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CANADIAN IMPORT DEMAND FOR FRESH FRUITS: A DIFFERENTIAL DEMAND SYSTEM APPROACH

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Abstract

The synthetic Rotterdam/CBS model developed by Barten was used to estimate Canadian fresh fruit import demand for the period from 1973 through 1987. Results suggest that (1) most imported fresh fruits are substitutes to each other; (2) the import demand for fresh grapefruit was neutral with respect to income changes; and (3) import demands for fresh grapefruit and oranges were insensitive to their own-price changes.

Key words: Canadian, demand, fresh fruits, fresh grapefruit, differential approach.

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During the period from 1973 through 1987, Canada's per capita fresh fruit consumption exhibited an upward trend (Agriculture Canada). Per capita consumption of lemons, bananas, grapes, strawberries, melons, and several other types of fruit have exhibited an upward trend. In contrast, consumption of oranges, apples and particularly fresh grapefruit, did not. As a result of expanding fresh fruit consumption, in general, the fresh grapefruit share of the total fresh fruit market declined during the study period (Agriculture Canada).

More than 80%, 35%, and 60% of the apples, grapes, and strawberries, respectively, supplied to the Canadian market were produced in Canada during the same period (Agriculture Canada). While domestic production of apples decreased, production of strawberries increased and that of grape remained almost the same.

Imports of fresh apples increased during the same time period[a]. Similar patterns are observed for fresh bananas and grapes. Per capita imports for all fruits and total fruit increased except for fresh grapefruit and oranges. For fresh grapefruit, average per capita imports per year decreased 8.34 percent and 14.01 percent between 1973-77 and 1978-82, and between 1978-82 and 1982-87, respectively; for fresh oranges, per capita imports decreased 0.53 percent and 3.38 percent, respectively, for the same time period (Agriculture Canada).

[a]. Assuming all imported fresh apples are actually utilized fresh and not processed.

Canada has been an important export market for U.S. fresh fruits. For example, during 1991, 17.35%, 37.67%, 59.52%, and 16.4% of the total U.S. apple, orange and tangerine, grape, and grapefruit exports, respectively, were sent to Canada. However, compared to 1990, exports of all fresh fruit listed above and total fresh fruit decreased (U.S. Department of Agriculture).

Expected abundant supplies of citrus in the United States for the upcoming years, decreasing consumption of citrus in the Canadian market in the past, and uncertain future consumption suggest the importance of understanding the demand for fresh fruit in terms of international trade. The objectives of this study is to investigate Canadian import demand relationships for selected fresh fruits.

Model

The models considered in this study are based on the concept of two-stage budgeting. As consistent data were available only on Canadian fresh fruit imports, the analysis focuses on the second stage allocation of total expenditures on the fresh fruit import category to individual fresh fruit imports. Imported fresh fruits are assumed to be weakly separable from all other groups of goods in Canada, and total import expenditures on fresh fruits is treated as given. Sub-system or conditional demand models for fresh fruit imports are examined. The conditional demand system for fresh fruit can be derived at the second stage of the budgeting process, based on the assumption of separability at the first stage.

Following Barten (1991), a synthetic model which combines the features of the Rotterdam model (Barten 1964, Theil 1965) and CBS model (Keller and van Driel), is used in this study.

Formally, this model can be written as

$$\bar{w}_i Dq_i = c_i + (a_i + \delta \bar{w}_i) DQ + \sum_j \pi_{ij} Dp_j + \varepsilon_i \qquad i,j = 1,2,...,n, \qquad (1)$$

where $DQ_t = \sum_i \bar{w}_{it} Dq_{it}$ is the discrete version of the Divisia volume index, $\bar{w}_{it} = (w_{it} + w_{i,t-1})/2$, the average budget share for the ith good with the t subscript indicating time; $Dq_{it} = \log(q_{it}) - \log(q_{i,t-1})$, the log change in quantity consumed of good i; $Dp_{jt} = \log(p_{jt}) - \log(p_{j,t-1})$, the log change in price for good j; and c_i is an intercept term for the ith good which is included to capture trends in demand over time (Theil, 1980). The time subscript t in equation (1) has been dropped for convenience. When $\delta = 0$, the model is reduced to the Rotterdam model, $\bar{w}_i Dq_i = c_i + \theta_i DQ + \sum_j \pi_{ij} Dp_j + \varepsilon_i$, and when $\delta = 1$, it collapses to the CBS model, $\bar{w}_i Dq_i = c_i + (\bar{w}_i + \beta_i) DQ + \sum_j \pi_{ij} Dp_j + \varepsilon_i$.

The demand restrictions on the parameter of equation (1) are

Adding-up: $\sum_i a_i = 1 - \delta$, $\Sigma_i c_i = 0$, and $\sum_i \pi_{ij} = 0$;

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

Symmetry: $\pi_{ij} = \pi_{ji}$.

The expenditure and price elasticities for the synthetic model can be obtained straightforwardly from the estimates, i.e.,

Expenditure Elasticity: $\eta_{im} = a_i/\bar{w}_i + \delta$ (2)

Compensated Price Elasticity: $\eta_{ij}^* = \pi_{ij}/\bar{w}_i$. (3)

Uncompensated Price Elasticity: $\eta_{ij} = \pi_{ij}/\bar{w}_i - \bar{w}_j\eta_{im}$, (4)

where η_{ij}^*, and η_{ij} indicate compensated and uncompensated price elasticities, respectively, and η_{im} indicates the expenditure elasticity. Note that in equations (2), (3), and (4), both expenditure and price elasticities are functions of the expenditure share.

Data

Annual data from 1973 through 1987 for quantities and values of fresh fruits imported by Canada were obtained from Statistics Canada. The data were classified into seven groups--oranges, grapefruit, bananas, apples, grapes, melons, and other imported fresh fruit. For the study period, the average quantity imported for fresh grapefruit was 185 million pounds, the second smallest average among the seven groups, next to fresh melons. Imports of fresh oranges averaged 601 million pounds, the largest average for this grouping of goods. The average import levels for fresh bananas, apples, grapes, melons, and other fresh fruit were 561, 192, 306, 158, and 431 million pounds, respectively.

Fresh fruit was assumed to be weakly separable from all other import groups at the first stage of the budgeting process and a sub-system or conditional demand analysis for fresh fruit was carried out at the second-stage of the budgeting process, treating total expenditure on imported fresh fruit as an exogenous variable. The demand system derived at the second stage of the budgeting process is conditional on the first stage allocation. At the second stage, import

expenditure on fresh fruit is allocated into seven groups--oranges, grapefruit, bananas, apples, grapes, melons, and all other fruit. The second stage allocation was estimated using the maximum likelihood estimation method with Slutsky symmetry and homogeneity restrictions imposed.

In consumer demand analysis, the quantity and expenditure variables are frequently put on a per capita or per person basis, implying that a proportionate increase in total expenditure or income and population results in the same proportionate increase in quantity demanded, leaving per capita demand unchanged. Following this convention, a per capita specification is used in this study.

Additionally, due to the fact that Canada's production of apples and grapes is relatively large, the import data set was augmented with domestic production for apples and grapes, and was analyzed. The augmented data set is referred to as wholesale data. The augmentation simply involved adding domestic production to import quantities for apples and grapes. The augmentation resulted in a particularly large increase in the per capita level for apples (more than a fivefold increase), increasing the average budget share for apples and decreasing the average budget shares for the remaining groups of fruit.

Results and Analysis

The model (1) was estimated by the maximum likelihood estimation method. The homogeneity and symmetry conditions were imposed, and the equation for the other fruit category was deleted since the data add-up by construction.

Parameter estimates which are twice or greater in size than their corresponding standard errors were considered significant. The criterion for significance is consistent with the asymptotic result that the critical value for a t-statistic with infinite degrees of freedom or, equivalently, a

normal random variable is 1.96 at the $\alpha = 0.05$ level. Table 1 shows estimates for the intercept terms, the $c_i's$, the price parameters, the $\pi_{ij}'s$, and expenditure parameters, the $a_i's$, and δ, for both import and wholesale data; the numbers in parentheses under the parameter estimates are the corresponding estimated standard errors.

Import Demand Model

For the import data, all expenditure parameters are significantly different from zero at the $\alpha = 0.05$ level; all the own-price parameters are negative and all are significantly different from zero except that for apples; and nine of the cross-price parameters are significant. The cross-price estimates indicate that oranges and bananas, oranges and apples, grapefruit and bananas, bananas and melons, bananas and the other fruit category, apples and melons, grapes and melons, and grapes and the other fruit category are substitutes; melons and the other fruit category are the only pair of complements. Each of the intercept estimates is insignificant at the $\alpha = 0.05$ level, although the estimate for the other fruit group is almost significant at this level of significance. Overall, the likelihood ratio test indicates that all seven intercept terms as a group are significant at the same α level.

Augmented Import Demand Model

For the wholesale data, at the same α level, three (oranges, grapes and melons) out of seven own-price parameters are negative and significantly different from zero; the own-price parameter for bananas is negative and almost significantly different from zero; and the own-price estimates for grapefruit, apples and the other fruit category are insignificant, not differing from zero (the

own-price parameter for apples was also insignificant when domestic production was not included in the analysis). Cross-price estimates indicate that, during the study period, oranges and bananas, oranges and grapes, bananas and grapes, and apples and melons are substitutes; grapefruit and bananas, apples and the other fruit category, and melons and the other fruit category are complements. The likelihood ratio test indicates that all seven intercept terms as a group are significant at the $\alpha = 0.05$ level. Notably, the two sets of expenditure effects in Table 1 differed substantially. The variation in the expenditure variable for imports was substantially different from the variation in the expenditure variable for imports plus domestic production for apples and grapes, and along with the augmented definition for the apple and grape variables underlie the results.

Table 2 presents estimates of the expenditure elasticity, and compensated and uncompensated own-price elasticities for each type of fruit at sample budget share means and at budget share values for the beginning and end of the sample for both import and wholesale data (1973-74 and 1986-87).

Focusing on grapefruit, the results based on the import data in Table 2 show that bananas are substitutes to grapefruit; grapefruit has changed from a normal good to a neutral good over time; and based on the uncompensated own-price elasticity estimates, the demand for grapefruit is inelastic. The results also show that, of the fruits studied, grapefruit has experienced the largest change in its own-price elasticity over the study period with its demand becoming less inelastic. Focusing on oranges, the results based on the import data show that bananas and apples are substitutes to oranges; and oranges are a normal good with an expenditure elasticity that has slightly decreased over the study period. The demand for oranges is also price inelastic.

For the augmented or wholesale data, the results indicate a number of significant relationships for oranges and grapefruit, as well as the other types of fresh fruit. Focusing on grapefruit and oranges, grapefruit has changed from a normal good with respect to expenditure at the beginning of the study period to a neutral good at the end of the study period, while oranges have remained a neutral good throughout the study period; grapefruit demand has been perfectly inelastic to its own price over the study period, while the own-price elasticity for oranges has remained relatively stable over the study period at -0.6.

Although the import and wholesale results differ in a number of ways, consistency in the two sets of results also exists. Focusing on grapefruit and oranges, both sets of results indicate that the expenditure elasticity for grapefruit has been decreasing over time, suggesting grapefruit may have become neutral with respect to income; oranges have remained a neutral (normal) good throughout the study period based on the wholesale (import) data. Based on the wholesale (import) data, the uncompensated own-price elasticity estimates indicate that grapefruit demand is perfectly inelastic (inelastic but not perfectly); the uncompensated own-price elasticity estimates suggest that oranges have an inelastic demand based on either data set, with the wholesale data suggesting a somewhat more inelastic demand.

Concluding Remarks

This study may be helpful in assisting the U.S. and, in particular, the Florida citrus industry, in formulating trade and marketing strategies for fresh grapefruit exports to Canada. Although, advertising and promotional effects were not included in the model, the basic expenditure and price estimates obtained may be useful in developing programs to improve export sales. Except

for growth in Canada's population, other demand factors are not likely to push demand out and put upward pressure on price. Grapefruit demand was found to be neutral with respect to income, relatively insensitive to its own price, as well as prices of other types of fruit, and the time trend variable, although insignificant, was negative, suggesting a slight reduction in demand over time. These possibilities suggest additional promotion and advertising may be needed in the Canadian market in the upcoming years to boost demand. Complementary strategies to expand other existing markets and open up new markets elsewhere in the world would also appear to be important in light of the present findings for the Canadian market.

Table 1. Synthetic Model Expenditure and Price Coefficients for Fresh Fruits in Canada, 1973 through 1987.

		Intercept	Expenditure		Price						
Group	i	c_i	a_i	δ	Oranges π_{i1}	Grapefruit π_{i2}	Bananas π_{i3}	Apples π_{i4}	Grapes π_{i5}	Melons π_{i6}	Other π_{i7}
						Import					
Oranges	1	-0.0041	-0.554*	4.151*	-0.102*	0.003	0.017*	0.040*	0.027	0.002	0.013
		(0.0028)	(0.108)	(0.425)	(0.014)	(0.006)	(0.005)	(0.013)	(0.016)	(0.004)	(0.014)
Grapefruit	2	-0.0013	-0.181*	4.151*		-0.033*	0.011*	-0.001	0.009	-0.005	0.017
		(0.0012)	(0.038)	(0.425)		(0.070)	(0.004)	(0.008)	(0.010)	(0.003)	(0.011)
Bananas	3	0.0002	-0.655*	4.151*			-0.082*	-0.007	-0.005	0.014*	0.051*
		(0.0010)	(0.086)	(0.425)			(0.005)	(0.007)	(0.009)	(0.002)	(0.012)
Apples	4	0.0022	-0.224*	4.151*				-0.026	-0.005	0.018*	-0.019
		(0.0034)	(0.095)	(0.425)				(0.024)	(0.025)	(0.005)	(0.020)
Grapes	5	-0.0025	-0.586*	4.151*					-0.125*	0.016*	0.084*
		(0.0041)	(0.134)	(0.425)					(0.036)	(0.007)	(0.022)
Melons	5	0.0003	-0.117*	4.151*						-0.015*	-0.031*
		(0.0009)	(0.024)	(0.425)						(0.002)	(0.007)
Other	7	0.0053	-0.835*	4.151*							-0.116*
		(0.0028)	(0.120)	(0.425)							(0.039)
						Wholesale					
Oranges	1	0.0006	-1.355*	10.239*	-0.069*	-0.001	0.021*	-0.007	0.048*	0.001	0.007
		(0.0024)	(0.090)	(0.434)	(0.011)	(0.005)	(0.006)	(0.015)	(0.011)	(0.002)	(0.008)
Grapefruit	2	-0.0016	-0.309*	10.239*		0.003	-0.025*	0.010	0.006	0.002	0.005
		(0.0010)	(0.032)	(0.434)		(0.004)	(0.004)	(0.007)	(0.006)	(0.002)	(0.009)
Bananas	3	0.0015	-1.219*	10.239*			-0.017	-0.017	0.023*	0.007	0.009
		(0.0012)	(0.064)	(0.434)			(0.009)	(0.009)	(0.009)	(0.004)	(0.011)
Apples	4	-0.0039	-2.947*	10.239*				0.040	0.008	0.013*	-0.046*
		(0.0068)	(0.238)	(0.434)				(0.045)	(0.026)	(0.004)	(0.017)
Grapes	5	-0.0011	-1.755*	10.239*					-0.097*	0.004	0.008
		(0.0040)	(0.140)	(0.434)					(0.020)	(0.004)	(0.013)
Melons	6	-0.0003	-0.170*	10.239*						-0.013*	-0.013*
		(0.0005)	(0.016)	(0.434)						(0.002)	(0.005)
Other	7	0.0049*	-1.485*	10.239*							0.031
		(0.0022)	(0.092)	(0.434)							(0.025)

Note: Numbers in parentheses are standard errors.

* Estimates are significantly different from zero at $\alpha = 0.05$.

Table 2. Expenditure, Compensated Cross-Price Elasticity Estimates at Sample Means and Two Selected Periods for the Canadian Fresh Fruit Market.

Commodity Group	Elasticity Estimates					
	Expenditure		Compensated Own-price		Uncompensated Own-price	
	Import	Wholesale	Import	Wholesale	Import	Wholesale
			1973-74			
Oranges	1.678*	0.789	-0.456*	-0.483*	-0.832*	-0.596*
Grapefruit	1.313*	2.670*	-0.524*	0.072	-0.607*	-0.037
Bananas	.636*	0.333	-0.439*	-0.143	-0.557*	-0.147
Apples	1.101	1.807*	-0.356	0.114	-0.437	-0.517*
Grapes	1.222*	0.763	-0.626*	-0.522*	-0.871*	-0.664*
Melons	0.259	1.403	-0.490*	-0.695*	-0.498*	-0.722*
Other	0.401	-0.181	-0.520*	0.214	-0.609*	0.240
			Mean			
Oranges	1.432*	0.322	-0.501*	-0.506*	-0.793*	-0.550*
Grapefruit	0.362	0.544	-0.699*	0.092	-0.716*	0.075
Bananas	0.586*	0.352	-0.445*	-0.139	-0.552*	-0.182*
Apples	1.647	1.207*	-0.292	0.123	-0.440*	-0.271
Grapes	1.301*	1.484*	-0.609*	-0.483*	-0.877*	-0.780*
Melons	-0.042	1.142	-0.528*	-0.715*	-0.526*	-0.737*
Other	0.702*	1.123*	-0.478*	0.188	-0.648*	0.005
			1986-87			
Oranges	1.331*	0.629	-0.520*	-0.491*	-0.781*	-0.579*
Grapefruit	-0.273	-0.293	-0.816*	0.010	-0.805*	0.108
Bananas	0.139	-0.145	-0.501*	-0.146	-0.523*	-0.128
Apples	1.970*	0.177	-0.254	0.137	-0.457*	0.085
Grapes	1.220*	1.729*	-0.626*	-0.469*	-0.870*	-0.826*
Melons	-0.402	1.031	-0.573*	-0.724*	-0.563*	-0.741*
Other	1.073*	2.617*	-0.427*	0.157	-0.718*	-0.353*

* Estimates are significantly different from zero at $\alpha = 0.05$ level.

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