A System-Wide Approach for Analyzing the Effect of Exchange Rates on Fresh Apple Import Demand

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This study examines the impact of changes in the exchange rate on the demand for U.S. fresh apples in UK, Malaysia, and Saudi Arabia using source differentiated import demand functions based on Theil's system-wide approach. The U.S. apple industry is facing increased challenges in both domestic and international markets. While production increased by more than 51 percent during the last three decades, domestic consumption decreased by 6 percent. Despite this demand shortage in the domestic market, a steady increase in export demand (about 28 percent per annum) during the last three decades helped the industry to maintain a robust growth. However, U.S. apples are losing market share much faster than anticipated due to factors such as frequent trade disputes (for instance the imposition of antidumping duties on Washington apples by Mexico and Taiwan's ban on U.S. apple imports), an appreciating U.S. dollar in major export markets (until recently), and increased competition particularly after China's emergence as a major player in the world apple market.

Although the U.S. still remains an important player in many developed and emerging markets, it is facing keen competition from other exporting countries including New Zealand, Chile, Australia, South Africa, Canada, France, and recently China. For example, recent figures show that the U.S. market share in Taiwan declined from 84 percent in 2000/2001 to approximately 66 percent in 2001/2002.

In an earlier study, Seale, Sparks, and Buxton estimated fresh apple import demand functions for four overseas import markets including the UK using annual data from 1962 to 1987. They observed that despite an increasing supply of fresh apples in the world market, the U.S. competitive advantage has not been seriously challenged. However, their study did not account for the possible impact of exchange rate fluctuation on import demand. The economic slowdown that began in 1997 and subsequent devaluation of Asian currencies against the U.S.

dollar (until recently) has reduced U.S. fresh apple exports to many Asian markets including Malaysia.

This study employs an econometric model to examine the import demand relationships between the United States and other major exporters in three important apple import markets. A series of import demand systems are developed, based on Theil's system-wide approach to demand analysis, in which the import demand for apples in each of these countries is disaggregated by country of origin. We follow Mountain in treating each of the importing countries as separate markets and estimate source differentiated import demand functions using more recent UN data series (1970-2002).

The key theoretical contribution of this study is that we modify the standard Rotterdam model to incorporate exchange rate effects by making use of the approach recently developed by Brown and Lee. In this approach, Brown and Lee revisit Barten's fundamental matrix equation of consumer demand theory in order to incorporate the proper "adding-up" conditions when one adds a preference variable to the standard Rotterdam model. Unlike several other studies that have attempted to do this previously (most of which have the objective of analyzing the effects of advertising) Brown and Lee derive a model that conforms exactly to the restrictions resulting from consumer demand theory. Under this approach, we are able to include more plausible restrictions on the intra-group effects of the exchange rate variable in a manner consistent with consumer demand theory and, more importantly, are able to test these restrictions using log-likelihood ratio tests. We adapt this methodology by viewing exchange rates as a "sticky" preference variable. This method allows empirical estimation of the impact of exchange rates on marginal utilities via adjusted prices.

We obtain empirical estimates of income, price, cross-price, and (exchange rate related) translation elasticities. Furthermore, we test for what amounts to essentially the same restrictions as block independence on the effects of the exchange rate variable against the unrestricted hypothesis that the real exchange rate between the importing country and the U.S. affects imports from all countries. The results indicate that certain translation elasticities are significant, and in some cases, much smaller than one. This indicates that exchange rate movements only partially impact import demand patterns through their interaction with import prices.

Conceptual Model

A number of previous studies have estimated source differentiated import demand functions for agricultural products assuming that the quality of products imported from different source countries vary significantly (Seale, Sparks and Buxton; Yang and Koo; Molina). However, most of these studies did not account for the impact of changes in real exchange rates on import demand. This issue is important particularly for agricultural trade because it is often governed by quota and non-tariff barriers reflecting trading preferences of importing countries (Swift). Moreover, many consumers in importing countries view products originating in different countries as differentiated. As a result, import prices may not reflect the changes in exchange rates (Froot and Klemperer; Goldeberg and Knetter; Dornbusch). Following developments in advertising literature (Basmann; Tintner; Duffy) we introduce exchange rates as a preference variable in the Rotterdam model to examine its impact on import demand (Brown and Lee).

Using Barten's framework, the complete system of demand equations can be derived by optimizing a representative consumer's decision problem, which can be expressed as

Maximize $u = u(q, z)$

Subject to $p'q = m$, (1)

where u is a well behaved utility function p and q are price and quantity vectors, respectively, m is total expenditure, and z is a vector of preference variables, which we will view as the "sticky" portion of exchange rate effects under the (testable) hypothesis that exchange rates do not exhibit complete pass-through. The solution to the first-order conditions is a set of demand equations, from which the variant of the Rotterdam model utilized in this paper is an approximation (Brown and Lee). Total differentiation of these first-order conditions results in the following set of demand equations:

$$\begin{aligned} Udq - pd\lambda &= \lambda dp - Vdz \\ p'dq &= dm - q'dp \end{aligned} \tag{2}$$

Relationship (2) is a variant of Barten's fundamental matrix of consumer demand, and the solution to (2) results in the following income-compensated demand equations:

$$dq = \partial q / \partial m = (dm - q'dp) + S(dp - Vdz / \lambda) \tag{3}$$

where $\partial q/\partial m = U^{-1}p/p'U^{-1}p$, $\partial\lambda/\partial m = 1/p'U^{-1}p$, and $S = \lambda U^{-1} - (\partial q/\partial m)\,(\partial q/\partial m)'(\lambda\,/\partial\lambda/\partial m)$). For our purposes, the important result from (3) is that the effect of the preference variable (the exchange rate) can be written as $\partial q/\partial z' = -SV/\lambda$.

The variant of the Rotterdam model that we are interested in is the following parameterization of (3), written in log changes as (Brown and Lee):

$$w_i d\ln q_i = \theta_i d\ln Q + \sum_j \pi_{ij} d\ln p + \beta_i d\ln z, \qquad \text{i=1, 2, …, n} \tag{4}$$

where $w_i = p_i q_i/m$ is the budget share for good i; $\theta_i = p_i(\partial q_i/\partial m)$ is marginal propensity to consume; $d\ln Q = \sum w_i d\ln q_i$ is the Divisia volume index; $\pi_{ij} = (p_i p_j / m)s_{ij}$ is the Slutsky

coefficient, with $s_{ij} = (\partial q_i / \partial p_j + q_j \partial q_i / \delta m)$ being the (i,j)th element of the substitution matrix S; and $\beta_i = w_i(\partial \ln q_i / \partial z)$ is the exchange rate coefficient.

The general restrictions on demand are (e.g., Theil as discussed in Brown and Lee)

Adding up: $\sum_i \theta_i = 1; \qquad \sum_i \pi_{ij} = 0; \qquad \sum_i \beta_i = 0;$

Homogeneity: $\sum_j \pi_{ij} = 0;$

Symmetry: $\pi_{ij} = \pi_{ji}$ (5)

In the original specification of the Rotterdam model, the coefficients θ_i and π_{ij} are treated as constants during estimation. We follow the same procedure. In several other studies that have attempted to add advertising or other preference variables to the Rotterdam model (with the exception of Brown and Lee), the procedure has been simply to treat the β_i's as constant, impose the adding up restrictions directly on the β_i's, and estimate equation (4) as it appears. However, when one does this without revisiting Barten's fundamental matrix and accounting for the fact that $\partial q/\partial z' = -SV/\lambda$, the resulting empirical estimates will not typically satisfy all of the general restrictions on demand as described in (5). Indeed, it may seem that the empirical estimates from such studies do satisfy all of the general demand restrictions, when in reality they do not. This is because Barten (1969) showed that for the original parameterization of the Rotterdam model, the solution can be found by arbitrarily removing one of the equations, estimating the parameters, and then deriving the missing parameters through adding-up constraints. However, when using variants of the Rotterdam model, one must carefully revisit Barten's Fundamental matrix (as did Brown and Lee) in order to be assured that deriving the missing parameters through adding-up constraints is appropriate. In such cases, it is easy to determine if the missing parameters were derived correctly by simply estimating the model once with one equation removed and then

estimating it again with a different equation removed. If the results are exactly (not approximately) the same, then the parameters derived for the variant of the Rotterdam model are appropriate and satisfy the restrictions of consumer demand theory.

Instead of treating the β_i's in (4) as constants and testing restrictions placed directly on them, an alternative approach is to make use of the following relationship:

$$\beta_i = \sum_h \pi_{ih}\gamma_h , \qquad \text{i=1, 2, …, n} \tag{6}$$

where $\gamma_h = \partial ln(\partial u/\partial q_h) / \partial lnz$ is the elasticity of the marginal utility of good h with respect to preference variable z (Brown and Lee). Adding-up and other restrictions can be imposed on the γ_i's instead of the β_i's and the system (4) can be estimated directly by eliminating the n^{th} equation and performing an iterative seemingly unrelated regression on the following:

$$w_i d\ln q_i = \theta_i d\ln Q + \sum_{j=1,\ldots,n-1} \pi_{ij}[d\ln p_j - d\ln p_n - \gamma_j^n d\ln z], \quad \text{i=1, …, n-1} \tag{7}$$

where $\gamma_j^n = \gamma_j - \gamma_n$. In equation (7) a change in the exchange rate (z) can be viewed as resulting in adjusted price changes. The first term following the Slutzky coefficient is the jth product's actual price change, less the impact of the exchange rate on the jth product's marginal utility relative to the nth product's price change, less the impact of the exchange rate on the nth product's marginal utility (Brown and Lee).[1]

As a practical matter, unrestricted estimation of (7) results directly in only one reduced-form coefficient (β_i) for each of the *i* equations associated with *dlnz*. However, this coefficient is actually comprised of *j-1* components that take the form of (6). Although, in the unrestricted case, the individual γ_j's can not be identified, a linear combination of them can be recovered from the β_i's through the following reduced form relationship:

[1] In fact, equation (6) can be rewritten (Brown and Lee) in terms of relative adjusted prices as $w_i d\ln q_i = \theta_i d\ln Q + \sum_{j=1,\ldots,n-1} \pi_{ij} d\ln p_j^*$ where $p_j^* = (p_j / z^{\gamma_j}) / (p_j / z^{\gamma_n})$

$$(\gamma^* - \iota\gamma_n) = -\pi^{*-1}\,\beta^* \quad \text{where} \quad \gamma^* = (\gamma_1 \ldots \gamma_{n-1})\,,\ \pi^* = (\pi_1 \ldots \pi_{n-1})\,,\ \beta^* = (\beta_1 \ldots \beta_{n-1}) \tag{8}$$

and ι is the summation vector.

Parameterization (7) of the Rotterdam model variant along with relationships (8) are useful for our purposes because they allow imposition of further restrictions on exchange rate effects. In the empirical application to follow, the real exchange rate of the importing country with respect to the U.S. is the only exchange rate under consideration.[2] Hence, it seems likely that a depreciation of the exchange rate in the importing country with respect to the U.S. should have a larger effect on imports from the U.S. than on imports from other countries. One such set of restrictions is that a depreciation of the importing country's currency with respect to the U.S. has a generic effect on imports from other countries, but a specific effect on its own marginal utility. After simplification, these assumptions result in a set of restrictions such that

$$\gamma_1^n = \gamma_1 \text{ and } \gamma_j^n = 0 \text{ for all j = 2,…,n.} \tag{9}$$

Under these specific restrictions, the parameter γ_1 becomes identifiable. Once γ_1 is found, the β_i's can be recovered through the following relationship:

$$\beta_i = -\pi_{ij}\gamma_1 \tag{10}$$

It should be noted that adding up conditions are now satisfied through γ_i's, leaving the β_i's somewhat free from the adding up restrictions. This is critical, because under direct estimation of system (4), one could not have the situation in which β_1 (associated with the real exchange rate of the importing country with respect to the U.S.) is non-zero while all other β_i's (those associated with exporting countries outside the U.S.) are zero, because that would violate the (more restrictive) adding-up conditions on the β_i's (5) from consumer demand theory. However,

[2] In the near future, we hope to be able to create a system that uses real exchange rates for the importing countries with respect to all exporters, not just the U.S. However, that is beyond the scope of this paper.

the question of whether the above restrictions on the impact of exchange rates are valid or not, is an empirical matter that we undertake in the next sections.

Data and Empirical Results

The main objective of this study is to examine the impact of exchange rate changes on the import demand for fresh apples in countries that are important for the U.S. apple industry using a system-wide approach. The resulting demand functions were approximated using differential functional forms consistent with the variant of the Rotterdam model (7) and estimated using annual import data obtained from UN Comtrade database and real exchange rates from USDA's on line database.

The major U.S. fresh apple export markets and their relative share in total exports are presented in Table 1. Since Canada and Mexico have a substantial amount of domestic production and Mexico imports mainly from the U.S., these two countries were excluded from the study because the effect of dlnQ in (7) dominates the regression results in such cases. Among remaining eight countries, U.K., Malaysia, and Saudi Arabia were selected based on the availability of exchange rate and import data from multiple source countries during the study period (1971-2002). Based on the last five years data, these three countries constitute about 10 percent of the total U.S. export market.

The import demand functions for all of these three countries were estimated by using the iterative seemingly unrelated regression method. For each importing country, the system (7) was first estimated with adding-up being the only restrictions on the γ_i's. Then the system was re-estimated again, imposing the restrictions in (9). Log-likelihood ratio tests were used to see if the restricted exchange rate model is rejected with respect to the unrestricted exchange rate model. Finally, the elasticities that result from the restricted model are estimated and discussed.

U.K. Model

The results for the unrestricted UK model are reported in Table 2. The system-wide R^2 (Bewley) is 0.886. All conditional marginal propensity to consume estimates, except for Italy, are positive. However, they are significantly different from zero only for U.S., France, and South Africa. As expected, all own price slutsky coefficients are negative but they are significantly different from zero only for U.S. and New Zealand. The reduced form coefficients associated with the U.K/U.S. exchange rate are significant only for the U.S. (second to last column of table 2). This shows that the full effect of the U.K/U.S. exchange rate has not passed through to import prices in the U.K., implying that there remains a significant "sticky" effect with respect to the U.K./U.S. exchange rate. The unrestricted structural coefficients resulting from (8) are provided in the last column of table 3.

This issue was further explored by imposing restrictions (9) on the exchange rate impacts and the results are reported in Table 3. The restricted structural coefficient associated with the U.S. is -1.496 which is very close to the unrestricted structural coefficient associated with the U.S. of -1.407. These restrictions are tested using a log likelihood ratio test (LRT) statistic, LRT = $-2[\text{Log } L(\theta^*) - \text{Log } L(\theta)]$, where θ^* is the vector of parameter estimates with the restrictions imposed, θ is the vector of parameter estimates without the restrictions, and Log L(•) is the log value of the likelihood function (bottom of table 2 and table 3). The LRT statistic can be compared to a critical value from a $X^2(q)$ distribution, where q is the number of restrictions imposed (see, for example, Schmitz and Seale). The Log Likelihood Ratio test statistics ($\chi^2 = 8.49$ with 5 d.f.) is not significant, providing further evidence that the U.K/U.S. exchange rate does not impact U.K. imports from other countries. Most of the coefficients are similar and there

was no change in the significance of any variable. The elasticity estimates corresponding to the parameter estimates for the restricted exchange rate model are reported in Table 4.

Malaysia

The unrestricted, restricted, and elasticity estimates for Malaysian fresh apple imports are reported in Tables 5-7. All marginal propensity estimates are significantly positive. As expected all own price coefficients are significant and negative except for New Zealand. Although the own price elasticity for New Zealand does not hold the expected sign, it is not significantly different from zero. Moreover, none of the exchange rate coefficients are significantly different from zero in this case. Although none of the exchange rate coefficients were significant, the demand system was estimated imposing four restrictions on the structural coefficients for completeness. The LRT test results are not significant at a five percent level indicating that there has been full exchange rate pass through in Malaysia in terms of prices for apples imported from the U.S.

All conditional, uncompensated elasticity estimates are significant and carry expected signs except for New Zealand. The elasticity for New Zealand, however, is not statistically different from zero. All of the significant elasticity estimates are elastic. The cross price elasticities show a substitute relationship between US and Australian apples but complementarity between US and New Zealand apples.

Saudi Arabia

U.S., Chile, and France are the major source countries for Saudi Arabian fresh apple imports. As expected, marginal propensity estimates for these source countries are significantly positive (Table 8). Although own price coefficients carry expected signs except for Chile, none

of them are significant. Moreover, all of the exchange rate coefficients are also insignificant. Restricted Slutsky parameters and elasticity estimates are reported in Tables 9 and 10, respectively. Although none of the own price elasticities are significant, the cross price elasticity between France and US is significantly positive indicating a substitute relationship.

Summary and Conclusions

A source differentiated import demand function based on Theil's system-wide approach was used to examine the impact of price and exchange rate changes on fresh apple imports in UK, Malaysia, and Saudi Arabia. The United States is one of the major players in all of these three markets. Out of the three markets analyzed in this study, incomplete pass-through of changes in exchange rates are observed in only one market, UK. That is, changes in the relative exchange rate between the U.S. and U.K. did not completely pass-through to import prices, as both the exchange rate parameter and the Slutzky coefficient for the U.S. were significant in the restricted and unrestricted model. Although the Asian Financial Crisis significantly affected the Malaysian currency during the study period, we did not find any impact of "sticky" exchange rates with respect to Malaysia. However, since the Slutzky parameter associated with U.S. imports is significant and negative, we conclude that the Malaysia/U.S. exchange rate did completely pass through for Malaysian apple imports from the U.S. Finally, in Saudi Arabia, no evidence was found that exchange rates or even prices affect the demand for apple imports.

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Table 1. Major U.S. Fresh Apple Export Markets

Importing Country	Export Quantity (MT)						
	1999	2000	2001	2002	2003	Average	%
Mexico	132105.3	184635.9	209330.0	141653.2	121248.2	157794.5	26.0
Canada	91326.6	89625.6	91447.0	108691.9	107613	97740.8	16.1
Indonesia	29057.8	34629.6	42560.5	43115.9	40783.3	38029.4	6.3
Hong Kong	31762.1	40165.4	40710.7	39047.3	36054.9	37548.1	6.2
UK	29325.6	25466.5	32331.6	28366.5	24076.8	27913.4	4.6
Malaysia	11508.3	10835.8	23721.2	23658.1	24428.8	18830.4	3.1
Unite Arab Emirates	18150.0	19849.9	20840.6	15681.7	19093.7	18723.2	3.1
Saudi Arabia	26675.1	17307.3	10420.9	9875.4	6924.5	14240.6	2.3
Thailand	12536.1	12695.7	12671.1	12008.9	9156.8	11813.7	1.9
Venezuela	16554.5	12207.3	14350.0	4547.3	1627.8	9857.4	1.6

Source: Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics.

Table 2. Unrestricted Model Parameters for U.K. Fresh Apple Import Demand Function [a]

Source Countries	MPC[b]	Slutsky Matrix						Ex_Rate	Gi-Gn[c]
		U.S.	France	South Africa	New Zealand	Italy	ROW		
U.S.	0.088	-0.034	0.019	-0.012	0.012	0.011	0.003	-0.071	-1.407
	(0.034)	(0.019)	(0.035)	(0.022)	(0.012)	(0.011)		(0.026)	
France	0.464	0.019	-0.136	0.052	-0.023	0.005	0.083	0.101	0.698
	(0.141)	(0.035)	(0.119)	(0.066)	(0.037)	(0.035)		(0.109)	
South Africa	0.294	-0.012	0.052	-0.113	0.081	-0.014	0.006	0.034	-0.278
	(0.107)	(0.022)	(0.066)	(0.068)	(0.028)	(0.031)		(0.083)	
New Zealand	0.072	0.012	-0.023	0.081	-0.049	-0.007	-0.014	0.012	-1.159
	(0.085)	(0.012)	(0.037)	(0.028)	(0.023)	(0.014)		(0.066)	
Italy	-0.038	0.011	0.005	-0.014	-0.007	-0.011	0.016	0.020	1.783
	(0.059)	(0.011)	(0.035)	(0.031)	(0.014)	(0.020)		(0.047)	
ROW	0.120	0.003	0.083	0.006	-0.014	0.016	-0.094	-0.096	0.363

Note: Asymptotic standard errors are in parenthesis. System R^2 =0.886 and Log Likelihood function value = 378.368.

[a] Model (3) or (5).

[b] marginal propensity to consume.

[c] elasticity of marginal utility of apples with respect to exchange rate minus elasticity of marginal utility of fresh apples imported from ROW, as defined in equation (5).

Table 3. Restricted Model Parameters for U.K. Fresh Apple Import Demand Function [a]

Source Country	MPC[b]	Slutsky Matrix						Ex_Rate	Gi-Gn[c]
		U.S.	France	South Africa	New Zealand	Italy	ROW		
U.S.	0.091	-0.036	0.020	-0.013	0.013	0.015	0.002	-0.054	-1.496
	(0.034)	(0.019)	(0.035)	(0.021)	(0.012)	(0.011)		(0.019)	
France	0.444	0.020	-0.121	0.063	-0.026	-0.006	0.069	0.030	0.000
	(0.140)	(0.035)	(0.123)	(0.066)	(0.038)	(0.034)			
South Africa	0.287	-0.013	0.063	-0.108	0.081	-0.016	-0.007	-0.020	0.000
	(0.106)	(0.021)	(0.066)	(0.068)	(0.028)	(0.030)			
New Zealand	0.070	0.013	-0.026	0.081	-0.050	-0.010	-0.009	0.020	0.000
	(0.084)	(0.012)	(0.038)	(0.028)	(0.023)	(0.014)			
Italy	-0.041	0.015	-0.006	-0.016	-0.010	-0.016	0.032	0.022	0.000
	(0.058)	(0.011)	(0.034)	(0.030)	(0.014)	(0.019)			
ROW	0.148	0.002	0.069	-0.007	-0.009	0.032	-0.088	0.003	0.000

Note: These results were obtained by restricting exchange rate impact in all except for UK/US. Asymptotic standard errors are in parenthesis. System R^2=0.869. Log likelihood function = 374.12. LR Test value = 8.489, which is insignificant at 5 percent level implying that the set of 5 restrictions are not rejected.

[a] Restrictions on model (5).

[b] marginal propensity to consume.

[c] elasticity of marginal utility of apples with respect to exchange rate minus elasticity of marginal utility of fresh apples imported from ROW, as defined in equation (5).

Table 4. Conditional, Uncompensated Elasticities for Restricted U.K. Model

Source Country	Income	Slutsky Coefficient						Ex_Rate
		U.S.	France	South Africa	New Zealand	Italy	ROW	
U.S.	1.486	-0.593	0.326	-0.219	0.219	0.237	0.030	-0.886
	(0.557)	(0.318)	(0.575)	(0.350)	(0.197)	(0.179)		(0.303)
France	1.331	0.060	-0.362	0.189	-0.077	-0.018	0.208	0.090
	(0.421)	(0.106)	(0.367)	(0.199)	(0.113)	(0.102)		
South Africa	1.579	-0.074	0.346	-0.595	0.447	-0.086	-0.038	-0.111
	(0.582)	(0.118)	(0.366)	(0.372)	(0.152)	(0.163)		
New Zealand	0.378	0.072	-0.138	0.437	-0.269	-0.052	-0.050	0.108
	(0.453)	(0.065)	(0.204)	(0.149)	(0.121)	(0.076)		
Italy	-0.799	0.285	-0.116	-0.308	-0.191	-0.307	0.638	0.427
	(1.132)	(0.216)	(0.671)	(0.584)	(0.277)	(0.383)		
ROW	0.795	0.010	0.372	-0.037	-0.049	0.174	-0.469	0.015

Note: Elasticities of restricted model using recent 3 year average budget shares. Asymptotic standard errors are in parenthesis.

Table 5. Unrestricted Model Parameters for Malaysian Apple Import Demand Function [a]

Source Country	MPC[b]	Slutzky Matrix					Ex_Rate	Gi-Gn[c]
		U.S.	New Zealand	China	Australia	ROW		
U.S.	0.431	-0.582	-0.102	0.093	0.478	0.113	-0.039	-0.304
	(0.086)	(0.194)	(0.071)	(0.065)	(0.167)		(0.239)	
New Zealand	0.057	-0.102	0.013	-0.020	0.010	0.100	-0.020	0.528
	(0.030)	(0.071)	(0.062)	(0.025)	(0.073)		(0.084)	
China	0.142	0.093	-0.020	-0.131	0.093	-0.034	0.160	0.704
	(0.044)	(0.065)	(0.025)	(0.037)	(0.058)		(0.124)	
Australia	0.326	0.478	0.010	0.093	-0.500	-0.080	-0.082	-0.313
	(0.079)	(0.167)	(0.073)	(0.058)	(0.206)		(0.218)	
ROW	0.044	0.113	0.100	-0.034	-0.080	-0.099	-0.020	-0.615

Note: Malaysia/US exchange rate is allowed to affect utility for all countries. Asymptotic standard errors are in parenthesis. System R^2 =0.96 and Log Likelihood function value = 202.51.

[a] Model (3) or (5).
[b] marginal propensity to consume.
[c] elasticity of marginal utility of apples with respect to exchange rate minus elasticity of marginal utility of fresh apples imported from ROW, as defined in equation (5).

Table 6. Restricted Model Parameters for Malaysian Apple Demand [a]

Source Country	MPC[b]	Slutzky Matrix					Ex_Rate	Gi-Gn[c]
		U.S.	New Zealand	China	Australia	ROW		
U.S.	0.434	-0.562	-0.118	0.103	0.462	0.115	0.042	0.074
	(0.086)	(0.191)	(0.068)	(0.065)	(0.164)		(0.101)	
New Zealand	0.057	-0.118	0.024	-0.023	0.018	0.098	0.009	0.000
	(0.030)	(0.068)	(0.062)	(0.025)	(0.073)			
China	0.138	0.103	-0.023	-0.132	0.085	-0.033	-0.008	0.000
	(0.045)	(0.065)	(0.025)	(0.038)	(0.058)			
Australia	0.327	0.462	0.018	0.085	-0.484	-0.081	-0.034	0.000
	(0.078)	(0.164)	(0.073)	(0.058)	(0.204)			
ROW	0.043	0.115	0.098	-0.033	-0.081	-0.099	-0.009	0.000

Note: Exchange rate restricted to Malaysia/US utility only. Asymptotic standard errors are in parenthesis. System R^2 =0.96 and Log Likelihood function value = 201.203. LR Test value = 2.61, which is insignificant at 5 percent level implying that the set of 4 restrictions are accepted.

[a] Restrictions on model (5).

[b] marginal propensity to consume.

[c] elasticity of marginal utility of apples respect to exchange rate minus elasticity of marginal utility of fresh apples imported from ROW, as defined in equation (5).

Table 7. Conditional, Uncompensated Elasticity Estimates for Malaysian Restricted Model

Source Country	Income	Slutzky Cross-Price					Exchange Rate
		U.S.	New Zealand	China	Australia	ROW	
U.S.	1.231	-1.593	-0.335	0.293	1.309	0.327	0.118
	(0.242)	(0.542)	(0.194)	(0.185)	(0.465)		(0.287)
New Zealand	0.599	-1.234	0.253	-0.239	0.192	1.027	0.091
	(0.313)	(0.714)	(0.644)	(0.260)	(0.759)		
China	1.107	0.829	-0.184	-1.060	0.682	-0.268	-0.061
	(0.365)	(0.524)	(0.200)	(0.308)	(0.466)		
Australia	1.056	1.491	0.060	0.274	-1.562	-0.263	-0.110
	(0.253)	(0.529)	(0.235)	(0.187)	(0.660)		
ROW	0.370	0.985	0.842	-0.286	-0.696	-0.846	-0.073

Note: Elasticities of restricted model using recent 3 year average budget shares. Asymptotic standard errors are in parenthesis.

Table 8. Unrestricted Model Parameters for Saudi Arabia Fresh Apple Demand [a]

Source Country	MPC[b]	Slutzky Matrix				Ex_Rate	Gi-Gn[c]
		U.S.	Chile	France	ROW		
U.S.	0.290	-0.089	-0.027	0.124	-0.008	-0.502	1.577
	(0.051)	(0.108)	(0.081)	(0.045)	(0.000)	(0.302)	
Chile	0.442	-0.027	0.071	-0.078	0.034	0.422	0.458
	(0.061)	(0.081)	(0.100)	(0.048)	(0.000)	(0.362)	
France	0.093	0.124	-0.078	-0.068	0.022	0.201	5.302
	(0.037)	(0.045)	(0.048)	(0.040)	(0.000)	(0.216)	
ROW	0.175	-0.008	0.034	0.022	-0.048	-0.120	-7.337

Note: US/Saudi Arabia exchange rate is allowed to affect utility for all countries. Asymptotic standard errors are in parenthesis.

[a] Model (3) or (5).

[b] marginal propensity to consume.

[c] elasticity of marginal utility of apples with respect to exchange rate minus elasticity of marginal utility of fresh apples imported from ROW, as defined in equation (5).

Table 9. Restricted Model Parameters for Saudi Arabia Apple Demand [a]

Source Country	MPC[b]	Slutzky Matrix				Ex_Rate	Gi-Gn[c]
		U.S.	Chile	France	ROW		
U.S.	0.295	-0.099	-0.014	0.124	-0.011	-0.137	-1.392
	(0.052)	(0.109)	(0.082)	(0.046)	(0.000)	(0.210)	
Chile	0.436	-0.014	0.055	-0.080	0.039	-0.020	0.000
	(0.062)	(0.082)	(0.101)	(0.048)	(0.000)		
France	0.092	0.124	-0.080	-0.065	0.021	0.172	0.000
	(0.037)	(0.046)	(0.048)	(0.041)	(0.000)		
ROW	0.177	-0.011	0.039	0.021	-0.050	-0.015	0.000

Note: Exchange rate is restricted to Saudi Arabia/US utility only. Asymptotic standard errors are in parenthesis. System R^2=0.947

[a] Restrictions on Model (5).

[b] marginal propensity to consume.

[c] elasticity of marginal utility of apple with respect to exchange rate minus elasticity of marginal utility of fresh apples imported from ROW, as defined in equation (5).

Table 10. Restricted Model Parameters for Saudi Arabia Apple Demand

Source Country	MPC[b]	Slutzky Cross-Price				Exchange Rate
		U.S.	Chile	France	ROW	
U.S.	1.293	-0.433	-0.063	0.542	-0.047	-0.602
	(0.230)	(0.476)	(0.358)	(0.202)		(0.922)
Chile	1.415	-0.047	0.178	-0.259	0.127	-0.065
	(0.202)	(0.265)	(0.330)	(0.155)		
France	1.019	1.371	-0.884	-0.722	0.234	1.908
	(0.412)	(0.511)	(0.528)	(0.453)		
ROW	0.474	-0.029	0.105	0.057	-0.133	-0.040

Note: Elasticities of restricted model using recent 3 year average budget shares. Asymptotic standard errors are in parenthesis.