ROW are on average 75% from Chile and 20% from Argentina. Apples imported from ROW are on average 64% from Chile and 32% from New Zealand. Avocados imported from ROW are on average 60% imported from Chile and 13% from Dominican Republic.

Demand Elasticities. The uncompensated own-price elasticities and the compensated cross-price elasticities of demand, calculated at the sample means, are reported in Table 5. Of 49 total elasticities, 35 were statistically significant at the 5% probability level.

Table 5. 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***

Note: *i* = 1, 2, …, 7; where 1 = berries from Mexico, 2 = berries from Canada, 3 = berries from ROW, 4 = apples from Canada, 5 = apples from ROW, 6 = avocadoes from Mexico, 7 = avocadoes from ROW. Berries imported from ROW are on average 75% from Chile and 20% from Argentina. Apples imported from ROW are on average 64% from Chile and 32% from New Zealand. Avocados imported from ROW are on average 60% imported from Chile and 13% from Dominican Republic. Asterisk (*) and double asterisks (**) denotes statistical significant at p = 0.05 and p = 0.01 respectively.

Own-Price Elasticities. All but one of the uncompensated own-price elasticities was statistically significant at the 5% probability level (Table 5). In addition, all uncompensated own-price elasticities were negative, 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 0.558% for berries imported from Mexico, by 0.939% for berries imported from Canada, by 0.907% for berries imported from ROW, by 0.935% for apples imported from Canada, by 0.979% for apples imported from ROW, and by 0.699% for avocadoes imported from ROW. The statistical significant elasticity estimates range from -0.979 for apples from ROW to -0.558 for berries from Mexico, which indicates the demand for fresh fruits were price inelastic. Our results are consistent with previous studies in that in most recent years own-price elasticities for apples are relative more elastic than berries and avocadoes (see also Table 1). Last, these elasticities of demand estimated for Mexico and Canada could be used to evaluate the impact of various market factors affecting the fresh-fruit trade among NAFTA countries.

Cross-Price Elasticities. The compensated cross-price elasticities determine the economic relationships between fresh-fruit categories differentiated by sources of origin. Negative cross-price elasticities imply that when the price of a given fruit from a given source increases by 1%, the quantity demanded of a different fruit category from the same or different source decreases which in turn implies that the categories are complements. On the other hand, positive cross-price elasticities imply that when the price of a given fruit from a given source increases by 1%, the quantity demanded of a different fruit category from the same or different source increases which in its turn implies that the categories are substitutes. Of the estimated 42 compensated cross-price elasticities, 14 were statistically significant at the 5% probability level (Table 5).

For example, if the average price of berries imported from Mexico increases by 1% with all other factors held constant, the quantities demanded are expected to increase by 0.150% for avocadoes imported from ROW and decrease by 0.136% for apples imported from ROW. If the average price of berries imported from Canada increases by 1% with all other factors held constant, the quantity demanded is expected to increase by 0.258% for berries imported from ROW and by 0.316% for apples imported from ROW. If the average price of berries imported from ROW increases by 1% with all other factors held constant, the quantity demanded is expected to increase by 0.216% for berries imported from Canada, 0.042% for apples imported from Canada, and 0.263% for apples imported from ROW. Similarly, if the average price of apples imported from Canada increases by 1% with all other factors held constant, the quantity demanded is expected to increase by 0.305% for berries imported from ROW and by 0.802% for avocadoes imported from Mexico. If the average price of apples imported from ROW increases by 1% with all other factors held constant, the quantity demanded is expected to increase by 0.289% for berries imported from Canada and by 0.288% for berries imported from ROW, while the quantity of berries demanded from Mexico is expected to decrease by 0.322%. Last, if the average price of avocadoes imported from Mexico increases by 1% with all other factors held constant, the quantity of apples demanded from Canada is expected to increase by 0.035%, and if the price of avocadoes imported from ROW increases by 1%, the quantity of berries demanded from Mexico is expected to increase by 0.499%.

Since the study analyzes imports of berries, apples, and avocadoes imported through NAFTA, it was expected that cases of substitutability were going to be more frequent than cases of complementarity. Our results indicated 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. There was only one statistically significant complementary relationship between berries imported from Mexico and apples imported from ROW.

Expenditure Elasticities. The expenditure elasticities of demand, calculated at the sample means, are reported in Table 6. The expenditure elasticities indicate the relationships between the overall change in expenditure on the selected group of fruit categories and the quantity demanded of those categories. All the estimated statistically significant expenditure elasticities had the expected positive sign, implying that the quantity demanded of all fruit categories is expected to increase when total expenditure increases, all other factors held constant. Particularly, as the total expenditure increases by 1%, on average, the quantity demanded increases by 1.760% for berries imported from Mexico, 0.988% for berries imported from Canada, 1.159% for berries imported from ROW, 0.554% for apples imported from Canada, 1.942% for apples imported from ROW, and 0.299% for avocadoes imported from Mexico. Berries imported from Mexico and ROW, and apples imported from ROW were found to be relatively more responsive to changes in total expenditure (also referred as luxury goods when the elasticity coefficient is greater than 1) while berries imported from Canada, apples imported from Canada, and avocadoes imported from Mexico were found to be relatively less responsive to the changes in the total expenditure.

Table 6. Expenditure Elasticities of Demand

i	Expenditure Elasticity	Standard Error
Berries from Mexico (1)	1.760**	0.0883
Berries from Canada (2)	0.988**	0.2464
Berries from ROW (3)	1.159**	0.1305
Apples from Canada (4)	0.554*	0.2198
Apples from ROW (5)	1.942**	0.1793
Avocadoes from Mexico (6)	0.299**	0.0873
Avocadoes from ROW (7)	0.496	0.3284

Note: Asterisk (*) and double asterisks (**) and denote statistical significant at p = 0.05 and p = 0.01 respectively.

Policy Implications. On Jan. 26, 2017, US White House spokesman Sean Spicer informed the US public that President D. Trump was 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 US border with Mexico (Flores 2017). Since this study 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 US imports in the wake of this tariff. Therefore, we estimate the impact of 20% tariff imposed on Mexico 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 a tariff on berries imported from Mexico was obtained using the estimated own-price elasticity of demand for berries. First, the own-price elasticity of demand for berries was used to estimate the percentage change in the monthly quantity of berries imported from the imposition of the tariff and then multiplied the result by the pre-tariff monthly quantity imported to obtain the expected monthly post-tariff quantity imported in tons. Second, average monthly price of berries was assumed to increase by the magnitude of the tariff to obtain after-tariff average price of berries. Third, the after-tariff quantity was multiplied by the after-tariff price to obtain the after-tariff monthly imports of berries in dollars. Finally, 20% of the total value of the new average monthly imports of berries in dollars were assumed to be the tariff revenues (Dharmasena and Capps 2012). Table 7 summarizes the calculations.

Table 7. Direct Impact of a 20% Tariff on Berries Imported from Mexico

	Berries from Mexico
Pre-Tariff Total Value of Average Monthly Imports (million $)	46.53
Pre-Tariff Total Quantity of Average Monthly Imports (1000 tons)	14.17
Pre-Tariff Average Price	3.28
Own-Price Elasticity	-0.56
Change in Total Quantity of Average Monthly Imports (%)	-11.17%
Change in Total Quantity of Average Monthly Imports (1000 tons)	-1.58
Post-Tariff Total Quantity of Average Monthly Imports (1000 tons)	12.59
Post-Tariff Average Price	3.94
Post-Tariff Total Value of Average Monthly Imports (million $)	49.61
Change in Total Value of Average Monthly imports (million $)	3.07
Change in Total Value of Average Monthly imports (%)	6.60%
Expected Tariff Revenue (million $)	9.92

Note: Monetary value of imports are in 2015 dollars.

A 20% tariff on berries imported from Mexico is expected to decrease average monthly imports of berries from Mexico by 1.58 thousand tons. Because the US demand for berries is inelastic, the tariff is expected to increase the value of total imports of berries despite the reduction in the quantity imported of berries. Therefore, holding everything else constant, the collected tariff revenues from berries are expected to be close to $10 million.

Similarly, the indirect impact of a 20% tariff was estimated using only the statistically significant cross-price elasticities of the other fresh fruits imported from Mexico included in this study. First, each statistically significant cross-price elasticity was used to determine the impact of a one percent change in the price of berries imported from Mexico on the corresponding quantity demanded of the other fresh fruits. Next, the result was augmented by the magnitude of the tariff (that is, multiplied by 20) and applied to the pre-tariff average monthly quantities imported in tons to obtain the post-tariff quantities imported in tons. Finally, the post-tariff average monthly imports were calculated by multiplying the post-tariff quantities by the average prices. Because a tariff on berries imported from Mexico is assumed to have no direct effect on the prices of the other fresh fruits, there will be no tariff revenues from the other fresh fruits (apples and avocadoes). Table 8 shows the expected indirect impact of a 20% tariff on berries imported from Mexico.

A 20% tariff on berries imported from Mexico will be expected to decrease the average monthly imports of apples from ROW by 0.33 thousand tons and to increase the average monthly imports of avocadoes from ROW (60% imported from Chile) by 0.24 thousand tons. Because of these changes in import quantities, the total value of average monthly imports are expected to decrease by $0.35 million for apples from ROW and to increase by $0.32 million for avocadoes from ROW. The combined indirect impact of a 20% tariff on berries imported from Mexico is estimated to be -$0.03 million.

The combined direct and indirect impacts from the imposition of a 20% tariff on berries imported from Mexico suggest that US monthly expenditures on berries, apples, and avocadoes is expected to increase by $6.25 million (Tables 7 and 8); and the tariff revenue is expected to be close to $10 million (Table 7).

Table 8. Indirect Impact of a 20% Tariff on Berries Imported from Mexico

	Apples from ROW	Avoca. from ROW
Pre-Tariff Total Value of Average Monthly Imports (million $)	12.68	10.54
Pre-Tariff Total Quantity of Average Monthly Imports (1000 tons)	12.01	7.96
Average Price ($/kg)	1.16	1.32
Cross-Price Elasticity Coefficients	-0.14	0.15
Change in Total Quantity of Average Monthly Imports (1000 tons)	-0.33	0.24
Change in Total Quantity of Average Monthly Imports (%)	-2.72%	3.00%
Post-Tariff Total Quantity of Average Monthly Imports (1000 tons)	11.69	8.20
Post-Tariff Total Value of Average Monthly Imports (million $)	12.33	10.85
Change in Total Value of Average Monthly imports (million $)	-0.35	0.32
Change in Total Value of Average Monthly imports (%)	-2.72%	3.00%

Note: Monetary value of imports are in 2015 dollars. Apples imported from ROW are on average 64% from Chile and 32% from New Zealand. Avocados imported from ROW are on average 60% imported from Chile and 13% from Dominican Republic.

SUMMARY AND CONCLUSION

The new USMCA is expected to have major impacts on the US dairy, pork, and poultry industries (Burfisher, Lambert, and Matheson 2019; Chepeliev, Tyner, and Mensbrugghe 2019), but minor changes to current trade trends of fruits and vegetables. Chepeliev, Tyner, and Mensbrugghe (2019) simulated the USMCA in a context of retaliatory agricultural tariffs by Canada and Mexico and found exports of fruits and vegetables experience only a minor drop. Similarly, Burfisher Lambert, and Matheson (2019) report mostly zero-base-tariff rates under the current USMCA for crops, which included vegetables, fruits, and nuts.

Our study estimated a SDAIDS for berries, apples, and avocadoes imported through NAFTA from 2005 to 2015, which is the period prior to the 2016 presidential debates and the new USMCA. The system of demand equations included imports of berries imported from Canada, Mexico, and ROW (75% imported from Chile and 20% from Argentina); apples from Canada and ROW (64% imported from Chile and 32% from New Zealand); and avocadoes from Mexico and ROW (60% imported from Chile and 13% from Dominican Republic).

Elasticities are useful for measuring consumers' responsive to changes in prices or expenditures of products or commodities. Our study found the demand for berries, apples, and avocadoes were price-inelastic; therefore, relatively less responsive to price changes. Our uncompensated own-price elasticities ranged from -0.979 for apples from ROW to -0.558 for berries from Mexico. Our results are consistent with previous studies in that in most recent years, own-price elasticities for apples are relative more elastic than berries and avocadoes (see also Table 1). As expected, cases of substitutability were more frequent than cases of complementarity. In addition, all but one of the statistically significant cross-price elasticities had positive signs. 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. There was only one statistically significant complementary relationship between berries imported from Mexico and apples imported from ROW. Last, berries imported from Mexico and ROW, and apples imported from ROW were found to be relatively more responsive to changes in total expenditure while berries imported from Canada, apples imported from Canada, and avocadoes imported from Mexico were found to be relatively less responsive to the changes in the total expenditure.

Since this study estimated import-source responses to changes in prices of fresh fruits through NAFTA, where more than 95% of the selected fresh-fruit imports come from Mexico, the study also assessed expected US import changes in the wake of a tariff on fresh-fruit imports as frequently propagated by politicians in the news. That is, the study evaluated the impact of a 20% tariff on berries imported from Mexico using the demand elasticity estimates assuming constant fresh-fruit prices. The combined direct and indirect impacts from the imposition of a 20% tariff on berries imported from Mexico suggest that US monthly expenditures on berries, apples, and avocadoes is expected to increase by \$6.25 million (Tables 7 and 8); and the tariff revenue is expected to be close to \$10 million (Table 7).

As illustrated by this study, our findings 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 United States.

The study is limited in that it analyzes only three important fresh fruits through NAFTA (berries from Mexico and Canada, apples from Canada, and avocados from Mexico). Future research may explore incorporating additional fresh fruits from Mexico and Canada. One obstacle for including additional fresh fruits in the analysis is that not all countries export fruits on a monthly basis to the United States. Another limitation of the study is that the AIDS model tends not to perform well when there are too many equations. Future research may explore models that are more suitable for handling a large number of equations such as the Exact Affine Stone Index (EASI) demand system model, which offers advantages over preceding demand systems (Hovhannisyan and Shanoyan 2019).

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