The Demand for National Brand and Private Label Frozen Concentrated Orange Juice: A Switching Regression Analysis

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Separate demand equations for national brand and private label frozen concentrated orange juice were estimated using a switching regression model. The results indicate that the demand for national brand frozen concentrated orange juice is more price responsive than the demand for private label juice, and household characteristics have different impacts on the demand for these two products.

Key words: demand, orange juice, switching regression.

During the past several years, a number of national food-processing corporations have invested in citrus-processing plants in Florida. A notable example is the recent acquisition by Proctor and Gamble of one of the largest processing operations in the state. One question of importance to the firms involved as well as to the citrus industry is whether to invest in the development of nationally branded products. Such products already comprise a substantial portion of the frozen concentrated orange juice (FCOJ) market. In the 1982–83 season, national brand sales accounted for 35% of the total sales of FCOJ. A study by the Stanford Research Institute (Pyszka, Walters, and Dresch) indicated that the orange juice market can be expanded by the introduction of more national brands, and recently the Florida Department of Citrus has increased funding for brand advertising and promotional programs.

Critical to the decision to invest in new brands is information about the nature of demand for national brand versus private label product. Knowledge of how the demand parameters differ between national brand and private label products can be important for developing market strategies. In order to advertise effectively, firms should take into consideration the demand differences between private label and national brand products. The purposes of this study are (*a*) to identify the factors that influence the consumers' decision to purchase national brand or private label FCOJ, and (*b*) to estimate a separate demand equation for each.

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Theoretical Model and Estimation Method

The statistical model used in this study is similar to the utility maximization model for discrete/continuous demand choices recently set forth by Hanemann. The general Hanemann model (1984) adapted for this paper is developed below.

Let an individual household's utility function u be

$$u = u(q_1, q_2, q_3, b_1, b_2, b_3, s) \tag{1}$$

where q_i is the quantity of the ith commodity; $i = 1$ for national brand FCOJ, $i = 2$ for private label FCOJ, and $i = 3$ for all other commodities; b_i is a vector of attributes for the ith commodity (e.g., for $i = 1$ and 2, b_i might include measures of FCOJ quality); and s is a

vector of household characteristics (e.g., household size and age-sex composition).

It is assumed that the household maximizes utility expressed by equation (1) subject to a budget constraint

$$\sum_{i=1}^{3} p_i q_i = m \tag{2}$$

where p_i is the price of the ith commodity and m is total household expenditures or income and subject to nonnegativity constraints

$$q_i \geq 0, \quad i = 1, 2, 3. \tag{3}$$

The household's decision or choice variables are the qs, with the ps, bs, m, and s being given.

Constraint (3) indicates the discrete/continuous nature of the utility maximization problem. Specifically, in this study either national brand or private label FCOJ is purchased, depending on the circumstances described by the ps, bs, m, and s.

First, suppose the household chooses a positive quantity of national brand FCOJ. Then, conditional on this decision, the household's utility function is

$$\bar{u}_1 = u(q_1, 0, q_3, b_1, b_2, b_3, s). \tag{4}$$

Assuming $q_2 = 0$ implies $\partial u/\partial b_2 = 0$, or "weak complementarity" as termed by Maler, equation (4) can be written as

$$\bar{u}_1 = \bar{u}_1(q_1, q_3, b_1, b_3, s). \tag{5}$$

This assumption seems reasonable but is not necessary for the following results.

The household can then be viewed as maximizing $\bar{u}_1$ subject to the conditional budget constraint

$$p_1 q_1 + p_3 q_3 = m \tag{6}$$

and nonnegativity conditions

$$q_i \geq 0, \quad i = 1, 3. \tag{7}$$

It is assumed that the properties of u are such that the above maximization yields positive quantities for national brand FCOJ and other goods. The demand functions under these circumstances, called conditional demand functions, can then be written as

$$q_i = f_i(p_1, p_3, b_1, b_3, s, m), \quad i = 1, 3. \tag{8}$$

Substituting the demand functions expressed by equation (8) into the utility function given by equation (5) results in the conditional indirect utility function

$$\bar{v}_1 = \bar{v}_1(p_1, p_3, b_1, b_3, s, m). \tag{9}$$

Alternatively, starting with conditional indirect utility function (9), the conditional demand functions can be derived by Roy's identity (Deaton and Muellbauer, p. 41), i.e.,

$$q_i = -(\partial \bar{v}_1/\partial p_i)/(\partial \bar{v}_1/\partial m), \quad i = 1, 3. \tag{10}$$

Similar arguments can be used if the household chooses to purchase private label FCOJ, i.e., if $q_1 = 0$. Under the conditions discussed above, the conditional demand functions can be written as

$$q_i = g_i(p_2, p_3, b_2, b_3, s, m), \quad i = 2, 3. \tag{11}$$

As before, the conditional demand functions expressed by equation (11) can be used to derive the following conditional indirect utility function for the purchase of private label FCOJ:

$$\bar{v}_2 = \bar{v}_2(p_2, p_3, b_2, b_3, s, m). \tag{12}$$

Again, under the circumstances Roy's identity implies that

$$q_i = -(\partial \bar{v}_2/\partial p_i)/(\partial \bar{v}_2/\partial m), \quad i = 2, 3. \tag{13}$$

With this background, the demand for FCOJ can be written as

$$\begin{cases} q_1 = -(\partial \bar{v}_1/\partial p_1)/(\partial \bar{v}_1/\partial m) \\ \qquad\qquad \text{if } \bar{v}_1(p_1, p_3, b_1, b_3, s, m) \geq \bar{v}_2(p_2, p_3, b_2, b_3, s, m) \\ q_2 = 0 \\ q_1 = 0 \\ q_2 = -(\partial \bar{v}_2/\partial p_2)/(\partial \bar{v}_2/\partial m) \quad \text{otherwise.} \end{cases} \tag{14}$$

The conditional demand equations for national brand and private label FCOJ differ with respect to their treatment of prices and quality. In the national brand equation, the price and quality measures for private label FCOJ are omitted; in the private label equation, the price and quality measures for national brand FCOJ are omitted (Hanemann 1982, 1984 discusses alternative approaches to modeling quality and demand). In subsequent empirical analysis, it was assumed that the quality measures, although different for national brand and private label products, were constant given the cross-sectional nature of the data employed. However, sufficient variation in the prices of national brand and private label products allowed estimation of price effects.

In the empirical analysis of this study, a switching regression technique (Maddala) to correct for selectivity bias was used to examine

the demand for national brand FCOJ and private label FCOJ in the United States. The data used in this study were generated by individuals choosing to belong to one group or another or by individual self-selection. The problem concerns whether the household purchases national brand or private label FCOJ, or the probability of $\bar{v}_1 \geq \bar{v}_2$ (Domencich and McFadden). Roy provides an early discussion of self-selectivity; later, Gronau, Lewis, and Heckman (1976, 1984) point out the econometric implications of this problem.

In addition to q_1 being the demand for national brand FCOJ and q_2 being the demand for private label FCOJ, let x_1, x_2, and z be vectors of explanatory variables. In general, the decision to purchase national brand or private label FCOJ is based upon a variable set which differs from those in the functions that determine the amount of national brand and private label FCOJ purchased. A linear approximation of the model is

$$(15)\quad q_1 = \beta_1' x_1 + u_1 \qquad \text{if } I^* = \gamma' z - \epsilon \geq 0$$

and

$$q_2 = \beta_2' x_2 + u_2 \qquad \text{otherwise,}$$

where γ, β_1, and β_2 are parameter vectors; and ϵ, u_1, and u_2 are disturbance terms. Model (15) is similar to the theoretical model (14). For tractability, model (15) has been specified without the aid of indirect utility functions.

In (15), I^* is an unobserved variable. What one observes is the dummy variable I, which equals one when the household decides to purchase national brand FCOJ and zero otherwise.

The error terms u_1, u_2, and ϵ were assumed to be trivariately normally distributed with zero mean and a common nonsingular covariance matrix for each observation. The variance of ϵ was assumed to be 1, and only contemporaneous correlation among the disturbance terms was allowed (Maddala). To correct for selectivity bias, a two-stage estimation procedure proposed by Lee and Trost and by Heckman (1976) was used to obtain the parameters in equations (15).

In brief, one obtains an estimate $\hat{\gamma}$ of γ by probit maximum likelihood (Maddala, pp. 26–27); then the demand equations can be estimated by ordinary least squares (OLS) with the addition of a variable $\hat{\phi}_i/\hat{\Phi}_i$ in the national brand equation and a variable $\hat{\phi}_i/(1 - \hat{\Phi}_i)$ in the private label equation where $\hat{\phi}_i = \phi(\hat{\gamma}' z_i)$ is the standard normal density function and $\hat{\Phi}_i = \hat{\Phi}(\hat{\gamma}' z_i)$ is the cumulative normal distribution function evaluated at $\hat{\gamma}' z_i$. Formally, (15) can be rewritten as

$$(16)\quad \begin{aligned} q_1 &= \beta_1' x_1 - \sigma_{1*}\hat{\phi}/\hat{\Phi} + \eta_1 && \text{if } I^* \geq 0 \\ q_2 &= \beta_2 x_2 + \sigma_{2*}\hat{\phi}/(1 - \hat{\Phi}) + \eta_2 && \text{otherwise,} \end{aligned}$$

where η_1 and η_2 are new disturbance terms with zero conditional means, i.e., $E(\eta_1 | I = 1) = 0$ and $E(\eta_2 | I = 0) = 0$; and $\sigma_{1*}^2 = \text{cov}(u_1, \epsilon)$, and $\sigma_{2*}^2 = \text{cov}(u_2, \epsilon)$. The residuals η_1 and η_2 are heteroscedastic (Maddala, pp. 225–26). Thus, weighted least squares should be used to estimate (16).

Data and Variables

This study used panel data for July 1981 through June 1982 from NPD Research, Inc. The panel consisted of 9,552 consumers selected by NPD to provide a representative sample of U.S. consumer demographics. Participants kept a weekly diary of all household purchases. The panel data used in this study relate to household purchases of FCOJ by trip.

The variables chosen for the decision function I^* (table 1) include characteristics of the purchase (the price differential, cents-off purchases), characteristics of the household (age, education, and employment status of the female head; income; presence of children; and family size), and seasonal and regional dummies. The same explanatory variables are used in the demand equations except that the price differential variable was replaced in both equations by the full (list) price. The dependent variables for the demand equations were both expressed in quantity purchased per capita.

The cents-off variable, defined as the amount discounted per capita on the total purchase of FCOJ for a given trip, was included in order to determine whether or not an absolute level of savings per shopping trip significantly affects the type and quantity of FCOJ purchased. The average monthly price differential between national brand and private label FCOJ was an approximation of the actual price differential faced by a consumer on a given day.

The demographic variables for the female head of household, assumed here to be the major food purchaser for the household (Zei-

Table 1. Variable Definitions

Variable	Definition
OJ purchased	Ounces of FCOJ purchased per person
Full price	List price of FCOJ in cents per ounce of frozen concentrate
Cents off	Cents off per capita on total purchase of FCOJ
Price differential	Difference between the average monthly price of national brand and private label FCOJ, in dollars per single strength gallon, by region
Employment	Employment status of female head of household, in average number of hours worked per week
Education	Educational status of female head of household; 1 for beyond high school, 0 otherwise
Age	Age of female head of household
Income	Annual per capita income, in thousands of dollars
Children	1 if at least one child present, 0 otherwise
Family size	Number of persons in household unit
Winter	1 for winter quarter (December–February), 0 otherwise
Spring	1 for spring quarter (March–May), 0 otherwise
Summer	1 for summer quarter (June–August), 0 otherwise
Fall	Seasonal base (September–November)
Atlantic region	1 for Atlantic region, 0 otherwise
Central region	1 for central region, 0 otherwise
Southern region	1 for south region, 0 otherwise
Pacific region	Regional base

thaml), along with the seasonal and regional variables were included to account for differences in consumer behavior related to household preferences and circumstances. For example, the age and education of the female head may directly reflect preferences, while the seasonal and regional variables may indirectly reflect preferences due to promotional differences related to time and place. No a priori relationships were hypothesized for these variables.

For the decision equation, cents-off and income were hypothesized a priori to be positively related to the probability of choosing national brand FCOJ. The price differential was expected to be negatively related to the probability of purchasing national brand FCOJ. For the demand equations, cents-off and income were expected to positively influence and full price and family size to negatively influence the quantity purchased per capita.

Sample means and standard errors of these variables are shown in table 2.

Results and Discussion

Table 3 shows the probit parameter estimates and the corresponding standard errors for the decision equation. All parameter estimates are significantly different from zero with the exception of those for the children dummy and

Table 2. Sample Means and Standard Errors

	National Brand		Private Label	
Variable	Parameter	Standard Error	Parameter	Standard Error
OJ purchased (oz.)	8.5983	9.4643	10.1931	9.9385
Full price (¢/oz.)	8.7599	1.8352	7.5144	1.5745
Cents-off (¢)	7.7853	18.9120	4.7115	15.6816
Price diff. ($/gal.)	3.0814	1.3081	3.2963	1.2992
Female employment (hr)	10.7606	15.8975	11.6672	16.1507
Female age (yr)	44.5597	14.9343	45.2770	14.5518
Income ($1,000)	8.1606	5.1773	7.7984	4.9264
Family size (persons)	3.2495	1.2756	3.2783	1.3044
Proportion				
Female education	.5004	.5000	.5084	.4999
Children	.5204	.4996	.5208	.4996
Winter	.2730	.4455	.2548	.4357
Spring	.2397	.4269	.2353	.4242
Summer	.2285	.4199	.2471	.4313
Atlantic region	.3100	.4625	.2454	.4304
Central region	.3268	.4691	.3798	.4853
Southern region	.1948	.3960	.2287	.4200
Number of observations	16,205		31,368	

family size variables (the $\alpha = .10$ level of significance was used throughout the paper).

The estimated marginal effect of an explanatory variable on the probability of purchasing national brand FCOJ is equal to the corresponding estimated parameter times the standard normal density $\hat{\phi}$ evaluated at the sample means for the vector of explanatory variables z, i.e., $\hat{\gamma}_k\hat{\phi}$ where $\hat{\gamma}_k$ is the probit estimate for the kth variable. Given $\hat{\phi}$ is a positive constant, the marginal effects are proportional and identical in sign to the estimated parameters, $\hat{\gamma}$. The estimated marginal effects are shown in the last column of table 3.

The cents-off coefficient signifies an increase in the probability of purchasing national brand FCOJ as total per capita savings increases. A possible explanation for this result is that there are consumers who would like to purchase national brand FCOJ but who buy private label FCOJ instead because of its lower price. If the total amount spent on the FCOJ purchase is reduced by a cents-off special, there is a greater probability of purchasing national brand FCOJ.

The coefficient for the price differential signifies that the greater the difference in cents between the average monthly prices of national brand and private label FCOJ, the greater the probability that consumers will purchase private label FCOJ.

The results for the demographic variables pertaining to the female head of household indicate a stronger preference for national brand FCOJ in households in which the female head is younger, works fewer hours outside the home, or has not gone beyond high school. Possible explanations for these results might be based upon differences in perceptions of quality or susceptibility to advertising among women of different ages, educational backgrounds, or employment experiences.

The positive income coefficient is consistent with the expectation that families with higher incomes are more likely to buy national brand FCOJ, the more expensive FCOJ. The dummy for children indicates that the presence of children within the household does not affect the probability of purchasing national brand FCOJ. The effect of family size also was insignificant.

The estimates for seasonal dummy variables indicate that consumers are more likely to purchase national brand FCOJ in winter and spring and less likely in summer relative to the fall season. In addition, there are regional differences in the probability of purchasing national brand FCOJ. The estimates for the regional dummy variables show that, relative to consumers located in the western region of the United States, consumers located in the Atlantic region are more likely to purchase national brand FCOJ, while those who reside in the central and the southern regions are less likely to purchase national brand FCOJ.

Table 3. Maximum Likelihood Estimates for Decision Equation, I^*

Variable	Decision Equation[a] Parameter	Standard Error	Marginal[b] Prob.
Intercept	−.0767	.0504	—
Cents-off	.0061	.0004	.0022
Price difference	−.0373	.0089	−.0135
Female employment	−.0031	.0004	−.0011
Female education	−.0630	.0125	−.0228
Female age	−.0049	.0006	−.0018
Income	.0110	.0014	.0040
Children	−.0261	.0215	−.0094
Family size	.0082	.0066	−.0030
Winter	.0236	.0176	.0085
Spring	.0405	.0176	.0146
Summer	−.0281	.0169	−.0102
Atlantic region	.0826	.0192	.0299
Central region	−.0774	.0273	−.0280
Southern region	−.0740	.0280	−.0267
Number of observations	47,573		

[a] Maximum likelihood estimators. Efron's $R^2 = .0226$, and McFadden's $R^2 = .0181$ (Amemiya).

[b] The discrete variables, of course, cannot experience marginal changes. Nevertheless, the marginal effects for the discrete variables were calculated as if they were continuous for consistent comparison across all variables. The effect for a discrete variable could also be calculated as the difference between the distribution function evaluated at the alternative discrete variable levels.

Table 4 shows the two-stage parameter estimates for equation (16). In the national brand demand equation, all variable coefficient estimates are statistically significant. In the private label equation, all estimates are significant except the coefficients for the winter and spring dummy variables.

For each demand equation, the own-price parameter is negative, in accordance with economic theory. The own-price elasticities, calculated at the mean values for price and quantity, are −.34 for national brand demand and −.21 for private label demand. These values indicate that the demand for national brand FCOJ is somewhat more price elastic than the demand for private label FCOJ. The greater elasticity for national brand FCOJ in compar-

Table 4. Two-Stage Estimates for Equation (16)

Variable	National Brand		Private Label	
	Parameter	Standard Error	Parameter	Standard Error
Intercept	−30.7478	2.1925	−4.4160	1.7756
Full price	−.3301	.0404	−.2857	.0363
Cents-off	.3975	.0083	.1903	.0109
Female employment	−.0875	.0072	.0489	.0054
Female education	−1.6176	.1844	1.6819	.1425
Female age	−.1439	.0107	.0766	.0087
Income	.3918	.0243	−.0949	.0199
Children	.9888	.2617	−.9292	.1987
Family size	−1.4702	.0860	−.9783	.0607
Winter	2.2763	.2019	.0711	.1632
Spring	.8294	.2028	−.0633	.1556
Summer	−.5658	.2211	.7069	.1592
Atlantic region	2.3971	.2189	−1.0045	.1967
Central region	−5.2288	.3618	2.5073	.2695
Southern region	−3.8270	.3752	3.4680	.2723
$\hat{\phi}/\hat{\Phi}$	−47.5974	2.4422		
$\hat{\phi}/(1-\hat{\Phi})$			25.0142	2.4925
Number of observations	16,205		31,368	
F-statistics	1,266.40		2,612.31	

Note: Weighted least squares method was used to correct for heteroscedasticity (Maddala, pp. 225–26).

ison with that of private label FCOJ is consistent with expectations based upon economic theory, according to which higher-priced products tend to be more elastic.

The cents-off coefficient indicates that buyers of both national brand FCOJ and private label FCOJ increase their purchases as the per capita discount increases. The elasticities for cents-off, calculated at the sample means, are .36 and .09 for national brand FCOJ and private label FCOJ, respectively. The result indicates that the demand for national brand FCOJ is more responsive to special cents-off than the demand for private label FCOJ.

The result shows that the per capita demand for national brand FCOJ decreases with the number of hours the female head is employed outside the home, whereas the opposite pattern holds for the per capita demand for private label FCOJ. A similar relationship is found between college education of the female head and the per capita demand for national brand FCOJ and private label FCOJ. In addition, the female age coefficients indicate that older households tend to purchase less national brand FCOJ and more private label FCOJ than younger households.

The coefficient estimate for the per capita income variable is positive for national brand FCOJ and negative for the demand for private label FCOJ, the latter indicating that private label FCOJ is an inferior good or, in other words, the demand for private label FCOJ decreases as per capita income increases. It appears that households which have children purchase more (less) FCOJ per capita if national brand (private label) product is chosen. This result may simply reflect preference differences between national brand and private label consumers. The estimates for the household size variable show that as household size increases, per capita consumption of FCOJ decreases indicating perhaps economies of scale in consumption. In addition, the demand for national brand FCOJ appears to be more sensitive to family size than the demand for private label FCOJ.

The estimates for seasonal dummy variables indicate different patterns of seasonal variation in the demand for the two regimes. The demand for national brand FCOJ is the lowest in summer, while the demand for private label FCOJ is higher in summer than in winter, spring, and fall. The results for the regional dummy variables show that the per capita demand for national brand FCOJ is higher in the Atlantic region and lower in the central and southern regions than that in the western region; and the demand for private label FCOJ is lower in the Atlantic region and higher in the central and southern regions than the demand in the western region.

Concluding Remarks

The results of this study show that the demands for national brand and private label FCOJ differ with respect to a number of factors. Notably, when the price differential between national brand and private label FCOJ is small, the probability that a consumer will purchase national brand product increases; and consumer demand for national brand FCOJ is more price responsive than the corresponding demand for private label FCOJ.

In order to advertise a brand effectively, firms should take into consideration the seasonal and regional variations in FCOJ consumption patterns and the different impacts of demographic characteristics on the demands for national brand FCOJ and private label FCOJ.

It should be pointed out that this study is one of the first to attempt to measure the demand for national brand and private label orange juice of any form. As such, it suffers from limitations which may restrict the applicability of the results of the study to the total U.S. orange juice market. The specific limitations stem from the scope of the study and the nature of the data used.

First, because this study is a first effort, it addresses the demand for only one orange juice product form: FCOJ. Second, the panel data utilized do not record any information on consumers who did not purchase FCOJ during the period covered by the study. Consequently, this study is conditional on consumers buying either national brand or private label FCOJ. The proportion of consumers making such purchases was about 71% in 1982.

This study provides an adaptation and an application of specific theoretical and statistical models of discrete/continuous choice to a well-defined consumer choice problem. This research is part of an emerging body of empirical research on choice among alternative product brands.

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