Demand Estimation for US Apple Juice Imports: A Restricted Source Differentiated AIDS Model

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Abstract

Although this paper focuses on apple juice, a restricted version of source differentiated Almost Ideal Demand System (RSDAIDS) was used to examine U.S. import demand for fresh apple, apple juice and other processed apple. Apple imports were differentiated by type and source of origin and the RSDAIDS model was estimated after imposing the general demand restrictions of adding-up, homogeneity and slutsky symmetry. Seasonality and trend variables were also included on the model. The estimation results showed that U.S. demand for apple juice from China was price inelastic with relatively high expenditure elasticity. We believe the result partially explains why China managed to have a 60 percent import market share in the sub-market despite U.S. imposition of high duties on Chinese apple juice.

Key words: Import demand estimation; apple juice; RSDAIDS;

Introduction

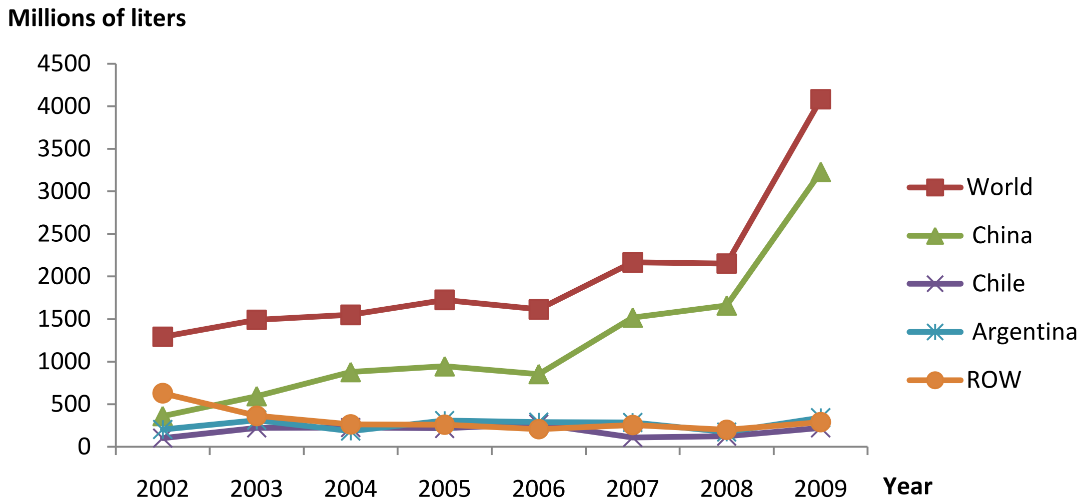
Although the United States produces and satisfies more than 90 percent of its domestic fresh apple consumption, it still heavily relies on imports for 86 percent of apple juice from other countries as of 2007/08 (Pollack and Perez, 2008). The U.S. imports apple juice mainly from China, Chile and Argentina while it imports fresh apple from Canada, Chile and New Zealand and other processed apples mainly from Chile, China and Canada. However, there is significant dynamics in the sources of apple imports into the U.S., particularly in the apple juice market. Among the major apple juice suppliers of the 1990s, Germany is no more in the list of apple juice exporting countries to the U.S., Argentina's market share has plummeted, China has increased its market share from 10 percent to 60 percent and Chile has maintained status-quo. The imposition of a 51.74% import duties on apple juice concentrate from China, after the Department of Commerce found antidumping practices in its 2000 study, did not slow down Chinese imports (USDA/ERS, 2009a; 2009b; Fonsah and Muhammad, 2008; Mekonnen, Fonsah and Borgotti, 2010), calling for a need to reliably estimate elasticities of the U.S. import demand for apples. Thus, the objective of this paper is to measure price and expenditure elasticities of the U.S. import demand for apple juice, as well as fresh and processed apple by source of supplies.

Data and Model

Data on monthly quantity and import value were obtained from USDA Foreign Agricultural Services for the period between January 2001 and October 2009. Unit value of imports was used as a proxy for price. For the econometric analysis, countries with 10 percent or more of the U.S. import for each type of apple were identified to be import sources for that product. Those whose import shares were below 10 percent were aggregated as the Rest of the World (ROW). 'Other processed apple' was defined in this study as dried, preserved and canned apples.

In the last decade, China dominated the U.S. apple juice imports by increasing its exports to the U.S. by about nine fold between 2002 and 2009 while other main exporting countries have at best maintained their export amount (Figure 1).

Figure 1: Volume of the U.S. Apple Juice Imports by Major Suppliers (2002- 2009)



Source: USDA, 2010

China has managed to keep its prices lower than other competing countries (USDA, 2010) giving it an edge in commanding an ever increasing share of the U.S. import expenditure. Chile is the only other country offering apple juice with a price competitive with that of China (USDA, 2010).

The basic model that we have started with to estimate US import demand for apple is the Almost Ideal Demand System (AIDS) model of Deaton and Muellbauer (1980). Unlike other competing demand estimation models, the AIDS model gives an arbitrary first-order approximation to any demand system without invoking homotheticity and additivity of the utility function (Deaton and Muellbauer, 1980). We investigated different types of apple imports, i.e. fresh apple, juice and 'other processed' and differentiated them by their source of origin to get the Source Differentiated Almost Ideal Demand System (SDAIDS) as recommended by Yang and Koo (1994) as follows:

$$w_{ih}=\alpha_{ih}+\sum_{j}\sum_{k}\gamma_{ihjk}\ln(P_{jk})+\beta_{ih}\ln(E/P^{*}) \qquad (1)$$

where

$$\ln(P^{*})=\alpha_{o}+\sum_{i}\sum_{h}\alpha_{ih}\ln(P_{ih})+1/2\sum_{i}\sum_{h}\sum_{j}\sum_{k}\gamma_{ihjk}\ln(P_{ih})\ln(P_{jk}) \qquad (2)$$

and w_{ih} is the import share of good i from country h in the total U.S. import of the good, P_{jk} is the price of good j from country k normalized by mean prices, P_{ih} is the price of good i from country h normalized by mean prices, E is total U.S. import expenditure on apple, $\ln(P^{*})$ is a price index and $\alpha_{o},\alpha_{ih},\beta_{ih}$ and γ_{ihjk} are coefficients of these variables to be estimated. The subscripts i and j denote goods (i, j=1,...,N), and h and k denote country of origin (h,k= 1,...,m).

Since the price index (P*) in equation (1) uses the price of each good from all its origins and all the possible interactions among these variables, it makes the SDAIDS model difficult to estimate, with more than 100 parameters in our case. A practical alternative is to use Stone's price index as a linear approximation as suggested by Deaton. The Stone's price index was specified as $\ln(P^{*})=\sum_{i}\sum_{h}w_{ih}\ln(P_{ih})$ and lagged values of w_{ih} were used to avoid the simultaneity problem that arises due to the fact that this variable was also the dependent variable in the model to be estimated.

However, our model is slightly different from that of Yang and Koo (1994) since we incorporated seasonality and trend terms in the SDAIDS model to account for the seasonality exhibited in the data. Fresh apple coming from Chile and New Zealand, in particular decreased significantly between October and January of each year.

By adopting the ten percent or more import share criteria, four products (import sources) for each good (type of apple) were identified; China, Argentina, Chile and rest of the world for apple juice; Chile, New Zealand, Canada and rest of the world for fresh apple; and Canada, Chile, China and rest of the world for 'other processed' apple. This resulted in 12 coefficients in each budget share equation to be estimated in the SDAIDS model. In developing the model, the high number of coefficients posed a degrees of freedom problem which is common in demand estimation models. The number of unknown coefficients in a general system of demand equations is of the order of n^2, where n is the number of commodities (Theil and Clements, 1987) implying that we needed to estimate about 144 coefficients in addition to the three seasonality dummies and one trend variable coefficient in each equation.

To solve the degrees of freedom problem, we imposed block substitutability on the SDAIDS model to reduce the number of parameters to a manageable level and estimated a restricted SDAIDS (RSDAIDS) as was done in previous works (Yang and Koo, 1994; Henneberry and huyk Hwang, 2007; and Molina, 1997). By adopting this technique apple juice from China responds differently to apple juice coming from Chile, Argentina and the rest of the world but responds the same to fresh and 'other processed' apple from each of their respective origins. In the budget share equation of apple juice from China, for instance, the variables included were the prices of juice from Chile, Argentina and the rest of the world, a weighted price of fresh apple and a weighted price of 'other processed' apple. The specific weights used were import shares of each country for that product. The same type of block substitutability assumption was imposed in each budget share equation for each product.

With the block substitutability assumption and the seasonality and trend variables, the resulting system of equation of the RSDAIDS model became

$$w_{ih}=\alpha_{ih}+\delta_{ih}t+\sum_{k}\theta_{ihk}D_k+\sum_{k}\gamma_{ihk}\ln(P_{ik})+\sum_{j\neq i}\gamma_{ihj}\ln(P_j)+\beta_{ih}\ln(E/P^*) \qquad (3)$$

where t is a trend variable and D_k denotes dummy variables for quarter I to III, $\ln(P_j)=\sum_k w_{jk}\ln(P_{jk})$ is the weighted average of the other good (j) from all its sources (k) when we are considering good i for i≠j while the weights used are the import shares for that product. As discussed above, the P_{ik}'s is the price of good i from country k normalized by mean prices, E is total import expenditure of the U.S. on apple and $\ln(P^*)$ is the Stone's price index.

The parameters in equation (3) were estimated using Seemingly Unrelated Regression (SUR) after imposing the general demand restrictions of adding up, homogeneity and Slutsky Symmetry on the model.

Adding up:

$$\sum_i \sum_h \alpha_{ih}=1; \sum_h \gamma_{ihk}=0; \sum_i \sum_h \gamma_{ihj}=0; \sum_i \sum_h \beta_{ih}=0;$$

Homogeneity:

$$\sum_k \gamma_{ihk}+ \sum_{j\neq i} \gamma_{ihj}=0$$

Slutsky Symmetry:

$$\gamma_{ihk}=\gamma_{ikh}$$

Using the SUR was needed to get efficient coefficients for the system of multiple equations with cross equation parameter restrictions and correlated error terms.

The estimated parameters were then used to formulate Marshallian price elasticities and expenditure elasticities for the RSDAIDS model as recommended by Yang and Koo (1994), thus:

Own-price elasticity:

$$\xi_{ihih}=-1+\gamma_{ihh}/w_{ih}-\beta_{ih}$$

Cross-price elasticities of product *i* among sources:

$$\xi_{ihik}=\gamma_{ihk}/w_{ih}-\beta_{ih}(w_{ik}/w_{ih})$$

Cross-price elasticities of product *i* from country h to prices of other blocks:

$$\xi_{ihj}=\gamma_{ihj}/w_{ih}-\beta_{ih}(w_j/w_{ih}) \text{ where } w_j \text{ is } \sum_{ih} w_{ihj}$$

The expenditure elasticity of demand was formulated as:

$$\eta_{ih}=1+\beta_{ih}/w_{ih}$$

Though theory doesn't preclude domestic production as an import source, the fact that unit values are not what consumers actually pay makes it difficult to construct budget shares using import data with domestic prices and more so when the importing goods have different marketing channels from their domestic counterparts (Yang and Koo, 1994). Thus, this study assumes separability between domestic and imported apples.

Results and Discussion

The share of China and Argentina in US apple juice import expenditure was positively related with their respective price so we expected to find own-price inelasticity for these countries (Table 1). A rise in the price of juice from China, perhaps as a result of the increasing trends in Chinese domestic consumption, may not depress the highest share that this country is enjoying in the US apple juice market. The seasonality dummies revealed that Chinese exports and market share start experiencing an upward trend in the fourth quarter of each year and gets even stronger in the first quarter of the following year. There is also a statistically significant evidence for an increasing trend in the Chinese market share in the U.S. apple juice imports. It was negatively related with apple juice prices from Chile indicating a complementary relationship between the two products which was confirmed in our elasticity estimation.

Chile's market share in the U.S. apple juice market was very sensitive to prices of other processed apple and vice versa. When the prices of other processed apple increases, the apple juice market share of Chile significantly decreases and when the juice price increases this country's share in the 'other processed' apples sub-market significantly decreases, implying a complementary relationship between the two products though the degree of complementarities is not symmetric. The last quarter of the year registered relatively strong market share for Chile in this sub-market compared to other quarters.

Argentina's apple juice market share in the U.S. was negatively related with its own prices giving a reason to expect own-price elastic demand. It is positively related with prices of other apple blocks (fresh apple and other processed apple) implying cross-block substitutability, a point to be confirmed in our results of elasticity estimation.

There is also a complementary relationship between fresh apple imports from Canada and apple juice imports. Our elasticity estimates in Table 2 satisfied most of our expectations implied by the estimated parameter coefficients of Table 1. As expected from the negative relationship of its market share and its own price, Chinese apple juice was found to face own-price inelastic demand. It is also consistent with the import trends of the last two decades and what happened after the imposition of higher tariff on Chinese apple juice imports.

Due to the price inelastic nature of imports, a 10 cent per litre rise in the price of apple juice from China increases its share by 12 percentage points. And the higher import share of China appears to be achieved mainly by displacing Argentina and the rest of the world while being a complement to apple juice imports from Chile.

Apple juice from Chile is complementary to the same product from China and more so to US demand for ’other processed’ apple. It is also a substitute to apple juice from the rest of the world. As expected in the earlier discussion of estimated coefficients, apple juice from Argentina and the rest of the world are elastic to their respective prices. High degree of block-substitutability is also found between Argentina’s juice export to the US and other processed apple. Juice from the rest of the world is a complement to US fresh apple imports.

On the other hand, Chilean fresh apple export to the US is highly sensitive to changes in the prices of imported apple juice with a significant complementary relationship between the two products.

Chinese apple juice exports are found to be less responsive to changes in the U.S. expenditure on apple with expenditure elasticity close to unitary. With an expenditure elasticity of about 1.5, Argentina is the country set to gain more from such expenditure changes. Apple juice originating from the rest of the world is also found to be expenditure inelastic.

China’s dominance in the U.S. apple juice imports rendered the other import origin countries very responsive to price developments of juice from this country than China’s response to developments from the other origins. This is consistent with the study by Fonsah and

Muhammad (2008) which revealed that the responsiveness of imports from China to apple juice prices in Argentina, Chile and the rest of the world was relatively small when compared to the responsiveness of imports from these countries to China's prices.

According to Yang and Koo (1994), a country is regarded as having strong export potential in an import market if demand for its product is price inelastic but expenditure elastic. Though there is no one single country satisfying this criterion in the apple juice sub-market, China found itself in a comfortable position with highly inelastic own-price demand (0.12) and expenditure elasticity close to unitary (0.81). This could partly explain the huge success China has made in penetrating and dominating the U.S. apple juice market in the past decade.

Conclusion

The U.S. apple juice import data from USDA's Foreign Agricultural Services showed a clear market share dominance of China in the past decade from a humble beginning at the turn of the century to exceeding 60 percent mark in 2009. After differentiating U.S. apple imports by type and source of origin, we have used the data to estimate a restricted version of Source Differentiated Almost Ideal Demand System (RSDAIDs) to examine the US import demand for fresh, juice and other processed apple.

The U.S. demand for apple juice from China is price inelastic, thus U.S. efforts in addressing China's alleged unfair trade practices by increasing tariff have been ineffective. The imposition of a 51.74 percent tariff in 2001 by the U.S. on apple juice from China has not deterred Chinese apple juice import (Mekonnen, Fonsah and Borgotti, 2010). In fact, apple juice import from China increased by a factor of eight between 2000 and 2007.

The price inelasticity and a higher expenditure elasticity of China as compared to the other apple juice import origins have given this country an even stronger export potential to the U.S. apple juice sub-market even for the years to come. If the dumping allegations on China are legitimate, the type and stringency of anti-dumping measures by the U.S. should seriously take into account these characteristics of U.S. demand for apple juice imports from China.

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Table 1: Parameter Estimates for Apple Import Demand of the US

Dep. Var (w_{ih})	Juice (γ_{ihk})				Other blocks (γ_{ihj})			Expenditure coeff. (β_{ih})	Seasonal Dummies (θ_{ihk})			Trend	
Juice	CN	CL	AR	ROW	Fresh	Juice	Processed	β_{ih}	θ_{ih1}	θ_{ih2}	θ_{ih3}	δ_{ih}	R^2
CN	0.12**	-0.09*	0.02	0.05	-0.06		0.25	-0.07**	0.15*	-0.015	-0.061**	0.004*	0.79
CL		0.04	0.00	0.03	0.16		-1.22*	-0.07*	-0.06*	-0.019	0.013	0.000	0.41
AR			-0.03*	0.01	0.31***		0.92***	0.04	-0.07*	-0.069*	-0.028	-0.001**	0.26
ROW				-0.10*	-0.35***		0.21	-0.05***	-0.01	-0.017	0.002	-0.003*	0.64
	Fresh (γ_{ihk})				Other blocks (γ_{ihj})								
Fresh	CA	CL	NZ	ROW	Fresh	Juice	Processed						
CA	-0.01	0.01	0.00	0.01***		-0.03**	-0.29***	-0.04*	-0.05*	-0.078*	-0.082*	0.000	0.84
CL		0.04***	-0.04**	0.00***		-0.02	-0.64	0.16*	0.06*	0.125*	0.088*	-0.001	0.69
NZ			0.04**	0.00		0.02	0.86**	0.10*	-0.02	0.077*	0.067*	-0.002*	0.74
ROW				0.00		0.00	-0.01	0.01	0.01**	0.007***	0.006***	0.000**	0.25
	Processed (γ_{ihk})				Other blocks (γ_{ihj})								
Processed	CL	CN	CA	ROW	Fresh	Juice	Processed						
CL	0.00	0.00	0.00	0.00	-0.02	-0.01***		-0.02*	-0.01*	-0.008**	-0.001	0.000**	0.65
CN		0.00	-0.01*	0.00	-0.03	-0.01		-0.01*	0.01*	0.003	-0.003	0.000*	0.53
CA			0.02**	0.00	-0.07*	-0.04		-0.04*	0.00	0.003	0.004***	0.000*	0.86

*,**, *** denote significant at one, five and ten percent levels, respectively.

Table 2: Marshallian Price Elasticities of US Import Demand for Apple Juice, Fresh Apples and Other Processed Apple

Apple Juice	Apple Juice Price				Other blocks	
Countries	China	Chile	Argentina	ROW	Fresh	Processed
China	-0.63*	-0.22*	0.06***	0.16***	-0.11	0.68
Chile	-0.86**	-0.41	0.12	0.56***	2.25	-15.81*
Argentina	0.03	0.01	-1.41*	0.07	3.56	11.06***
ROW	0.51	0.28	0.12	-1.71*	-2.57***	1.58
Fresh Apple	**Fresh Apple Price**				**Other blocks**	
Countries	Canada	Chile	New Zealand	ROW	Juice	Processed
Canada	-1.18*	0.30***	0.00	0.14***	0.00	-5.10***
Chile	0.03	-0.76*	-0.49*	-0.05	-1.35*	-6.52
New Zealand	-0.14	-0.79*	-0.49	-0.03	-0.79***	13.53**
ROW	1.08***	-0.64	-0.27	-1.09***	-0.52	-1.07
Processed	**Processed Price**				**Other blocks**	
Countries	Chile	China	Canada	ROW	Fresh	juice
Chile	-0.92*	0.13	0.21**	0.04	-0.72	0.35
China	0.16	-1.11*	-0.38**	0.12	-1.34	0.04
Canada	0.12**	-0.15**	-0.58*	0.00	-1.46*	-0.20***
ROW	0.07	0.19	-0.03	-1.18**	6.42	7.90

Note: *,**, *** denote significant at one, five and ten percent levels, respectively.

ROW refers to the Rest of the World

Table 3: Expenditure Elasticities of U.S. Import Demand for Apple Juice, Fresh Apples and Other Processed Apple

	Elasticity	Std.err	t-stat
Apple Juice			
China	0.809	0.085	9.483
Chile	0.100	0.270	0.368
Argentina	1.496	0.306	4.895
ROW	0.661	0.196	3.381
Fresh Apple			
Canada	0.227	0.140	1.627
Chile	2.629	0.233	11.291
New Zealand	2.641	0.274	9.644
ROW	1.950	0.658	2.966
Other Processed			
Chile	-0.020	0.135	-0.152
China	0.462	0.185	2.500
Canada	-0.036	0.065	-0.556

Note: ROW refers to the Rest of the World