DEMAND SUBSTITUTION BETWEEN NATURAL, FLAVORED, AND SYNTHETIC CITRUS JUICES

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Formulation of marketing policies often is based on the knowledge of various demand elasticities for the commodities under consideration. One important aspect of demand analysis is to inquire qualitatively or quantitatively into the extent of demand substitution between commodities. The Florida citrus growers and processors have been much concerned about the impact of flavored and synthetic citrus product substitutes for which the market, in terms of absolute sales, has doubled in less than one decade (Table 1).

The entry of a new product often takes place during the time when a dramatic leftward shift in supply occurs. A most recent example is the introduction of textured vegetable protein in ground beef when a severe shortage and a dramatic increase in the price of beef occurred in 1973. In the case of the citrus juice market, the introduction and market penetration of synthetic and partially natural citrus-flavored drinks were stimulated during the two Florida freezes in 1957 and 1962.

In a study of the earlier stage of the development of the synthetic citrus juice markets, Polopolus and Black [6] concluded that synthetic citrus products have weakened the economic position of Florida citrus producers and that the availability of newly developed synthetics and substitutes hampers demand growth of natural citrus juice products.

The main objective of this study is to estimate the extent of demand substitution between natural, flavored, and synthetic citrus juices based on the statistical estimation of retail demand for 10 selected processed citrus products. Myers [3] and Myers and Liverpool [5] previously have estimated the retail demand for selected orange juice products. The regression results from their models show that numerous significant cross-price coefficients have a negative sign, implying a complementary relationship between orange juice products. The inference about demand substitution based on their regression equations is, therefore, unconvincing. The present model has imposed a constraint on the cross-price coefficients such that a complementary relation is not permitted. Furthermore, the present model includes both processed orange and grapefruit products, and thus, the scope of possible substitution among citrus products is much extended.

A DEMAND MODEL

The statistical inference in this study relies upon the estimation of the consumer demand for selected processed citrus products at the retail level. The retail demand for a citrus product is assumed to be functionally related to its own price, prices of competitive products and other demand shifters. Specifically, the general statistical model can be expressed as:[1]

$$(1) \quad y_{it} = \alpha_i + P_t \beta_i + Z_t \gamma_i + \epsilon_{it} \qquad t = 1, \ldots, T$$

where t specifies the time period, y_i is the per capita retail sales of the ith citrus product, P is an own-price and cross-price vector, Z is a vector of demand shifters, α is an unknown scalar, β_i and γ_i are vectors of unknown parameters in the demand equation, ϵ_i is the error term, and T is the number of observations. The study considers 10 citrus products and, therefore, P is at most a 1 x 10 vector. Two demand shifters in Z are per capita consumer incomes and the temperature index. The temperature index is included to measure the seasonal impacts on retail demand.[2]

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[1] For a detailed description of variables and their units of measurement, see the Appendix.

[2] Initially, temperature data were collected for the 13 largest cities in the nation. Since these 13 data series have very high correlations, the index in New York City, which has the largest population, is chosen for this analysis.

Table 1. VOLUMES AND MARKET SHARES OF NATURAL CITRUS JUICES, AND FLAVORED AND SYNTHETIC ORANGE JUICES, 1965-1966 to 1972-1973*

Season	Total Natural Citrus Juices		Total Flavored and Synthetic Orange Juices		Grand Total
	Volume[a]	Market Share	Volume[a]	Market Share	
	mil. gals.	%	mil. gals.	%	mil. gals.
1965-66	322.6	77	94.9	23	417.5
1966-67	381.9	79	98.7	21	480.6
1967-68	391.9	78	109.2	22	501.1
1968-69	396.3	75	129.3	25	525.6
1969-70	462.0	73	173.0	27	635.0
1970-71	504.8	76	163.2	24	668.0
1971-72	532.6	76	164.3	24	696.9
1972-73	589.1	77	176.5	23	765.6

[a]Single - strength equivalent gallons.

*Source: Citrus Digest, published monthly by the Market Research Dept., Fla. Dept. of Citrus, Lakeland, Fla., selected issues.

The 10 selected citrus products can be grouped into: (1) the natural citrus juices – frozen concentrated orange juice (FCOJ), chilled orange juice (COJ), canned single-strength orange juice (CSSOJ), canned single-strength grapefruit juice (CSSGJ), and frozen concentrated grapefruit juice (FCGJ); (2) the flavored citrus products – frozen concentrated orange drink (FCOD), chilled orange drink (COD), and canned orange fruit drink (COFD); and (3) the synthetic products – frozen concentrated orange synthetic (FCOS) and powdered orange drink (POD).

DATA

Monthly data on retail sales and prices of 10 citrus products are obtained from Market Reasearch Corporation of America (MRCA), an agency which has collected the consumer survey data from a consumer panel of 7,500 households for the Florida Department of Citrus since 1951. Monthly data on population are obtained from the U.S. Bureau of Census [7], while the monthly temperature data are reported by the U.S. National Oceanic and Atmospheric Administration [9]. Both personal incomes and the consumer price index are taken from the U.S. Department of Commerce [8]. The consumer price index is used to deflate all prices and incomes.

EMPIRICAL RESULTS

The general model (1) was fitted using the monthly data over the period of July 1968 to June 1973. All data were transformed to logarithms prior to being used for estimation. One constraint was imposed while estimating (1) for each of the 10 selected citrus products. That is, all cross-price coefficients must be non-negative. This implies that no complementary relationship between citrus juice products is permitted. The reason for this constraint is because the complementarity between orange juice products as established in previous studies [3, 4, and 5] is extremely difficult to explain and accept.[3] It is

[3]It is recognized that the appearance of negative cross-price coefficients might not be much of a specification problem. It is more likely a data problem. The market structure may be such that two price series are reflecting the same supply situation, or the same types of promotional activities are used for two products in the same time, and as a result, the characteristics of substitution cannot be isolated from these price movements. The problem of multicollinearity between price variables can result in unreasonable estimates of price coefficients. Despite this reasoning, it is realized that the elimination of some price variables must be handled with much caution. Unless further improvement on the estimation can be made, an appearance of significant negative cross-price coefficients is rather misleading. Thus, it is preferred to eliminate variables with an incorrect sign.

Table 2. ESTIMATED CONSUMER DEMANDS FOR SELECTED ORANGE AND GRAPEFRUIT JUICE PRODUCTS IN UNITED STATES, JULY 1968 TO JUNE 1973[a]

Eq. No.	Est. Method	FCOJ price log P_1	COJ price log P_2	CSSOJ price log P_3	CSSGJ price log P_4	FCGJ price log P_5	FCOD price log P_6	COD price log P_7	COFD price log P_8	FCOS price log P_9	POD price log P_{10}	Temp. index log Z_1	Consumer incomes log Z_2	Constant	T	ρ	R^2	d
								FCOJ (Dependent variable = log Y_1)										
1.1	OLS	-1.163*		0.918*	0.364*		0.147*					-0.135*	2.454*	-0.654	60		0.933	1.75
		(0.17)		(0.32)	(0.11)		(0.08)					(0.02)	(0.18)	(0.92)				
								COJ (Dependent variable = log Y_2)										
2.1	OLS		-1.247*			0.365*						-0.159*	2.250*	4.398*	60		0.936	0.95[b]
			(0.13)			(0.21)						(0.02)	(0.30)	(0.90)				
2.2	CORC		-1.328*			0.411*						-0.155*	2.051*	4.774*	59	0.535	0.951	1.85
			(0.18)			(0.17)						(0.03)	(0.48)	(1.23)				
								CSSOJ (Dependent variable = log Y_3)										
3.1	OLS	0.263		-0.389	0.615*							-0.161*	0.644*	-0.626	60		0.502	1.63
		(0.31)		(0.57)	(0.20)							(0.03)	(0.30)	(1.45)				
								CSSGJ (Dependent variable = log Y_4)										
4.1	OLS				-1.118*							-0.07*	1.640*	4.108*	60		0.472	0.84[b]
					(0.20)							(0.04)	(0.39)	(0.88)				
4.2	CORC				-1.337*							-0.075	1.380*	5.258*	59	0.567	0.631	2.22
					(0.31)							(0.05)	(0.68)	(1.43)				
								FCGJ (Dependent variable - log Y_5)										
5.1	OLS				1.188*	-0.975						-0.005	8.606*	-12.78*	60		0.766	0.81[b]
					(0.37)	(0.77)						(0.08)	(0.78)	(3.5)				
5.2	CORC				1.022*	-1.436						0.024	7.122*	-9.077*	59	0.624	0.850	1.97
					(0.62)	(0.58)						(0.10)	(1.42)	(3.66)				
								FCOD (Dependent variable = log Y_6)										
6.1	OLS	0.537*					0.419					0.107	1.164	-4.46*	60		0.128	0.83[b]
		(0.30)					(0.34)					(0.10)	(0.87)	(1.64)				
6.2	CORC	0.862*					-1.032*					-0.003	0.048	0.665	59	0.66	0.524	2.34
		(0.53)					(0.39)					(0.11)	(1.55)	(2.76)				

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Table 2. continued

Eq. No.	Est. Method	FCOJ price log P_1	COJ price log P_2	CSSOJ price log P_3	CSSGJ price log P_4	FCGJ price log P_5	FCOD price log P_6	COD price log P_7	COFD price log P_8	FCOS price log P_9	POD price log P_{10}	Temp. index log Z_1	Consumer incomes log Z_2	Constant	T	ρ	R^2	d
								COD (Dependent variable = log Y_7)										
7.1	OLS							0.748*				0.169*	-3.667*	3.726	60		0.700	0.59[b]
								(0.41)				(0.06)	(1.08)	(2.95)				
7.2	CORC							-0.621*				0.054	-1.114*	6.092*	59	0.933	0.874	1.87
								(0.33)				(0.06)	(1.76)	(2.55)				
								COFD (Dependent variable = log Y_8)										
8.1	OLS								-1.530*	1.009*		-0.064	-1.850*	5.906*	60		0.391	0.74[b]
									(0.78)	(0.25)		(0.05)	(0.91)	(3.51)				
8.2	CORC								-2.943*	0.625*		-0.121*	-2.020	12.16*	59	0.780	0.653	1.91
									(0.65)	(0.23)		(0.07)	(1.38)	(3.68)				
								FCOS (Dependent variable = log Y_9)										
9.1	OLS		1.833*						3.884*	-1.111*	1.865*	-0.05	9.254*	-33.98*	60		0.608	1.84
			(0.55)						(1.16)	(0.41)	(1.00)	(0.07)	(1.34)	(5.17)				
								POD (Dependent variable = log Y_9)										
10.1	OLS										-0.609	-0.175*	2.395*	6.464*	60		0.623	1.06[b]
											(0.47)	(0.04)	(0.87)	(3.05)				
10.2	CORC										-0.616	-0.166*	2.582*	6.223*	59	0.471	0.692	1.91
											(0.55)	(0.06)	(1.09)	(3.58)				

*The estimated coefficient is at least significantly different from zero at the 10 percent level according to the t-test.

[a]The figures under parentheses are estimated standard errors, T is the number of observations used in the regression, ρ is the estimated first order serial correlation coefficient, R is the correlation between the observed and estimated values of the dependent variable, and d is the Durbin-Watson statistic.

[b]The hypothesis of no positive serial correlation is rejected at the 5 percent level.

*The estimated coefficient is at least significantly different from zero at the 10 percent level according to the t-test.

[a]The figures under parentheses are estimated standard errors, T is the number of observations used in the regression, p is the estimated first order serial correlation coefficient, R is the correlation between the observed and estimated values of the dependent variable, and d is the Durbin-Watson statistic.

[b]The hypothesis of no positive serial correlation is rejected at the 5 percent level.

worth noting that a system of equation approach suggested by Zellner [10] is not applicable to the previous models for improving their estimates because the same independent variables were used for each of the products under their consideration.

The ordinary least squares (OLS) approach was first employed to estimate the unknown coefficients in (1). The Durbin-Watson test indicated the presence of serial correlation in 7 out of 10 products. The Cochrane and Orcutt (CORC) iterative procedure then was to correct the first order autocorrelation. [4] In this situation, both OLS and CORC estimates are presented for comparison.

The final regression equations are presented in Table 2. All cross-price variables appearing in these final equations have the expected sign and are statistically significant with only one exception for CSSOJ. The inclusion of the FCOJ price in the equation (3.1) for CSSOJ is necessary for the own-price coefficient to maintain the expected sign. When a first order autocorrelation was present, the CORC approach improved substantially the estimates of own-price coefficients for FCOD and COD. [5]

The results in Table 2 show that the estimates of the own-price coefficient were statistically significant and had the expected sign for most products with exceptions of CSSOJ and POD. [6] From these estimates, it can be reasonably concluded that demand for processed citrus products is generally price-elastic. Also, the temperature index and per capita consumer income are significant in most cases. The results confirm the general belief of Florida citrus processors that consumers tend to purchase more citrus juices in the winter than in the summer.

In determining the degree of demand substitution, it is noted that no more than three cross-price variables reasonably can appear in each demand equation. [7] The symmetric condition does not always hold. For example, FCOD is a substitute for FCOJ in equation (1.1), and vice versa as occurred in equation (6.2). In contrast, while CSSGJ appears to be a significant substitute for FCOJ in (1.1), no substitute is identified for CSSGJ in (4.2).

One important aspect of demand substitution in this study is the substitution between natural citrus juices and flavored and synthetic products. In the natural juice category, all significant substitutes are those in the same group. The only exception is the substitution of FCOD, a flavored drink, for FCOJ in equation (1.1). Furthermore, most natural citrus juices do not appear to be important substitutes for flavored and synthetic juices. Such a substitution occurs only in two cases. They are FCOJ substituting for FCOD and COJ substituting for FCOS as shown in equations (6.2) and (9.1), respectively.

In general, it seems reasonable to conclude that a strong substitution between natural citrus juices and flavored and synthetic juices does not exist. FCOJ and FCOS are the two products which apparently have witnessed more substitution effect than other citrus products.

CONCLUSIONS

The results of this study show that the demand substitution between natural citrus juices and flavored and synthetic citrus products has not been as great as one might expect. This rather small degree of substitution might have resulted from the impact of advertising. It is noted that the Florida citrus industry has, in recent years, been heavily advertising its natural citrus juices by generic and brand promotion activities. In the meantime, producers of the flavored and synthetic products also attempted to establish and improve their market position through brand-advertising. As a result, the product differentiation is becoming too well established to permit a pronounced degree of direct competition between these products. If this trend persists, it would be unnecessary in the future for the Florida citrus industry to emphasize the impact of non-natural juice products in formulating their promotional strategies.

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[4] See [2]. It is noted that under the presence of a first order serial correlation, the OLS estimator is not efficient, even though it is unbiased. The CORC estimator, on the other hand, is both consistent and asymptotically efficient.

[5] It is noted that the CORC estimates of cross-price coefficients differ substantially from the OLS estimates in many cases when the model was estimated with a full set of price variables. Thus, the CORC approach proved to be very helpful for identifying those plausible cross-price variables included in these final regression equations.

[6] The estimation of the demand function for CSSOJ is relatively unsatisfactory as R^2 is much lower than that obtained for other products. This also occurred in previous studies [3 and 5]. It is suspected that the inclusion of other non-citrus substitutes might be necessary to improve the estimation for this particular product.

[7] The cross-price variables excluded from the final set of equations were either insignificant or had a negative sign when the model was estimated with a full set of price variables. It is noted that the 10 price variables do not have particularly high correlations. The correlations generally are smaller between prices of natural juices and prices of flavored and synthetic juices than those between prices in the same group. The regression results with a full set of variables are reported in [1].

APPENDIX

Definition of Variables

Variables	Product	Symbol	Unit of measurement
Per capita retail sales	FCOJ	y_1	gallons x 0.001
	COJ	y_2	gallons x 0.001
	CSSOJ	y_3	cases x 0.001
	CSSGJ	y_4	cases x 0.001
	FCGJ	y_5	gallons x 0.001
	FCOD	y_6	gallons x 0.001
	COD	y_7	gallons x 0.001
	COFD	y_8	gallons x 0.001
	FCOS	y_9	gallons x 0.001
	POD	y_{10}	ounces x 0.001
Average retail price[a]	FCOJ	p_1	cents/6 oz.
	COJ	p_2	cents/32 oz.
	CSSOJ	p_3	cents/46 oz.
	CSSGJ	p_4	cents/46 oz.
	FCGJ	p_5	cents/6 oz.
	FCOD	p_6	cents/6 oz.
	COD	p_7	cents/64 oz.
	COFD	p_8	cents/46 oz.
	FCOS	p_9	cents/9 oz.
	POD	p_{10}	cents/18 oz.
Temperature index		z_1	
Per capita consumer income[a]		z_2	thousand dollars

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