A Dynamic Application of the AIDS Model to Import Demand for Tropical Fresh Fruits in the USA

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Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

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Abstract

We estimate a dynamic version of an almost ideal demand system (AIDS) model for U.S.A. imports of fresh tropical fruits: bananas, pineapples, avocadoes, papayas, mangoes/guavas, grapes and other fresh fruit imports. An error correction model specification is justified after unit root and cointegration test results confirm nonstationarity and cointegration of the data. Estimated income elasticities show that fresh grapes and other fresh fruit imports appear to be considered luxury commodities. All own-price elasticities were negative and significant. While imported bananas, pineapples, U.S.A. grapes and other fresh fruit were quite inelastic, demand for papayas and mangoes/guavas were elastic. Fresh fruits that are shown to be complementary to imported fruits include bananas, imported grapes, U.S.A. grapes and avocados, and imported avocados/other fresh fruits.

Key Words: Tropical Fruits, Import Demand, Almost Ideal Demand Systems, Error Correction

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Introduction

Demand for fresh fruits has risen in the U.S. for the last three decades due to a combination of factors. The purchasing power of U.S. consumers rose over the years due to rising personal income, while research evidence in health, food, and nutrition also modified U.S. consumer perceptions and habits toward consuming more fresh fruits and vegetables. The heightened influx of an immigrant population accustomed to fresh-produce diets, mainly Asians, Africans, the Caribbean and Hispanic populations, have also impacted the demand for fresh fruits.

Supply factors, such as the largely unfavorable U.S. continental climate and a limited farm labor supply, on the other hand, have restricted the ability of U.S. producers to respond to the rising demand, making imports the more viable solution to satisfy the rising demand for fresh fruits (Martin & Thompson, 1992; Pollack, 2001; Lucier, Pollack, Ali, & Perez, 2006; Huang & Huang, 2007; Wells & Buzby, 2008; Nzaku, Houston, & Fonsah, 2010). Free trade agreements, such as NAFTA and CAFTA, and technological advances in shipping and handling of fresh produce have also provided more access to fresh fruit imports over longer periods of time. Thus, the importance of imports to U.S. fresh fruit consumption continues to grow.

According to USDA reports, between 1985 and 2005, the import share of U.S. fruit consumption rose from 2.3 percent to 15.5 percent for citrus and from 41.2 percent to 53 percent for non-citrus fruits (Huang & Huang, 2007). The import share is even higher for U.S. tropical fruits consumption, due to climatic factors. The annual value of fresh fruits and vegetable imports increased from US$2.7 billions to US$7.9 billions from 1992 to 2006, of which tropical fresh fruits were the primary imports. The main fresh fruit imports comprise of bananas, grapes, and other tropical fruits such as guavas, mangoes, and papayas with bananas accounting up to 44% of the total imported fresh fruits. These fruits largely originate from banana-exporting countries, the southern hemisphere, and Mexico (Huang and Huang 2007).

Despite these developments, few studies have examined demand for fresh fruits imports, particularly tropical fruits. Most of the available literature focuses on the competitiveness of U.S. farm fresh produce in general or in the domestic market (You, Epperson, & Huang, 1996; Cook, 2001; Pollack, 2001) and on the main U.S. export markets for fresh (Lee, Seale, & Jierwiriyapant, 1990; Seale, Sparks, & Buxton, 1992; Sparks, 1992; Yang & Koo, 1994; Andayani & Tilley, 1997; Schmitz & Seale, 2002). Little reference has been made to the U.S. fresh fruit import market except for bananas and the import demand for fruit juices (Fonsah & Muhammad, 2008).

This study contributes to the few existing published studies by analyzing the short-run U.S. import demand for the top tropical fresh fruits, which comprise the bulk of U.S. fresh fruit imports. We estimated a dynamic version of the Almost Ideal Demand System (AIDS) model for U.S. imports of tropical fresh fruits by incorporating cointegration and an error correction concept. The fresh tropical fruits selected for the study include bananas, pineapples, avocadoes, papayas, mangoes/guavas and grapes. For comparative coverage, all other fresh fruit imports and U.S fresh grapes are included in the estimated system. The objectives of the study are to estimate the short-run elasticities of demand for the major tropical fresh fruits imported to the U.S.

The remainder of the paper is organized in sections as follows. A brief review of tropical fresh fruit imports and the related literature are presented in the next two sections. A detailed presentation of the methods of analyses and a description of the data, results and discussion are followed by implications and conclusions.

Trends and Literature Review

Since the late 70's, U.S. demand for fresh fruits and vegetables, and especially for tropical fruits, has been rapidly increasing due to rising U.S. consumer incomes, nearly acquired taste by Americans who have lived overseas, increased awareness of the health benefits of consuming more fresh produce, and the growing immigrant populations in the U.S., especially Africans, the Caribbean, Asians and Hispanics. These cultures typically incorporate more fresh produce into their diets. However, the ability to raise domestic production to meet the increased demand of tropical fresh fruits is impaired by an unfavorable climate and the availability of farm labor, given the labor-intensive nature of fresh fruit production (Martin & Thompson, 1992; Cook, 2001; Huang & Huang, 2007). Consequently, the U.S. is mainly dependent on imports to satisfy its demand for tropical fresh fruits.

Although the demand for fresh fruit imports has risen steadily over the last three decades, most of that growth was for tropical fresh fruits, mainly mangoes/ guavas, papaya, pineapples, avocados, and fresh grapes. The picture in Figure 1 shows the growth of U.S. imports of fresh fruit imports from 1990 to 2006. The value of fresh imported pineapples, mangoes, guavas, papayas, and avocados was six times greater in 2006 compared to 1990, while the imported value for grapes in 2006 grew by over 250 percent compared to 1990. Fresh bananas, which comprise the bulk of fresh fruit imports, showed no significant growth during that entire period (Huang & Huang, 2007).

U.S. fresh fruit import supply is dominated by a few regions, perhaps due to high transport costs, the perishability of fresh fruits, and sanitary and phytosanitary (SPS) controls (U.S. Department of Agriculture, 2008a; U.S. Department of Agriculture, 2008b). The main sources of U.S. fresh fruit imports are the so-called "banana-exporting countries", the southern hemisphere countries, and NAFTA partners. The banana exporting countries include Colombia, Costa Rica, Ecuador, Guatemala, Honduras and Panama and supply 36% of fresh fruit imports, of which two-thirds are bananas (Huang & Huang, 2007). Second to the banana-exporting countries in supplying U.S. with fresh fruits imports are the Southern Hemisphere countries, which include Argentina, Australia, Brazil, Chile, New Zealand, South Africa, and Peru. Together, Southern Hemisphere countries supply 32% of U.S. fresh fruit imports. The third major source of U.S. fresh fruit imports is NAFTA, which contributes approximately 27% of the total fresh fruit imports, mostly from Mexico (Cook, 2001; Huang & Huang, 2007; U.S. Department of Agriculture, 2007).

The entry of more trading partners, such as the Dominican Republic-Central America Free Trade Agreement (CAFTA-DR) and the Chile-U.S. Free Trade Agreement, further improved the availability of imports and encouraged more consumption of exotic fresh fruits. Other supply factors that have encouraged imports include improved technology in shipping and storage, U.S. farm labor shortages and costs, and a largely unfavorable U.S. continental climate (Lucier, Pollack, Ali, & Perez, 2006). As a result, the U.S. increasingly depends on importation of tropical produce to satisfy its domestic demand.

Modeling Approach

Common import demand analysis approaches involve the use of consumer demand theory or production theory. The consumer demand theory approach treats imports as final products that directly enter a consumer's utility function (Schmitz & Seale, 2002), while production theory treats imports as inputs (Washington & Kilmer, 2002). The consumer demand theory approach enables the derivation of traditional consumer demand and labor supply functions from utility maximization. On the other hand, input demand and output supply functions from profit maximization or cost minimization can be obtained from the production theory approach.

Applications of consumer approach to import demand analysis are extensive and include empirical models such as the Armington model (Armington, 1969), AIDS model (Deaton & Muellbauer, 1980) and Rotterdam model (Theil, 1980). However, imports may not be fully treated as final goods (Lee, Seale, & Jierwiriyapant, 1990; Seale, Sparks, & Buxton, 1992). This is because most imported goods are intermediate commodities which require certain processing or repackaging before they are finally distributed to the consumer (Washington & Kilmer, 2002; Muhammad, Jones, & Hahn, 2007). In such cases, a production approach is better able to estimate import demand. However, in the case of fresh fruits and vegetables in this study, there is very little value-added processing involved, and the fresh produce is justifiably classified as final goods, implying that the AIDS model is appropriate.

Following Deaton and Muellbauer (1980; 1993), the AIDS model can be expressed as follows:

$$w_i = \alpha_i + \sum \gamma_{ij} \ln p_j + \beta_i \ln(Y / P^*) + u_i \tag{1}$$

where w_i is the expenditure share of good *i*, *y* is total expenditure, u_i denotes the disturbance term, and P^* is a price index defined as,

$$\ln P^* = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \tag{2}$$

Based on consumer demand theory, adding up and homogeneity conditions hold if $\sum_i \alpha_i = 1$ and $\sum_j \gamma_{ij} = 0$ while symmetry restrictions require that $\gamma_{ij} = \gamma_{ji}$. The intercept α_i represents the subsistence consumption of commodity i, and the β_i's represent the change in commodity i's expenditure share with respect to change in real income, ceteris paribus. Commodity i if $\beta_i > 0$ and a necessity if $\beta_i < 0$. The price coefficients, γ_{ij}, represent the change in the ith budget share with respect to a percentage change in the jth price, with real expenditures held constant. If $\gamma_{ij} > 0$, goods i and j are considered substitutes, whereas, if $\gamma_{ij} < 0$, they are considered complementary goods.

The nonlinear price index P^* in equation (2) poses some empirical challenges. To mitigate the possible estimation difficulties, we adopt the geometric weighted average index proposed by Moschini (1995):

$$\ln P^* = \sum w_i^0 \ln p_i \ , \tag{3}$$

where w_i^0 is the mean budget share for commodity j.

The Marshallian (uncompensated) demand elasticities from the linearized model are calculated as follows:,

$e_{ij} = \delta_{ij} - \left(\frac{\gamma_{ij}}{w_i}\right) - \beta_i \left(\frac{w_j}{w_j}\right)$, where $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ for $i \neq j$ (price elasticity),

$$\eta_i = 1 + \left(\frac{\beta_i}{w_i}\right) \text{ (expenditure elasticity)} \tag{4}$$

The Hicksian (compensated) price elasticities can be calculated from the Marshallian elasticities as,

$$\varepsilon_{ij} = e_{ij} + \eta_i w_j \,. \tag{5}$$

The AIDS model presented thus far assumes that consumption is always in equilibrium, which is not always true, especially with time series data. In reality, habit persistence, adjustment costs, imperfect information and incorrect expectations interfere with instant expenditure adjustment to prices and income changes. A recommended practice is to undertake stationarity and cointegration tests when working with time series data to determine if the data are nonstationary and/or cointegrated. Nonstationarity in variables and the presence of cointegration in the equations would jeopardize the consistency of the parameters. In such cases, a dynamic version of the AIDS model is more suitable. We tested for stationarity and cointegration in our prices, expenditures shares and real expenditure using the Philips Perron test. We then modified the AIDS model to an Error Correction Model version (ECM-AIDS), following Banerjee, Dolado, & Smith (1986), Karagiannis, Katranidis, & Velentzas (2000), and Kremers, Ericsson, & Dolado (1992) as follows:

$$\Delta w_i = \varphi_i \Delta w_{it-1} + \sum_j \sum_i^n \gamma_{ij} \Delta \ln p_j + \beta_i \Delta \ln(y / P^*) + \lambda_i u_{it-1} + \nu_i \qquad (5)$$

where Δ denotes the difference operator and u_{it-1} are the lagged estimated residuals from the cointegration equations. The term ϕ_i is the deviation of actual budget shares in the previous period, w_{it-1}. The ECM-AIDS is then estimated by iterated seemingly unrelated regression (ISUR). Adding-up and symmetry conditions are expected to hold, just as in the AIDS model.

Data

The selected U.S. tropical fresh fruit imports included bananas, pineapples, papayas, mangoes/guavas, grapes, avocados, and all other imported U.S. fresh fruits. To capture the effects of imported grapes on U.S. fresh grapes, domestic fresh grapes supply was included in the analysis. Although the U.S. supplies some avocados and pineapples, mainly from California and Hawaii, they were excluded in this analysis because their contribution were relatively unimportant and the price data were unavailable.

The data utilized in this study were monthly quantities, Cost, Insurance, and Freight (CIF) import values from USDA's Foreign Agricultural Service, measured in metric tonnes and thousand U.S. dollars, respectively. The data sample ranged from January 1989 through December 2008. CIF import values were preferred to avoid the exclusion of shipping costs of tropical fresh fruits. Monthly per-unit values were calculated by dividing the monthly import values by quantities for all the selected tropical fresh imports and were used as proxies for import prices. For U.S. grapes, monthly shipments of fresh grapes were sourced from USDA's Agricultural Marketing Service to serve as a proxy for U.S. domestic quantities of fresh grapes. The prices of U.S. grapes were obtained from the Economic Research Service Fruits and Nuts Yearbooks.

Monthly expenditures were calculated from the quantities and prices, following which the total expenditure was derived by adding up all the individual fruit group expenditures. For each fresh fruit, expenditure shares were derived by dividing the total outlay by the individual fresh fruit expenditure. A dummy variable was also introduced to capture the effect of NAFTA trade policies since 1995 when NAFTA was enacted. A summary of the average monthly quantities, prices, expenditures, and budget shares is shown in Table 1. The graph in Figure 2 presents the evolution of aggregate cereal budget shares of the selected tropical fresh fruits. Although the graphs showed the presence of seasonality and trends in the expenditure shares, formal unit tests and cointegration tests were needed to confirm the presence of unit roots in the data series.

Results

The Phillips-Perron unit and cointegration tests shown in Table 2 demonstrated that the price series, real expenditures, and budget shares were nonstationary at the 10% significance level. Cointegration was present in all the fresh fruit expenditure share equations at the 10% significance level. All the unit root and cointegration statistic values were smaller than the critical values of -3.13 and -4.42, respectively, thus justifying the application of an error correction specification of the model.

Since cointegration tests are known to have a low power, we adopted Banerjee, Dolado, & Smith (1986) and Kremers, Ericson, & Dolado (1992) approach to test for cointegration. The procedure involved the estimation of an error correction model, followed by a test for the significance of the error correction term. If the null hypothesis is not rejected, then the series are not cointegrated. This step includes the estimation of the dynamic AIDS model using TSP 5.0 by the ISUR technique. Adding-up, homogeneity and symmetry conditions were imposed to conform to demand theory. To avoid singularity problems, the equation for papaya expenditure shares was dropped from estimation and its parameters derived from economic theory restrictions.

Results of the ECM-AIDS model are presented in Table 3. As shown, the error correcting coefficient is negative and significant at the 1% level in all the expenditure share equations, which supports the Phillips-Perron test for cointegration. Table 3 also presents the estimated coefficients of the ECM AIDS model.

Estimated ECM expenditure parameters for grapes and other fresh fruit imports were positive, implying that these two fresh fruit groups were considered luxuries. While this finding was expected, we did not expect that mangoes/guavas, papaya, and avocado would appear to be necessities. NAFTA trade policy seems not to be important to U.S. tropical fresh fruit expenditure shares, perhaps reflecting little or no change in tariff conditions for non-competitive (tropical) commodities.

The estimated short-run (monthly) elasticities of demand for the tropical fresh fruits analyzed were calculated at sample means. Uncompensated elasticities of demand are presented in Table 4, while the compensated demand and expenditure elasticities are shown in Table 5. In the interest of brevity, however, we restrict our discussion to the compensated demand and expenditure elasticities in Table 5.

All the expenditure elasticities of demand were positive and significant at the 0.01 level, confirming that the expenditure shares for imported fresh fruits were sensitive to changes in income. The expenditure elasticities for fresh grapes imports and other U.S. fresh fruit imports were greater than one (3.3193 and 1.2355 for imported fresh grapes and other fresh fruits respectively), thus implying that they were luxury goods. Bananas are staple commodities in U.S. consumption, mainly consumed for breakfast and desert. It was, therefore, not surprising that the short-run expenditure elasticity for bananas was 0.2491. The short-run expenditure elasticities for imported fresh pineapples and papaya were 0.4179 and 0.4612, respectively, implying that these two exotic fresh fruits were also quite inelastic, thus contrary to our expectations. Avocado and U.S. fresh grapes expenditure elasticities were also less than unitary, 0.7998 and 0.7884, respectively.

Own-price elasticities of demand for all eight imported fresh fruits had the expected negative sign and were significant at the 0.01 and 0.05 levels, confirming that they were considered normal goods. Own-price elasticities range from -0.0952 for bananas to -1.3869 for mangoes/guavas. Fresh papaya and fresh mango/guava import expenditure shares were shown to be price elastic, which was expected, given their exotic nature. Own-price elasticities of demand for papaya and mango/guavas were -1.3211 and -1.3869, respectively, implying that the short-run expenditure shares increased by about 1.32% and 1.39%, respectively, given a 1% percent decrease in the respective prices.

The magnitude of own-price elasticity of imported banana was quite small compared to the -0.4236 reported by You, Epperson, & Huang (1996) and -0.4999 by Huang & Lin (1987). This very inelastic response was, however, very likely to be related to the monthly time period for changes in the demand specification of the ECM-AIDS. The price of fresh pineapple imports was also quite inelastic, at -0.3883, implying that if the price of imported fresh pineapple increased by 10%, the expenditure shares of imported fresh pineapples would decrease by only 3.9%. Similarly, the own-price elasticities of demand for other U.S. imported fresh fruit and U.S. fresh grapes were also inelastic within this short time adjusting period; -0.4212 and -0.3758, respectively. This finding was counter to our expectations for the demand for exotic fresh fruits to be very sensitive to own prices. Fresh grape imports and fresh avocado, on the other hand, were only slightly price inelastic at -0.6062 and -0.8524.

Table 5 also showed the estimated cross-price elasticities of demand, which were important in determining the short-run demand relationships of the various imported fresh fruits. The fruits that appeared to be complementary goods included bananas and fresh grapes imports, avocados and U.S. fresh grapes, and avocados and other fresh fruit imports. Their respective cross-price elasticities were negative and significant at the 10% levels or better.

Fresh avocado imports appeared to be significant substitutes with bananas, papayas, mangoes/guavas, and imported fresh grapes, as their respective cross-price elasticities of demand were positive and significant. Although imported fresh grapes were believed to complement domestic supply of fresh grapes during winter months, our results showed the contrary. The demand for imported fresh grape and U.S. fresh grapes imply that the two were significant substitutes. Fresh grape import expenditures increased by 1.9%, if the prices of U.S. domestic grapes increased by 10%. This short-run finding could be attributed to the overlapping of grapes seasons over the years. Other significant fresh fruit substitutes included bananas and mangoes/guavas, papaya and pineapples, and fresh grapes imports and mangoes/guavas.

Conclusions

Demand for tropical fresh fruits was analyzed using a dynamic, error correction Almost Ideal Demand System model to determine relationships among the leading U.S. fresh fruit imports. The fruits chosen for the study included imported fresh bananas, pineapples, papaya, mangoes/guavas, grapes, avocados, and other imported fresh fruit, as well as domestic table grapes. Unit root and cointegration tests results showed that all the series were nonstationary and cointegrated, hence justifying an error correction specification of the AIDS model.

The inception of NAFTA does not appear to influence trade policy for tropical fresh fruit imports, perhaps due to the fact that, with an exception of mangoes, these commodities originated largely from non-NAFTA countries. All the fresh fruits expenditure shares were significant and positively responded to real income/expenditures, reinforcing the industry's perceptions that consumer incomes were a major determinant of U.S. fresh fruit imports and that all the fresh fruits were normal goods. Fresh grape imports and other fresh fruit imports were found to be luxury commodities, while bananas were shown to be staple goods.

Among the imported fresh fruits, papayas and mangoes/guavas were shown to be own-price elastic, while bananas, pineapples, other fruit imports and U.S. grapes were price inelastic in the short run. These findings also showed that imported fresh grape were significant substitutes to domestic grapes, although they were purportedly meant to complement domestic supply seasonally. Avocados appear to be substitutes with bananas, papaya, mangoes/guavas, and grape imports. In other pairings, bananas and mangoes/guavas, pineapples and papaya, and mangoes/guavas and grape imports also demonstrate substitute relationships. On the other hand, complementary fresh fruit pairings included bananas and grape imports, avocado and other fruit imports and U.S. grapes. Although some of the findings differed from our *a priori* expectations, the study provided dynamic, short-run elasticity estimates for U.S. fresh fruit imports for many tropical fruits, such as mangoes, papaya, avocados and pineapples, which were unavailable in the existing literature.

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Table 1. Monthly Average Quantities, Expenditures, Prices, and Expenditure Shares of U.S. Tropical Fresh Fruit Imports, 1989:1 – 2008:12.

Tropical Fresh Fruit	Monthly Average			
	Quantity (MT)	Price (US$/MT)	Expenditures (US$ 1000)	Shares
Banana Imports	328316.5	354.96	116326.00	0.3569
Pineapple Imports	26596.8	526.45	15537.20	0.0378
Papaya Imports	5404.8	675.05	3751.36	0.0094
Mango/Guava Imports	16396.1	1019.01	13424.90	0.0359
Grapes Imports	35975.9	1455.55	54094.30	0.1331
Avocado Imports	8183.8	1356.76	12593.70	0.0284
All Other Fruit Imports	131452.8	721.24	95638.50	0.2432
U.S. Grapes	53075.2	1185.03	116326.00	0.1554

Table 2. Unit root and Cointegration Tests of Monthly U.S. Domestic and Import Demand for Tropical Fresh Fruits, 1989-2008.

Fresh Fruit Share	Label	Phillips Perron Test	
		Unit Root	Cointegration
Bananas	S1	-10.689	-13.521
Pineapple	S2	-6.5119	-9.7897
Papaya	S3	-4.7768	-8.2909
Mango/Guavas	S4	-7.0149	-9.6486
Grapes	S5	-7.1414	-9.2496
Avocados	S6	-6.2447	-7.9932
Other Fruits	S7	-7.7598	-10.247
U.S. Grapes	S8	-7.3276	-8.4329
Log Prices			
Bananas	LNP1	-4.4100	
Pineapple	LNP2	-5.3567	
Papaya	LNP3	-4.5395	
Mango/Guavas	LNP4	-7.3855	
Grapes	LNP5	-11.552	
Avocados	LNP6	-7.0697	
Other Fruits	LNP7	-8.7277	
U.S. Grapes	LNP8	-9.9580	
Real Expenditure (log)	LN E	-10.007	

Critical values at 10% are -3.13 and -4.42 for unit root and cointegration tests, respectively.

Table 3. Estimated Coefficients of ECM-LA/AIDS for U.S. Domestic and Imported Fresh Fruits, 1989–2008.

	BANANA$_{IM}$ Δs_1	**PINEAP$_{IM}$** Δs_2	**PAPAYA$_{IM}$** Δs_3	**MANGO /GUAVA$_{IM}$** Δs_4	**GRAPES$_{IM}$** Δs_5	**AVOCAD$_{IM}$** Δs_6	**OTHER FRUITS$_{IM}$** Δs_7	**GRAPES$_{US}$** Δs_8
Δs_{it-1}	0.0793*** 0.0182	0.0383* 0.0221	-0.4937*** 0.1261	0.0746*** 0.0195	0.0733*** 0.0178	0.0682*** 0.0190	0.0828*** 0.0179	0.0773*** 0.0179
$\Delta \ln p_1$	0.1956*** 0.0150							
$\Delta \ln p_2$	-0.0095* 0.0051	0.0217*** 0.0040						
$\Delta \ln p_3$	-0.0014 0.0016	0.0015* 0.0009	0.0031*** 0.0012					
$\Delta \ln p_4$	0.0029 0.0053	0.0006 0.0017	-0.0006 0.0005	0.0151*** 0.0035				
$\Delta \ln p_5$	-0.0707*** 0.0047	-0.0032*** 0.0012	-0.0005* 0.0003	0.0038* 0.0022	0.0347*** 0.0122			
$\Delta \ln p_6$	-0.0003 0.0055	0.0037** 0.0019	0.0009** 0.0004	0.0150*** 0.0025	0.0010 0.0021	0.0034 0.0035		
$\Delta \ln p_7$	-0.0731*** 0.0100	-0.0106*** 0.0026	-0.0018*** 0.0006	-0.0009 0.0042	0.0307*** 0.0077	-0.0138*** 0.0040	0.0816*** 0.0129	
$\Delta \ln p_8$	-0.0436*** 0.0055	-0.0043*** 0.0014	-0.0012*** 0.0003	-0.0057** 0.0026	0.0041 0.0126	-0.0100*** 0.0025	-0.0121 0.0104	0.0727*** 0.0177
$\Delta \ln E$	-0.2683*** 0.0143	-0.0220*** 0.0035	-0.0050*** 0.0008	-0.0329*** 0.0065	0.3093*** 0.0355	-0.0057 0.0063	0.0573* 0.0294	-0.0328 0.0469
u_{t-1}	**-0.5001*** 0.0225**	**-0.4805*** 0.0250**		**-0.5009*** 0.0233**	**-0.5070*** 0.0225**	**-0.4672*** 0.0221**	**-0.5122*** 0.0226**	**-0.5090*** 0.0225**
Nafta	0.0005 0.0024	-0.0002 0.0006		0.0001 0.0011	-0.0006 0.0061	-0.0001 0.0011	0.0015 0.0051	-0.0013 0.0080

Notes: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1. Below the estimated parameters, are the respective standard errors. IM= Imports. US=U.S. domestic supply.

Table 4. Uncompensated Elasticities of Demand for ECM-LA/AIDS for U.S. domestic and Imported Tropical Fresh Fruits, 1989–2008.

	$BANANA_{IM}$	$PINEAP_{IM}$	$PAPAYA_{IM}$	$MANGO/GUAVA_{IM}$	$GRAPES_{IM}$	$AVOCADO_{IM}$	$OTHER\ FRUITS_{IM}$	$GRAPES_{US}$	REAL Expenditure
$BANANA_{IM}$	**-0.1842*** ** **0.0447**	0.0019 0.0142	0.0030 0.0045	0.0351** 0.0148	-0.0979*** 0.0124	0.0205 0.0154	-0.0220 0.0284	-0.0055 0.0190	0.2491*** 0.0399
$PINEAPPLE_{IM}$	-0.0425 0.1377	**-0.4041*** ** **0.1049**	0.0465 0.0239	0.0366* 0.0461	-0.0065 0.0302	0.1151** 0.0506	-0.1391** 0.0694	-0.0238 0.0455	0.4179*** 0.0936
$PAPAYA_{IM}$	0.0387 0.1761	0.1867** 0.0971	**-1.3254*** ** **0.1243**	-0.0438 0.0523	0.0209 0.0268	0.1094** 0.0476	-0.0666 0.0703	-0.0419 0.0405	0.4612*** 0.0858
$MANGO/GUAVA_{IM}$	0.4099** 0.1625	0.0513 0.0492	-0.0078 0.0137	**-1.3898*** ** **0.0974**	0.2287*** 0.0579	0.4457*** 0.0692	0.1979* 0.1188	-0.0169 0.0889	0.0810 0.1820
$GRAPES_{IM}$	-1.3590*** 0.1023	-0.1113*** 0.0143	-0.0252*** 0.0034	-0.0546*** 0.0191	**-1.0489*** ** **0.0838**	-0.0577*** 0.0187	-0.3335*** 0.0769	-0.3292*** 0.1197	3.3193*** 0.2665
$AVOCADO_{IM}$	0.0621 0.2076	0.1394** 0.0677	0.0311** 0.0156	0.5396*** 0.0867	0.0634 0.0704	**-0.8750*** ** **0.1239**	-0.4403*** 0.1447	-0.3219*** 0.1078	0.7998*** 0.2228
$OTHER\ FRUITS_{IM}$	-0.3847*** 0.0602	-0.0525*** 0.0117	-0.0098*** 0.0028	-0.0122 0.0176	0.0950*** 0.0310	-0.0634*** 0.0172	**-0.7217*** ** **0.0544**	-0.0863 0.0540	1.2355*** 0.1211
$GRAPES_{US}$	-0.2053* 0.1114	-0.0198 0.0150	-0.0056 0.0035	-0.0292 0.0193	0.0545 0.0739	-0.0583*** 0.0191	-0.0266 0.0809	**-0.4981*** ** **0.1435**	0.7884*** 0.3022

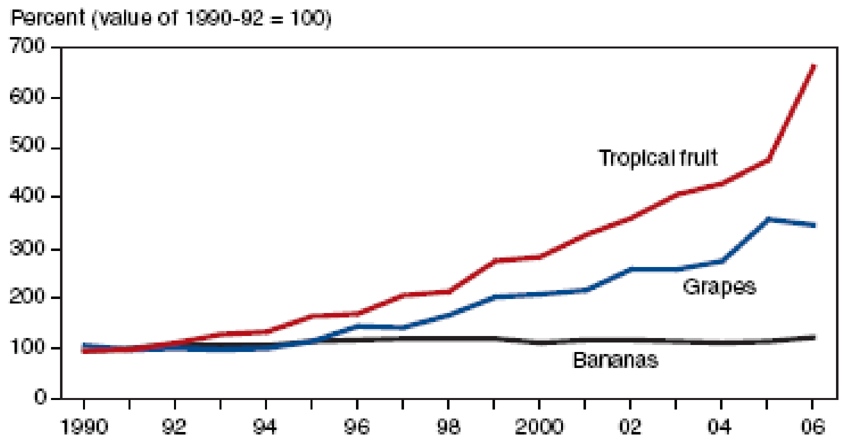
Notes: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1%. Below the estimated elasticities, are the respective standard errors. IM= Imports. US=U.S. domestic supply.

Table 5. Expenditure and Compensated Elasticities for ECM-LA/AIDS for U.S. Domestic and Imported Tropical Fresh Fruits, 1989 – 2008.

	$BANANA_{IM}$	$PINEAP_{IM}$	$PAPAYA_{IM}$	MANGO $/GUAVA_{IM}$	$GRAPES_{IM}$	$AVOCAD_{IM}$	OTHER $FRUITS_{IM}$	$GRAPES_{US}$	REAL Expenditure
$BANANA_{IM}$	**-0.0952****	0.0113	0.0053	0.0440***	-0.0646***	0.0275*	0.0386	0.0332**	0.2491***
	0.0420	0.0141	0.0045	0.0148	0.0133	0.0153	0.0280	0.0153	0.0399
$PINEAPPLE_{IM}$	0.1068	**-0.3883*****	0.0504**	0.0516	0.0492	0.1269**	-0.0375	0.0410	0.4179***
	0.1338	**0.1048**	0.0239	0.0461	0.0325	0.0503	0.0686	0.0369	0.0936
$PAPAYA_{IM}$	0.2034	0.2041**	**-1.3211*****	-0.0273	0.0824***	0.1224***	0.0456	0.0296	0.4612***
	0.1737	0.0970	**0.1243**	0.0523	0.0294	0.0474	0.0673	0.0328	0.0858
MANGO / $GUAVA_{IM}$	0.4389***	0.0544	-0.0071	**-1.3869*****	0.2395***	0.4480***	0.2176*	-0.0043	0.0810
	0.1475	0.0486	0.0136	**0.0977**	0.0620	0.0685	0.1167	0.0719	0.1820
$GRAPES_{IM}$	-0.1731***	0.0139	0.0363	0.0643***	**-0.6062*****	0.0360**	0.4737***	0.1856**	3.3193***
	0.0356	0.0092	0.0946	0.0166	**0.0915**	0.0160	0.0575	0.0942	0.2665
$AVOCADO_{IM}$	0.3478*	0.1696**	0.0385**	0.5682***	0.1701**	**-0.8524*****	-0.2458*	-0.1979**	0.7998***
	0.1935	0.0672	0.0158	0.0869	0.0758	**0.1228**	0.1427	0.0868	0.2228
OTHER $FRUITS_{IM}$	0.0567	-0.0058	0.0017	0.0320*	0.2598***	-0.0285*	**-0.4212*****	0.1053**	1.2355***
	0.0411	0.0106	0.0026	0.0172	0.0315	0.0166	**0.0531**	0.0428	0.1211
$GRAPES_{US}$	0.0764**	0.0100	0.0018	-0.0010	0.1596**	-0.0360**	0.0956	**-0.3758*****	0.7884***
	0.0353	0.0090	0.0020	0.0166	0.0811	0.0158	0.0633	**0.1143**	0.3022

Notes: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1%. Below the estimated elasticities, are the respective standard errors. IM= Imports. US=U.S. domestic supply.

Figure 1. Import value growth of nontraditional fresh fruit, 1990-2006



Source: USDA, ERS, 2007