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Bangladesh J. Agric. Econs XXVIII, 1&2 (2005)1-16

AN ARMINGTON ASSUMPTION APPROACH TO MODEL INTERNATIONAL TRADE FLOW AND MARKET SHARE FOR APPLES IN CANADA

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ABSTRACT

The purpose of this study is to estimate elasticities of substitution for apples imported from US, New Zealand and Chile. The study also tested the impact of NAFTA on the apple trade using trade data from 1988 to 2004. The assumptions of Armington model are used to model trade flow of apples employing Linear Approximate of Almost Ideal Demand System. NAFTA has a significant affect on the exporters' share of Canadian import market. Further, New Zealand is emerging one of the strong exporters of apples to Canada by gaining most of the share lost by other countries.

Import demand of apples in the case of New Zealand and Chile are elastic while just above unit elastic in case of US. Apples imported from New Zealand were complements to those imported from Chile. The elasticities of substitution of New Zealand and Chile are statistically significant and slightly elastic while that of US is insignificant and inelastic. The rest of the world has elastic elasticities of substitution mainly due to the low share in Canadian imports of apples. Homotheticity could not be rejected that has important implications for international trade and CGE modeling. However, more evidence on testing of the Armington assumptions in trade flow investigations of fruits and vegetables are required.

I. INTRODUCTION

Elasticities of import demand are used to estimate the effects of trade barriers on trade and to evaluate trade policy regimes. Domestic policies that have implications for international trade use these elasticities to compare policy regimes. Thompson (1988) reported that the price responsiveness of import demand of U.S. agricultural sales became the single most important issue in the policy debate during the `80s. In addition to other, the criteria of elastic foreign import demand were used to justify decrease in floor prices

However, the estimate of elasticities of import demand changes with the type of empirical model adopted. Thompson (1981) evaluated different approaches to model trade and concluded that most of the empirical models assume that agricultural commodities are homogenous in nature. The implications of such an assumption are that agricultural products are perfect substitutes, hence elasticity of the substitution is infinite and corresponding price ratio is constant. However the inter industry trade where countries import and export the same agricultural commodity is the common characteristic in trade of fruits and vegetables. The wide variety of the same kind of fruit and vegetables in the grocery stores supports this fact.

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Grennes et al. (1978) reported a number of reasons for agricultural commodities to be heterogeneous. These include intrinsic heterogeneity of agricultural products, importers view products differently, cross hauling and the type of competition. Hence trade models, such as multiple-region; non-spatial and spatial price equilibrium models that make the assumption of homogeneity of product have limited application in modeling trade of differentiated goods. In case of apples, there is wide range of varieties and the most popular are Gala, Red Delicious, Ambrosia, Honey Crisp, Jona Gold and Gold Rush that make apples a differentiated product.

The Armington model is a popular specification to estimate import demand of the products differentiated not only by type but also by country of origin. According to Alston (1990), the Armington model is disaggregated which distinguishes commodities by country of origin, permits calculation of cross price elasticities between imports from all sources, easy to estimate and flexible. The model often generates results that are judged to be successful because of both plausible parameter estimates and statistical significance.

Armington (1969) assumed that consumer utility was separable and a single constant elasticity of substitution exists between products and across markets. He carried a two-stage procedure assuming in the first stage that a buyer decides on the total volume of imports and then in the second stage allocates total volume to individual suppliers to minimize cost. Elasticities of substitution were estimated using this procedure because it accounted for differentiated products. Several studies applied the approach of Armington to model trade in agricultural products. Grennes et al. (1978) were the earliest to adopt such a model, followed by others.

However, the assumptions of single CES, homotheticity and separability were the limiting factors of the original Armington model. Researchers including Ito et al. (1990), Alston et al. (1990), Yang and Koo (1993) and George and Kruse (1993) tested these assumptions and proposed different changes to the original Armington model. These studies are evaluated while discussing the theoretical framework in the next section. However, they tested the assumptions of the Armington model for a commodity traded by a particular country under a particular policy setting' therefore; the modifications they proposed may not be relevant to this investigation.

This study used Linear Approximate of Almost Ideal Demand System (LA-AIDS) of Deaton and Muellbauer (1980) to estimate the parameters of import demand equations for apples. The affect of North American Free Trade Agreement (NAFTA) on the import behavior of Canadian importers of apples from all sources is tested. This study also tested the assumption of the homothetic market share of the Armington model.

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[1]I believe that each country has its own domestic and trade policies that affect the preferences of importers (or exporters) in importing (or exporting) the commodity which in turn affect the data available to researcher to test the hypothesis of a particular theory. In such cases, the data may not fall to the assumptions while investigating trade of commodity employing a particular model in a certain policy settings but may fall to assumptions in other policy settings.

Apple Industry:

The Canadian apple industry is a major component of horticultural industry. Canada exports most of its fresh apples to Mexico while imports the same from 15 countries, depicting the existence of inter-industry trade. However, on average the value of imports is about $150 million, which is almost double the value of exports. About 80 percent of Canadian imports are from the United States while the rest are mostly imported from New Zealand, Chile, South Africa and Argentina. The US is also the world's largest exporter of apples with an average annual value of $360 million. Canadian imports mostly included the varieties of Granny Smith, Red Delicious, and Golden Delicious and to lesser extent Gala, Fuji, Brae burn and McIntosh. Imports are made between April and August, with the largest import being made in June.

The sector is facing issues in market access in the WTO negotiations. Agriculture and Agrifood Canada (2003) reported that one of the major issues the apple trade faces is high tariffs e.g. there is 50% tariffs on imports of apples from Asia, 15% in Venezuela, 13% in Argentina, 10% in Taiwan and 5% in Indonesia. The European Union follows a complex tariffs composition that changes every month and for each variety during the crop season.

Besides the market access issues, Canada faces strong competition from US markets. Apples in the US mature early, which set the price, causing depressing effects on prices of Canadian apples, limiting the opportunities of market expansion of Canadian exporters. Since Canadian markets are already open to the world's largest producer of apples i.e. the US under NAFTA, liberalization of the world's markets under WTO would help Canadian exporters.

II. CONCEPTUAL FRAMEWORK

The Armington model distinguishes products by place of production and describes trade flows for non-homogenous goods. The good produced by one country (typically called product) is an imperfect substitute for the same good produced in another country. Hence, the model allows consumers' preferences to influence the trade flow pattern.

Armington (1969) employed a two-stage budgeting procedure assuming weak separability. The procedure assumes that in the first stage, consumers allocate their total expenditure to the broad groups of goods while in the second group expenditures are allocated to individual commodities to minimize cost. Deaton and Muellbauer (1980) suggested that the assumption of weak separability of the direct utility function is the necessary and sufficient condition for two stage budgeting procedure. Armington (1969) in the first stage specifies the total demand for foreign and domestic products, assuming that an importer maximizes utility, U, subject to income.

$$\text{Max } U = U(Q_1, Q_2, \ldots, Q_n) \text{ subject to } E = \sum_{i=1}^{n} Q_i P_i \qquad (1)$$

where Q_i is the ith good or market, P_i is the price index in ith market and E is the income. The maximization process generates Marshalian demand as a function of income and prices.

For the second stage, Armington assumes single Constant Elasticity of Substitution (CES) i.e. elasticity of substitution is constant and same between any pair of products in a

given market. He also assumes homothetic market share to get the expenditure as $E = \sum_{i=1}^{n} P_i X_i$. Armington then minimizes this expenditure subject to the generalized single CES function to get Hecksian demands. The ratio of the first order conditions yields:

$$\frac{Q_{ij}}{Q_{ik}} = \left(\frac{b_{ik} P_{ij}}{b_{ij} P_{ik}} \right)^{-1/1+\rho_i} \tag{2}$$

where b_{ij} and b_{ik} are constants for product i imported from country j and k, Q_{ij} and Q_{ik} are quantities of the products from jth and kth supplier to ith and kth markets and P_{ij} and P_{ik} are their respective prices. ρ_i is constant elasticity of substitution for all markets. Rewriting $1/\rho_i + 1 \equiv \sigma_i$, he derives the single CES demand function for Q_{ij}. The demand function in the market share form is given as equation (3).

$$\frac{Q_{ij}}{Q_i} = b_{ij}^{\sigma_i} \left(\frac{P_{ij}}{P_i} \right)^{-\sigma_i} \tag{3}$$

Multiplying both side of equation (3) by $\frac{P_{ij}}{P_i}$ yields

$$\frac{P_{ij} Q_{ij}}{P_i Q_i} = b_{ij}^{\sigma i} \left(\frac{P_{ij}}{P_i} \right)^{1-\sigma i} \tag{4}$$

Equation 4 expresses market share in expenditure. The expression on right hand side shows the share of expenditure of country j in the total expenditure made on imports of product i. If $\sigma_i = 1$, then market share is constant, if $\sigma_i > 1$, then a relative fall in P_{ij} yields an increase in market share of Q_{ij} and vice versa. Most of the empirical studies took the double log of either equation (3) or (4) to estimate the elasticities of substitution. This study uses Linear Approximate of Almost Ideal Model (LA-AIDS) of Deaton and Muellbauer (1980) to estimate the elasticities of substitution for apples imported from the United States, Chile, New Zealand and Rest of the World (RoW).

Several studies applied the approach of Armington (1969) to model the trade in agricultural products. Honma and Heady (1984), Babula (1986) and Figueroa and Webb (1986) used Armington procedure and contributed to it by modifying some of its assumptions. Ito et al. (1990) modeled trade of rice using modified Armington procedure. Yang and Koo (1992) estimated Armington model for Japanese import of red meat. A summary of these studies is given in Table 1.

Ito et al. (1990) criticized the original Armington method for ignoring domestic production in his trade model and making unrealistic assumptions. They argued that preferences of importing country determines market share for individual exporter and cannot be homothetic. Alston et al. in 1989 and 1990 also extended such criticism. Ito et al. (1990)

Table 1. Description of the first and second stage equations of the selected studies.

Author(s) and Year	Commodity	1st-stage Estimation			2nd-stage Estimation				
		Dependent variable	Domestic production[1]	Other independent variables	Time Series/Cross Sectional	Dependent Variable	Price Variable	Other Independent Variables	# Importer and Exporters
Honma – Heady (1984)	Wheat	Total imports (Per capita)	Yes	Wheat price Corn price Income Ending stock Government imports Dummy variables	Time series with SUR[2]	q_{ij}	$P_{ij} - P_i$	Time trend Dummy variables	10 importers 5 exporters
Babula (1986)	Wheat, corn and cotton	Total imports	No	Wheat price Corn price Oil price GDP Lag dependent variables	Time Series	q_{ij}	P_{ij}/P_i	Total imports Time trend Ship service supply Oil price index	6 importers USA and ROW[3] are exporters
Figueroa – Webb (1986)	Wheat and corn	Total imports	Yes	Wheat price Corn price GNP CPI Dummy variables	Time series with SUR and OLS	q_{ij}/Q_i	P_{ij}/P_i	Dummies	8 importers 6 exporters
Ito et al., (1990)	Rice	Total Imports	Yes	Domestic demand Ending stock Domestic production	Time series with SUR and OLS	Model 1 – q_{ij} Model 2 – q_{ij}/E_j	P_{ij}/P_i	----	1 importer (all regions are lumped) 6 exporters
Yang and Koo (1992)	Red Meat	Total Imports	No	P_{ij}/P_i	Time series with SUR and OLS	Q_i/E_r	P_j/P_T	Total expenditure	1 importer (Japan) 4 exporter

[1] Implies inclusion of domestic production as exogenous variable
[2] Seemingly unrelated regression
[3] Rest of the world

estimated the original Armington model and later made changes by violating the assumptions of Armington model to suggest a modified procedure for modeling trade shares.

Ito et al. (1990) rejected the assumptions of single CES and homotheticity assumptions at 1% significance level. They also found that market shares for individual exporters were not always independent of the changes in the level of expenditures allocated to the imports. Therefore the assumption of homotheticity may be erroneous. They concluded that the results of their study did not imply total rejection of the basic Armington procedure rather the original model should be modified according to their procedure.

Yang and Koo (1993) followed Ito et al. (1990) and relaxed the assumptions of single CES and homotheticity to estimate the Japanese import demand for red meat using the Generalized Least Square (GLS) technique. They used expenditure-share dependent equations. They found that Armington elasticity of substitution was 0.28 and the estimated single CES was 0.72. The generalized model produced statistically significant elasticities of substitution for different countries implying the rejection of homotheticity and symmetry. The own price elasticities estimated through Armington were lower as compared to generalized model, implying the assumptions of homotheticity and single CES can lead to lower price elasticities.

Alston et al. (1990) used non-parametric methods, double log import demand model nesting the Armington model and Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) to test the restrictions of Armington parametrically following Winter (1984). The non-parametric method used results of the revealed preference analysis to derive algebraic conditions on demand functions. Generalized Axiom of Revealed Preference (GARP) and Homothetic Axiom of Revealed Preferences (HARP) *were* respectively used to test the compatibility of data with utility maximization behavior and existence of homothetic utility function. All the data sets rejected HARP implying rejection of homotheticity by all the import demand equations. None of the data satisfied homothetic and separability conditions together.

The double log specification of import demand comprehensively rejected the assumptions of Armington model but homotheticity could not be rejected in four cases while separability, homothetic separability and Armington model were rejected in all cases. Similarly results of AIDS showed that homotheticity in wheat were rejected for Japan and USSR and was not rejected for China, Brazil and Egypt. Homotheticity for cotton was rejected for Hong Kong, France and Japan and was not rejected for Taiwan and Italy. Separability was comprehensively rejected for cotton and 9 out of 18 cases for wheat. The joint test of homotheticity and separability was rejected at least once in each country case.

The article concluded that all the three approaches i.e. non-parametric methods, double log import demand and AIDS, comprehensively rejected Armington restrictions in case of wheat and cotton. Authors recommended the use of less restrictive set of assumptions about demand relationships than those of Armington model. However, researchers used AIDS to test the assumptions of Armington model irrespective of the outcome of GARP that a wellbehaved utility function exists that might limit the outcome of their research. Further they did

not include prices of the commodities from outside of the group when separability was tested which may limit his outcome of the rejection of separability.

George and Kruse (1993) reported the problems associated with Armington procedure identified by Ito et al. (1990) and Alston (1990) and developed a method to remove these problems. They estimated Japanese import demand for wheat for the years 1960 to 1985. In the second stage, George and Kruse (1993) argued that the aggregate quantity index in Armington model is CES utility function and not total imports as Armington reported. Such misrepresentation of the quantity index resulted in using an approximating index for the true index, which created approximation bias. Therefore, instead of minimizing expenditure subject to the quantity index, George and Kruse (1993) maximized utility (i.e. quantity index) subject to the expenditure constraint to get the Marshalian demands.

George and Kruse (1993) found that the elasticity of substitution as 3.41 compared to Armington elasticity of substitution of 1. The authors concluded that it is time to wither Armington model since the parameters estimated using the traditional Armington procedure were not consistent and there was approximation problem.

The study in hand tests the assumptions of homothetic market share for apple. Further most of the studies tested for separability ignoring prices outside of the group. Testing of separability is beyond the scope of this study, however, it is important to reinvestigate the issue considering prices outside from the group of commodities. Further, a proof for testing these assumptions in fruits and vegetables is required because the commodities are highly differentiated.

Empirical Framework:

Equation (4) can also be expressed in the expenditure share form as:

$$w_i = b_i^{\sigma}\left(\frac{P_i}{P}\right)^{(1-\sigma)} \tag{5}$$

where w_i is the market share of the expenditure made on apple imports from country *i*. Linear Approximate of Almost Ideal Demand System (LA-AIDS) of Deaton and Muellbauer (1980) was used to estimate equation 5. LA-AIDS was selected for estimation because the system is a good approximation of AIDS and comparatively easy to estimate. Alston et al. (1994) reported that LA-AIDS provides quite accurate estimates of elasticities when true data generating process is AIDS. However AIDS has well known properties of flexibility, first order approximation, satisfaction of the axioms of choice, aggregates perfectly over consumers without invoking a parallel Engel curve and can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters.

In AIDS specification, the budget share for imports from source i is given as

$$w_i = \alpha_i + \sum_{j=1}^{n}\gamma_{ij}\ln P_j + \beta_i \ln\left(E/P^*\right), \text{ i= 1, ..., n} \tag{6}$$

where E was the total expenditure on imports and P_j were prices of imports from source j. γ_{ij} and β_i were the parameters estimated in the system of equations. γ_{ij} are compensated cross price elasticities but in the current study these represent the elasticities of substitution between the products imported from different sources. As suggested by theory, the own price elasticity should be negative while the sign of cross price can both be negative or positive depending on the nature of relationship among the imports from different sources. β_i is the coefficient of adjusted expenditure and its sign can classify the product as necessity or luxury. The conditions of adding-up, homogeneous of degree zero in expenditure income and prices and Slutsky symmetry requires that $\sum_{i=1}^{n}\alpha_i = 1,\ \sum_{i=1}^{n}\gamma_{ij} = 0,\ \sum_{i=1}^{n}\beta_i = 0$ and $\gamma_{ij} = \gamma_{ji}$ hold. The restriction on adding up was assumed to hold and could not be imposed because of singularity problem while rests of the conditions were imposed on the system. Deaton and Muellbauer (1980) reported the log of price deflator as

$$\ln P^* = \alpha_0 + \sum \alpha_k \ln P_k + 1/2 \sum_j \sum_k \gamma_{kj} \ln P_k \ln P_j \qquad (11)$$

Equation (11) was approximated as Stone's geometric price index for imports i.e. $\ln P^* = \sum_{k=1}^{n} w_k \ln P_k$ where w_k was the expenditure share of source k in total imports. Alston et al. (1994) evaluated different formulas for calculation of the elasticities of substitution and own price elasticities from LA-AIDS model and provided the following relationship if $\beta_i = 0$ for all i i.e. when preferences are homothetic.

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} \qquad (12)$$

where ε_{ij} is the own price elasticity if $\delta_{ij} = 1$, for i=j and elasticity of substitution if and $\delta_{ij} = 0$ for $i \neq j$ and δ_{ij} is the Kronecker delta. Compensated price elasticities (ε_{ij}^*) were calculated using Slutsky's equations as:

$$\varepsilon_{ij}^* = \varepsilon_{ij} + w_j \varepsilon_{ix} \qquad (13)$$

where ε_{ix} are expenditure elasticities calculated as $\varepsilon_{ix} = 1 + \frac{\beta_i}{w_i}$.

Following the observation of Hickman and Lau (1973) that Armington applied his model to the cross sectional data and in time series data the share of exporters may change as exporters tried to expand their exports. Therefore, the behavior of exporters may not be mutually independent and the error term of the ordinary least square (OLS) analysis of suppliers may be correlated. Given these observations, LA-AIDS was estimated using Seemingly Unrelated Regressions (SUR) technique developed by Zellner (1963). Maximum likelihood estimates of the parameters were estimated using Shazam 6.0. Although one of the equations was dropped to avoid the singularity problem, yet the estimates of the parameters are in variant to dropping of the equation in case of SUR (Barten, 1969) Ito et al. (1990), Alston et al., (1990) and many others used the same technique in their studies. SUR requires the assumptions of normally distributed disturbances as well as linear or log-linear specifications for each equation.

There may have been a change in exporter share of the Canadian import market as well as a change in Canadian preferences with respect to exporters' prices due to NAFTA. Therefore, likelihood ratio procedure is used to test the effect of NAFTA on the imports of apples to Canada during the period of 1988 to 2004.

$$2[\lambda_u - \lambda_r] \sim \chi^2(j) \qquad 14$$

where λ_u was the log likelihood for the unrestricted model and λ_r was the log likelihood for the model with all j parameters. The assumption of homotheticity is also tested by using the likelihood test ratio assuming that the effect of $\beta_i = 0$.

Data:

Initially the monthly data on imports of fresh apple other than for processing having 8 digits SITC code of 08081090 was obtained from Canadian international trade data base for the years 1988 to 2004. However, the data did not consistently include imports for the same set of countries and therefore, monthly data on the quantity (Kgs) and value (US$) of fresh apples imports having 6 digits SITC code of 080810 was collected. There were 21,160 observations of imports made from all over the world during this period. Annual observations of quantity in million kgs and value in million dollars of imports were generated. USA, South Africa, Chile, Argentina and New Zealand were the major apple exporting countries to Canada during the study period accounting for more than 90 percent of exports.

Per Capita Income (PCI) data, converted to current US thousand dollars was obtained from United Nations database, UN Statistics Division. Both value of imports and PCI were nominal. South Africa was having some missing observations and therefore was lumped with Rest of the World (RoW). Similarly the contribution of Argentina in total exports of apples to Canada was less than 7 percent and was also lumped with RoW. On average the contributions of USA, New Zealand and Chile in the total exports of apples to Canada were about 73.4, 10.8 and 9.1 percent.

III. RESULTS

Impact of NAFTA:

LA-AIDS of equations with and without NAFTA dummy as unrestricted and restricted equations were estimated using Seemingly Unrelated Regression (SUR) technique. The likelihood ratio procedure was used to test for the hypothesis that coefficient of dummy is equal to 0. The test failed to reject the hypothesis at 95 percent level of significance (Table 2); therefore the model was estimated with dummies.

Table 2. Testing the impact of NAFTA, 1988-2004.

Type of model	Log of likelihood	χ^2
Restricted (λ_r)	114.685	27.772 (0.000)
Un-restricted (λ_u)	128.571	

A figure in parenthesis shows significance.

To investigate the sources of differences in exporters' share of the Canadian import market as well as changes in Canadian preferences about exporters' prices due to NAFTA, comparison of means of quantity, value and unit values of imports and trade shares before and after NAFTA was carried. Table 3 shows that both the quantity and value of US exports to Canada increased significantly after NAFTA due to significant decrease in the unit values of their exports. Similarly the quantity and value of RoW exports to Canada increased significantly after NAFTA.

Table 3 reveals that while the share of US in the total exports to Canada did not change significantly, RoW export share decreased significantly. New Zealand might have gained the decrease in export share of RoW as its share increased significantly after NAFTA. The significant increase in the export share of New Zealand is also due to significant decrease in the unit values of their exports[2].

Table 3. Comparison of means of quantity, total value, unit value and trade share before and after NAFTA, 1988-2004.

Country	Quantity (Million Kgs)[d]		Total Value (Million US $)		Unit Value ($/Kg)		Trade Share	
	Before	After	Before	After	Before	After	Before	After
USA	7635.17[a]	10174.78[a]	60.70[a]	106.88[b]	0.010[a]	0.008[b]	0.744[a]	0.729[a]
New Zealand	1004.51[a]	898.20[a]	11.25[a]	13.10[a]	0.015[a]	0.012[b]	0.140[a]	0.091[b]
Chile	872.37[a]	1090.87[a]	8.00[a]	13.41[a]	0.012[a]	0.010[b]	0.098[a]	0.087[a]
RoW[e]	138.72[a]	954.32[b]	1.43[a]	12.37[b]	0.013[a]	0.010[b]	0.093[a]	0.018[b]
Total Imports	9650.73[a]	13118.17[a]	81.4[a]	145.76[b]	0.011[a]	0.009[b]	---	---

[d] Means across rows with different letter are significantly different at 95 percent.
[e] Rest of the world

[2] It was hypothesized that the increase in New Zealand trade share might be due to decrease in tariff under market access requirements of world trade organization, however, the hypothesis could not be accepted.

The Demand System:

On overall the system fitted the data very well as 94 percent of the variation in expenditures on apple imports is explained by the variation in prices and per capita income. The log of likelihood function is significant at 95 percent level of significance suggesting that the combined effect of all the estimated parameters in the system of equations is statistically different from zero.

We expect that the own price effects are negative while the cross price effects could be either negative or positive, depending on the nature of relationship between imports. Results of the estimated equations for US, New Zealand and Chile are given in Tables 4 to 6. Except US, data for both New Zealand and Chile fitted their equations very well. For all the countries, the own price effect on expenditure on apple purchase is negative and follows the economic theory. In case of US, a 10 percent increase in the price of US apple will decrease expenditure on US imports by 0.56 million dollars, keeping other variables constant. The own price effect for New Zealand is the highest compared to others while that of US and Chile are almost the same.

Further, the expenditure made on imports of apples from New Zealand significantly decreased since the inception of NAFTA as depicted by the dummy variable. The effect of income on the expenditure made on imports of apples is insignificant for all the three countries. New Zealand apples are found as inferior as compare to apples imported from other sources.

To test for autocorrelation, residuals from all the equations were plotted. This is done because Durban-Watson and other statistics used to detect autocorrelation may not accurately detect it in case of SUR technique. The residuals showed pattern only in case of US. Autocorrelation typically leads to under estimation of the standard errors that could over estimate the t-statistics and lead to wrong conclusion on hypothesis testing. However, in case of US all the estimated parameters are statistically insignificant and there is no chance that autocorrelation would lead to wrong hypothesis testing.

Homotheticity was tested using the likelihood ratio test by assuming that all (3; = 0. Testing this assumption also implies that in the absence of price changes budget shares will not change. The likelihood ratio test suggested that homotheticity is accepted. This result is in contrast to what Ito et al. (1990) and Alston et al. (1990) found. The acceptance of homotheticity in case of apples also implies that outcome of the tests of Armington assumptions may vary with the type of good, and the model needs further testing before it can be withered. Further, the initial assumption by Alston et al. (1990) that wheat and cotton are differentiated goods may need reconsideration since as compared to fruits and vegetables, these goods may not be highly differentiated as required under the assumptions of Armington.

Table 4. Estimated equation for the United States, 1988-2004.

	Parameter	Standard Error	P-value	Descriptive Statistics
USA	-0.056	0.119	0.642	$R^2 = -0.164$
New Zealand	-0.020	0.069	0.772	
Chile	0.087	0.072	0.243	Mean of dependent
Rest of the World	-0.010	0.064	0.878	Variable = 0.734
D	-0.028	0.025	0.272	
PCI	0.112	0.079	0.178	
Constant	-0.137	0.629	0.831	

Table 5. Estimated equation for New Zealand, 1988-2004.

	Parameter	Standard Error	P-value	Descriptive Statistics
USA	-0.020	0.069	0.772	$R^2 = 0.60$
New Zealand	-0.104	0.080	0.209	
Chile	0.111	0.052	0.049	Mean of dependent
Rest of the World	0.014	0.049	0.781	variable = 0.108
D	-0.537	0.014	0.001	
PCI	-0.440	0.035	0.229	
Constant	-0.159	0.259	0.548	

Table 6. Estimated equation for Chile, 1988-2004.

	Parameters	Standard Error	P-value	Descriptive Statistics
USA	0.087	0.072	0.243	$R^2 = 0.44$
New Zealand	0.111	0.052	0.049*	
Chile	-0.061	0.065	0.363	Mean of dependent variable = 0.091
Rest of the World	-0.014	0.037	0.002*	
D	-0.011	0.156	0.493	
PCI	0.004	0.032	0.907	
Constant	0.075	0.180	0.680	

Elasticities of Demand and Substitution:

Elasticities of demand show the proportionate change in quantity demanded due to a proportionate change in prices. Demand in case of New Zealand and Chile are elastic while just above unit elastic in case of US. Therefore, a small decrease in the unit values of New Zealander and Chilean apples will lead to proportionately higher increases in the demands of their apple exports.

Elasticity of substitution is the proportionate change in the ratio of imports from one country to the imports from other country for a given percentage change in the ratio of import prices (or unit value of imports in this study). Thus it is the rate at which Canadian importer is induced to alter say the ratio of US apple to Chilean apple for the change in the unit values of US apples relative to the price index of apples. The Armington model assumes a single CES for each importer that implies that apples imported from US substitute for Chilean apples at the same rate as apples imported from Chile with those from New Zealand.

Results show that apples imported from New Zealand are complements to those imported from Chile, therefore, as imports from New Zealand increases then imports from Chile also increase. Further both the countries have elastic and almost same own price elasticities. These similarities might be due to the reasons that both the countries have almost equal share in the total imports of apple and the unit value of imports from both the countries is almost the same (Table *3)*.

Table 7 further reveals that US is facing inelastic elasticities of substitution from New Zealnd (-0.19) and Chile (0.95) while Chile faces slightly elastic elasticities of 1.02 from New Zealand and New Zealand also faces elastic elasticties of substitution from Chile. This might be due to the reasons that apple can be imported from both the countries during the same season or fresh apple might be harvested during the same period in both countries. Rest of the world has elastic elasticities of substitution mainly due to low share in the total imports. Blonigen and Wilson (1999) studied the factors that explain substitutability between home and foreign goods to explain elasticity of substitution. Such analyses though beyond the scope of this study, yet important to determine the most important factors that explain elasticity of substitution.

Table 7. **Own price elasticities and elasticities of substitution, 1988-2004.**

	USA	New Zealand	Chile	Rest of the World
USA	-1.08	-0.19	0.95	-11.82
New Zealand	-0.03	-1.96	1.22	-3.89
Chile	0.12	1.02	-1.67	10.28
Rest of the World	-0.01	0.21	-0.21	-0.85

However, trade shares determine elasticities in LA-AIDS, which significantly changed for some countries after NAFTA (Table *3).* Therefore, means of own price elasticities and substitution elasticities were compared before and after NAFTA and results are compiled in table 8. Two outliers were removed from rest of the world own price elasticities. In almost all cases, the direction of change remained the same. However, the cross price elasticities of New Zealand with respect to USA (Chile) decreased (increased) significantly. For Chile, the elasticities of substitution with respect to USA changed from relatively inelastic to elastic after NAFTA while the same significantly changed from elastic to inelastic in case of New Zealand.

It is evident from tables that all the expenditure elasticities were elastic while compensated elasticities were elastic only in case of New Zealand and Chile (tables 8 and 9). Therefore, the proportionate change in the expenditure made on the purchase of apple would be higher than the proportionate change in their prices. The sign of the elasticity of expenditure in case of New Zealand is unexpected but it might be due to the reason that apples imported from New Zealand are inferior. However in case of compensated elasticities all the signs are according to the prior expectation.

Table 8. Own price elasticities and elasticities of substitution before and after NAFTA.

	USA		New Zealand		Chile		Rest of the World	
	Before	After	**Before**	**After**	**Before**	**After**	**Before**	After
USA	-0.881[a]	-1.076[a]	-1.179[a]	-0.808[b]	0.902[a]	1.118[a]	-11.811[a]	-9.638[a]
New Zealand	-0.033[a]	-0.027[a]	-1.808[a]	-2.179[6]	1.150[a]	1.426[a]	-10.724[b]	-14.895[a]
Chile	0.118[a]	0.119[a]	0.862[a]	1.258[b]	-10.013[a]	-12.176[a]	-1.881[a]	-2.003[a]
Rest of the World	-0.014[a]	-0.014[a]	0.109[a]	0.131[a]	-0.152[8]	-0.145[a]	-53.493[a]	-13.455[b]

[d]Means across rows with different letter are significantly different at 95 percent.

Table 9. Compensated and expenditure elasticities of the selected importers.

Country	Compensated Elasticities	Expenditure Elasticities
USA	-0.23	1.15
New Zealand	-2.29	-3.06
Chile	-1.58	1.04
Rest of the World	-0.46	5.89

Conclusion:

This study estimated Armington model employing Linear Approximate of Almost Ideal Demand System (LA-AIDS) to estimate the parameters of important demand equations for apples. Apple is one of the biggest contributors to the Canadian trade of horticultural commodities and is highly differentiated. Besides the assumptions of homotheticity, the study tested the affect of NAFTA on the import behavior of Canadian imports of apple. Data for the years 1988 to 2004 were used for the analysis. Import demand equations for USA, Chile and New Zealand were estimated using SUR, while it was derived for the rest of the world.

The likelihood ratio procedure showed that NAFTA had significant affect on the exporters' share of Canadian import market as well as Canadian preferences about exporter prices. The major reasons for this affect were the significant increase in the US and RoW exports to Canada after NAM caused by significant decrease in the unit values of their exports. Further, New Zealand is emerging as one of the strong exporters of apples to Canada by gaining most of the share lost by RoW.

The own price effect for New Zealand is the highest compared to others while that of US and Chile are almost the same. The affect of income on the expenditure made on imports of apples was insignificant for all the three countries. Also the combined effect of these incomes was insignificant and the assumption of homotheticity was accepted. Further, the expenditure made on imports of apples from New Zealand significantly decreased since the inception of NAFTA.

Demand in case of New Zealand and Chile are elastic while just above unit elastic in case of US. The relatively low elasticity of demand of US as compared to other countries may be due to large share of US in the imports of apples to Canada. Apples imported from New Zealand were complements to those imported from Chile. The elasticities of substitution of both the countries are statistically significant and slightly elastic. Chile and New Zealand face

elastic elasticities of substitution from each other. This might be due to the reasons that apple can be imported from both the countries during the same season or fresh apple might be harvested during the same period in both countries. Rest of the world has elastic elasticities of substitution mainly due to low share in the total imports.

The study contributed to the existing knowledge about the value and direction of own price elasticities, elasticities of substitution, elasticities of expenditure and compensated elasticities. The impact of NAFTA on apple trade was estimated and elasticities before and after were compared. Homotheticity, one of the Atmittgton assumptions, was tested. However, the study covered only short duration of 17 years of Canadian apple imports and the results should be considered with caution. However, testing of the Armington assumptions are recommended for fruits and vegetables because the group is highly differentiated.

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