An Empirical Analysis of the U.S. Import Demand for Nuts

by

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Abstract

The U.S. is one of the world's major producers and importers of nuts, with 9% average increase in imports in the last decade (1996-2016). Given that nuts account for, on average, 18% of the U.S. total imports of fruits, it is important to empirically analyze and better understand the U.S. demand for nuts. This study estimates import elasticities of demand using an Almost Ideal Demand System (AIDS) and quarterly data reported by the USCIS for the period of 1996-2016. The parameter estimates of the AIDS model were employed to estimate the elasticities of demand for coconuts, brazil nuts, cashews, almonds, hazelnuts, walnuts, chestnuts, and pistachios. Other nuts as pecans and peanuts are included in the category "other". Additional adjustments were made to the empirical model in order to account for seasonality and trend, as well as to provide necessary remedies for serial correlation and endogeneity. Our results revealed that all Marshallian own-price elasticities had the expected negative signs and in absolute terms were greater than one indicating that the U.S. demand for these nuts was price-elastic for the period analyzed. The Hicksian cross-price elasticities indicated both complementary relationships and substitutability between the selected nut types.

Introduction

Nuts contain protein, fiber, unsaturated fats, and important vitamins and minerals. The U.S. consumption of tree nuts amounted to 4.08 pounds per person per year in 2015 (2017) with Vietnam, Mexico, and India accounting for 56% of the U.S. imports (Table 1). United States production is forecast up 5 percent to record 1.0 million tons on continued area expansion, although yields are expected to drop slightly (USDA 2017). The U.S. is also one of the world's major producers and importers of nuts, with a 9% average increase in imports for the period of 1996-2016 (add source here). With nuts on average accounting for 18% of the total fruit imports (add source here), it is important to analyze recent trends in the U.S. demand for nuts. Estimation of import demand elasticities is an effective approach for building economic models and predicting possible development scenarios for international trade.

Few studies have estimated the U.S. demand for nuts. The authors are not aware of recent studies that analyze the U.S. import demand for nuts. The main objective of this study is to analyze the U.S import demand for nuts while the specific objectives are to estimate and interpret the Marshallian own-price, Hicksian cross-price, and expenditure elasticities of demand; and to discuss the policy implications from this study’s findings.

Literature Review

Few studies have examined the demand for nuts at the retail level in the U.S. Lerner (1959)examined the demand interrelationships between improved pecans and seedling or native pecans, and among pecans and other tree nuts. The results suggested that the estimated own-price elasticities were -2.73 for native pecans and -3.44 for improved pecans, estimated cross-price elasticities suggested that pecans and walnuts were complementary nuts while pecans and filberts, pecans and almonds, and walnuts and almonds were substitute nuts. Ibrahim, and Florkowski (2009) attempted to forecast the U.S. tree nuts prices over the period 1992-2006 by using a vector auto regression model with Johansen cointegration technique, in which a little evidence of long run relationship among the prices of pecan, walnut, and almond was revealed. Russo, Green, and Howitt (2008) examined price elasticities of supply and estimated own-price, cross-price, and income elasticities of demand for several California commodities at the retile level, including almonds and walnuts, by applying Box-Cox specification and the nonlinear AIDS. The study results revealed inelastic own-price elasticities for almonds and walnuts and no substitution between almonds and walnuts. In extant literature there are several studies focusing on promotion of nuts both in local and in international markets. Halliburton and Henneberry (1995) evaluated federal government's programs for almond export in five countries of the Pacific Rim and concluded that the programs are not effective in South Korea and Singapore. Onunkwo and Epperson (2001) examined the U.S. export promotion programs effect on the foreign demand of walnuts, pecans and almonds and summarized the results in several studies. Moore et al. (2009) evaluated the economic effectiveness of the Texas Pecan Checkoff Program, which confirmed its success on increasing sales of improved varieties of Texas pecans.

Guo Cheng et al. (2017) tried to explore consumers' variety-seeking behaviors by utilizing nuts market data. They found that consumptions of nuts products that are not sensitive to their prices only account for a small amount. Consequently, utilizing demand analysis to address demand interrelationships among nuts products are meaningful since consumers do respond to price change of 90% of total consumptions. The study also revealed that the consumers do seek variety when facing tree nuts products.

Model

After Almost Ideal Demand System was first introduced by Deaton and Muelbauer in (1980), it has gained wide popularity and became more flexible and applicable. At each level of utility, the AIDS model assumes that the consumers minimize expenditure to realize the given utility (Deaton 1980). In this study the AIDS model was estimated as:

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

where i and j represent any two nuts; w_i is the import expenditure share for i^{th} nut; p_j is the import price of j^{th} nut; X is total import expenditures on all goods included in the model; t represents a trend variable; $\alpha_i,\ \gamma_{ij},\ \beta_i, c_i\ s_i$ and z_i are the population parameters that will be estimated by the model; P is a nonlinear price index; $sin_t=f(t,SL)$ *and* $cos_t=g(t,SL)$ are trigonometric functions capturing seasonality; ρ is the first-order autoregressive coefficient; and ε_i is an error term.

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

$$(2) \qquad \varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta_i(\alpha_j + \sum_{k=1}^{n}\gamma_{jk}\log(p_k))}{w_i}$$

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

$$(3) \qquad \varepsilon_{ix} = 1 + \frac{\beta_i}{w_i}.$$

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

$$(4) \qquad e_{ij} = \varepsilon_{ij} + w_i * \varepsilon_{ix}.$$

Seasonality is very common in Agriculture. There are several ways to capture it, including the use of dummy variables and harmonic regression. The dummy variable method introduces binary variables that take the value of 1 if the given season and 0 if otherwise. The method of harmonic regression consists of including two additional trigonometric variables, *sine* and *cosine*, in the model. The sine and cosine variables have the following general forms:

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

and

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

where t_i is the corresponding trend variable taking up the value of 1 for the first observation and the value n for the n^{th} observation; π is a mathematical constant approximately equal to 3.1416; and SL is the seasonal length which is equal to 12 for the monthly data. This study uses a Harmonic regression model to capture the seasonality.

Endogeneity of the expenditure is a modeling issue encountered in systems of demand equations (Attfield 1985). In this study, total expenditure is defined as the sum of expenditures on all selected types of nuts, while the expenditure share, w_i is defined as the ratio of the i_{th} expenditure share to the total expenditure, causing the endogeneity of the total expenditure. To deal with 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:

(7) $$\log(X) = \alpha_0 + \sum_i \vartheta_i \log(p_i) + g\log(GDP) + \varepsilon_i$$

where *log(X)* is the logarithm of total expenditure; p_i is the price of i^{th} nut; GDP is the real monthly gross domestic product; α_0, g, and v_i, are population parameters to be estimated; and ε_i is an error term.

Data

This study analyzes data on quarterly imports (in dollars and kilograms) of 8 nuts (coconuts, Brazil nuts, cashews, almonds, hazelnuts, walnuts, chestnuts, and pistachios) for 10 years from 2006 to 2016 from the United States International Trade Commission (USITC 2017). Nut prices were adjusted for inflation, using the CPI reported by the U.S. Bureau of Labor Statistics (2017). The U.S. quarterly Gross Domestic Product data reported by the U.S. Department of Commerce (2017) was used to address the problem of endogeneity. All data are publicly available.

Estimation Results

Expenditure Elasticities

All the estimated expenditure elasticities were positive except for coconuts and walnuts. Elasticities for Brazil nuts, cashew nuts, almonds, hazelnuts, walnuts and the combined category labeled as “other” were statistically significant at 5% significance level. Cashew nuts and pistachios revealed to be necessity goods, as their elasticities were less than one indicating that one percent change in total expenditure on nuts is expected to have less than one percent impact on the quantity of these nuts demanded. Brazil nuts, almonds, hazelnuts were considered as luxury goods, as their elasticities were greater than one indicating that one percent change in total expenditure is expected to cause more than one percent change in quantity demanded of these products. Coconuts and walnuts had properties of inferior goods, as the estimated expenditure elasticities had negative signs; which means that if the income increases, the quantity demanded for these nuts is expected to decrease, all other factors held constant.

Own-Price Elasticities

All the own-price elasticities were negative and statistically significant at 5% level of significance except coconuts and chestnuts which also had the expected negative signs but were not significant at 5%. The estimated own-price elasticities were greater than one for Brazil nuts, cashew nuts, almonds, hazelnuts, walnuts, pistachios and other nuts indicating that the U.S. import demand for these nuts was price-elastic. Our elastic own-price elasticity estimates for almonds and walnuts are consistent with Russo, Green, and Howitt (2008). It is expected that a 1% change in price will lead to more than a 1% change in quantity demanded in the opposite direction, holding everything else constant. Although not significant at the 5% level, coconuts and chestnuts demand was price inelastic, as their corresponding own-price elasticities were less than one in absolute terms, meaning that the consumers were not sensitive to the price changes of these nuts.

Compensated Cross-Price Elasticities

Among the cross-price elasticity estimates that were statistically significant at the 5% significance level are Brazil nuts and coconuts, Brazil nuts and almonds, Brazil nuts and other nuts, cashew nuts and hazelnuts, cashew nuts and chestnuts, cashew nuts and other nuts, pistachios and other nuts. These cross-price elasticities also obtained positive signs indicating that these nuts were substitutes. The cross-price elasticity between chestnuts and other nuts had negative sign indicating that these two nuts had a complementary relationship. Consistent with Russo, Green, and Howitt (2008), and unlike Lerner (1959), walnuts and almonds (and vice versa) were found not statistically significant (Table 1), which suggest no substitution between them.

Conclusions and Policy Implications

The purpose of this study was to analyze the U.S. import demand for nuts and to interpret elasticities. The analysis estimated an Almost Ideal Demand System (AIDS) using time series data. All expenditure elasticities were found positive except for coconuts and walnuts, which indicate U.S. consumers are willing to import fewer coconuts and walnuts and more Brazil nuts, cashew nuts, almonds, hazelnuts, chestnuts, pistachios, and other nuts as their expenditure budget increasing. Expenditure elasticities for Brazil nuts, cashew nuts, almonds, hazelnuts, walnuts and other nuts were all statistically significant at 5% confidence level. Coconuts, cashew nuts, walnuts, and pistachios were found to be necessary goods, while Brazil nuts, almonds, hazelnuts were found to be luxury goods. All the own- price elasticities were negative and statistically significant at 5% confidence level except for coconuts and chestnuts. The own-price elasticities suggested that demand is price-elastic for Brazil nuts, cashew nuts, almonds, hazelnuts, walnuts, pistachios and other nuts, it is inelastic for coconuts and chestnuts. All the cross-price elasticities were statistically significant at 5% confidence level. All the nuts were substitute products, except chestnuts and other nuts being complements.

The estimated elasticities of demand can be used to evaluate the impact of various economic factors that influence the U.S. import price of nuts, and to measure the degree of U.S. responsiveness to changes in the prices of imported nuts. For example, the nuts that were found to be price inelastic are expected to be impacted the least by price changes compared to those with higher own-price elasticities of demand. This information can be useful in making policy-related decisions, and in developing possible scenarios of U.S. nuts imports.

Appendix

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Tables and Figures

Figure 1. U.S. imports of tree nuts by country in 2016

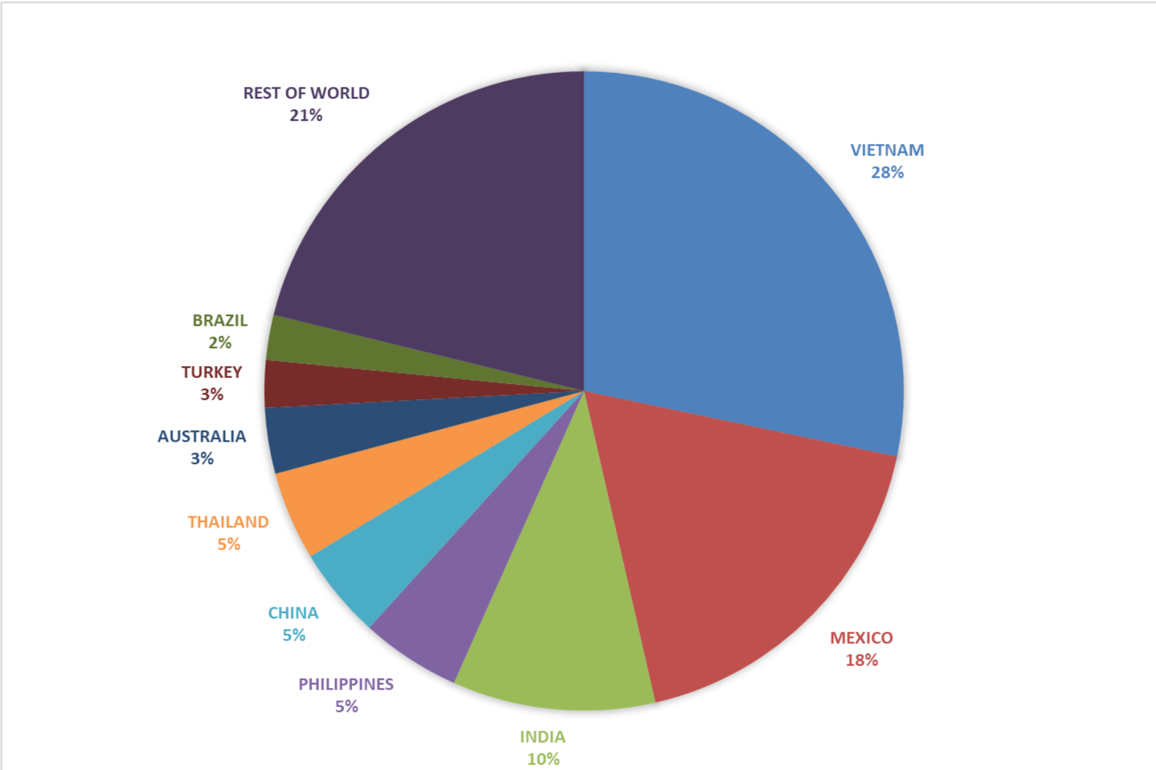

Table 1. Uncompensated own-price and expenditure elasticities, and compensated cross-price elasticities of demand

	Coconuts	Brazil Nuts	Cashew Nuts	Almonds	Hazelnuts	Walnuts	Chestnuts	Pistachios	Other	Expenditure
Coconuts	-0.0563	0.1496*	0.0535	-0.0144	-0.0316	0.0002	-0.0288	0.0005	-0.0708	-0.0286
Brazil nuts	0.2787*	-1.3415*	0.3386	0.1398*	0.0841	-0.0204	-0.0337	-0.0232	0.521*	1.4597*
Cashew nuts	0.0067	0.0227	-1.0704*	-0.0029	0.0391*	0.0147	0.0627*	0.0003	0.3849*	0.9362*
Almonds	-0.0762	0.3977*	-0.125	-1.1745*	-0.0934	0.0181	0.1511	0.0466	0.8221	2.458*
Hazelnuts	-0.0952	0.136	0.9453*	-0.0531	-1.0033*	0.0723	-0.0861	0.0146	0.0114	2.4218*
Walnuts	0.0046	-0.2048	2.204	0.0638	0.449	-1.4113*	0.543	0.0558	-1.6926	-2.9935*
Chestnuts	-0.183	-0.115	3.1984*	0.1814	-0.1818	0.1847	-0.145	-0.064	-2.8927*	1.5162
Pistachios	0.0136	-0.3469	0.0615	0.2449	0.1349	0.0831	-0.2804	-1.0692*	1.1574*	0.4168
Other	-0.0201	0.0795*	0.8768*	0.0441	0.0011	-0.0257	-0.1291*	0.0118*	-1.1431*	1.1987*

Note: Blue colored numbers summarize compensated cross-price elasticities that were significant at 5% significance level, purple colored numbers report complementary commodities, and green colored numbers show uncompensated own-price elasticities. Parameter estimates marked by an asterisk (*) are statistically significant at 5% confidence level.