

Are Fruit Juice Categories Separable?

Erika Knight, Lisa House, Jonq Ying Lee and Thomas Spreen

Food and Resource Economics Department at the University of Florida
IFAS, University of Florida, 1083 McCarthy Hall B
PO Box 110242 IFAS, Gainesville, FL 32611-0240

eknight@ufl.edu; lahouse@ufl.edu; tspreen@ufl.edu



**Paper prepared for presentation at the 110th EAAE Seminar ‘System Dynamics and Innovation in Food Networks’ Innsbruck-Igls, Austria
February 18-22, 2008**

Copyright 2008 by [Knight, House, Lee, Spreen]. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Are Fruit Juice Categories Separable?

Erika Knight, Lisa House, Jonq Ying Lee and Thomas Spreen

Food and Resource Economics Department at the University of Florida

IFAS, University of Florida, 1083 McCarthy Hall B

PO Box 110242 IFAS, Gainesville, FL 32611-0240

eknight@ufl.edu; lahouse@ufl.edu; tspreen@ufl.edu

Introduction

Supermarket shelves are saturated with numerous varieties and brands of juice beverages. This high level of assortment has dramatically changed beverage consumption patterns and trends throughout the United States. In fact, during 2004–2005, energy and sport drinks experienced significant increases in sales, 65.9% and 20.6 %, respectively. During the same period of time, refrigerated juice sales increased a mere 2.2%, shelved non-fruit drinks decreased 0.9%, bottled juices and cocktails both decreased 1.5 % and frozen juice decreased by 12.8% (Food Industry Review 2006). The beverage industry has undergone many transformations, but consumer theory states that a shift in demand for one good has to be compensated by a shift in the opposite directions in the demand for the other good. Thus, with more brands competing for consumers' dollars, it is important for brand managers, retailers, and other industry officials to understand demand interrelationships among various beverages. This study examines the competitiveness and structure of the beverage industry. Existing research suggests the demand for fruit beverages is independent from other food and non-food groups (Heien 1982; Lee 1984); therefore, information pertaining to other goods can be omitted without compromising the validity of the study. Our study will allow us to better understand how consumers make decisions concerning purchases patterns of beverage expenditures.

To accomplish our goal separability tests are conducted among refrigerated and shelved beverages and orange juice and fruit drinks. Compensated price effects and income elasticities are also calculated to identify the degree of substitutability between brands. Various studies have evaluated the relationship among types of fruit juice beverages, (Brown 1993; Brown and Lee 2002; Lee, Brown, and Seale 1992), but these studies assume separability rather than empirically testing within the beverage category. This study will contribute to the existing body of literature by providing information on consumers' behavior regarding their beverage purchases and the structure of this beverage industry, which is the second largest component of the food and beverage manufacturing industry (ERS 2005; Lee 1984; Brown, Lee and Seale 1994). This study will have multiple marketing implications which can be utilized to better understand and position juice products. Considering the many transformations that have occurred in the beverage industry, it is expected that major competitors of orange juice are no longer limited to other breakfast juices, but also sports drinks and single serve juices.

Model and Estimation Methods

The constrained utility maximization problem assumes that given a fixed amount of income to spend, an individual will buy those quantities that exhaust total income. The differential demand model, developed by Barten (1964) and Theil (1965, 1980) is based not on a particular utility function but, more generally, on a first-order approximation to the demand functions themselves. This model is most often used in agricultural economics to test consumption theory (Lee 1984; Brown, Lee and Seale 1994; Lee, Brown and Seale 1992). The Rotterdam model is

derived from the maximization of a general utility function or total differentiation of a general demand function. This model directly incorporates advertising in the demand function, making it possible to estimate the effect of promotions on demand. The model can be written as

$$(1) \quad w_i d(\log q_i) = \theta_i d(\log Q) + \sum_j \pi_{ij} (d \log p_j) \quad i = 1, \dots, n$$

where $w_i = (w_{it} + w_{i,t-1})/2$ represents the average expenditure share for good brand i with subs

cript t standing for time; $d \log q_i = \frac{q_{it} - q_{i,t-1}}{q_{i,t-1}}$ is the log change in the consumption level for brand

$\theta_i = p_i \frac{\partial q_i}{\partial m}$ is the marginal propensity to consume; $d(\log Q) = \sum_i w_i d \log q_i$ is the Divisia vo

lume index; $\pi_{ij} = \left(\frac{p_i p_j}{m} \right) s_{ij}$ is the compensated price effect and s_{ij} is the Slutsky coefficient,

with $s_{ij} = \frac{\partial q_i}{\partial p_j} + \frac{\partial q_i}{\partial m} q_j$, and $d \log p_i = \frac{p_{it} - p_{i,t-1}}{p_{i,t-1}}$ represents the log change in the price of brand i .

The general restrictions of demand theory can be directly applied to the parameters of the Rotterdam model, specifically,

$$(2) \quad \text{Adding up: } \sum_i \theta_i = 1, \quad \pi_{ij} = 1;$$

$$(3) \quad \text{Homogeneity: } \sum_j \pi_{ij} = 0; \text{ and}$$

$$(4) \quad \text{Symmetry: } \pi_{ij} = \pi_{ji}.$$

[The demand elasticities can be calculated using the parameters of the Rotterdam model in equation (1) as:

$$(5) \quad \text{compensated price: } \varepsilon_{ij} = (\pi_{ij} / w_i)$$

$$(6) \quad \text{income: } \eta_i = (\theta_i / w_i).$$

When empirically estimating demand systems, one equation must be omitted to prevent singularity of the variance-covariance matrix of the disturbance terms. The demand parameters of the omitted equation are ultimately recovered.

Separability

The test for block dependence proposed in this study is based on the result found by Glodman and Uzawa (1964). The necessary and sufficient condition for weak separability is that the off-diagonal term in the Slutsky substitution matrix is proportional to the income derivatives of the two separable goods.

$$(7) \quad s_{ik} = \phi_{GH} \left(\frac{\partial q_i}{\partial m} \right) \left(\frac{\partial q_k}{\partial m} \right)$$

all $i \in G$ and all $i \in H$ where s_{ik} is the appropriate element in the Slutsky substitution matrix and ϕ_{GH} is the factor of proportionality between groups g and h . Multiplying both sides of (7) by $p_i p_j / m$ one obtains

$$(8) \quad \pi_{ik} = \phi_{GH} \theta_i \theta_k$$

Block dependence is a special case of weak separability. Under conditions (3.31) the change of marginal utility of a dollar spent on the i^{th} good ($i \in S_i$) caused by an extra dollar spent on the j^{th} good which belongs to a different groups equals $\phi_{GH} \theta_i \theta_k$. This effect is independent of goods i and j , which implies the result is the same for all pairs of commodities in the selected groups. Thus if orange juice and fruit juice are weakly separable groups, an extra dollar spent on either Brand A or Brand B orange juice has the same effect on the marginal utility as a dollar spent on any brand in the fruit juice category. Therefore, utility interaction of two products in different groups is dependent of groups rather than individuals goods (Theil, 1980).

Proposed utility trees are shown in Figure 1. The first utility tree is partitioned based upon the form of the juice (i.e. refrigerated and shelved). The second utility tree is also partitioned by form and then the type. In the final utility tree beverages are partitioned solely by type.

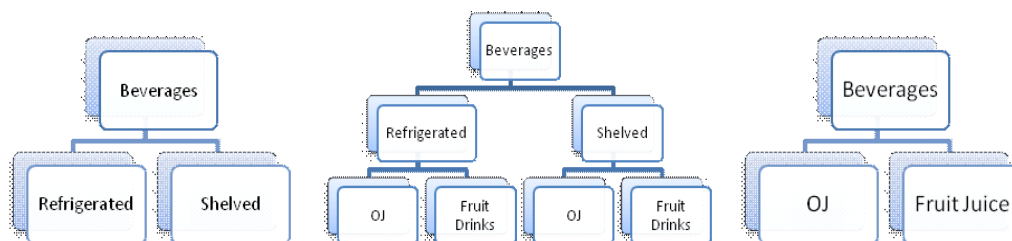


Figure 1. Proposed Utility Trees

Data

The data used in this study is from ACNielsen aggregated scanner data on orange juice, fruit juice blends, and fruit drinks sold in major U.S. retail accounts with annual sales of \$2 million or more. Weekly data covered the period of July 7, 2004 through December 30, 2006 were studied. The data were 52nd differenced to account for seasonality (for the 52 weeks in the year). The dataset contains unit sales and sales dollars for all brands of refrigerated and shelved orange juice, grapefruit juice, and fruit drinks sold during the 122 week study period. For simplification purposes, brands controlling less than five percent of market share in their respective cate-

gory were not included in the study. The categories used in this analysis are refrigerated orange juice (OJR) which consists of 3 brands, shelved orange juice (OJS) which consist of 3 brands, refrigerated fruit juice (FJR) which consists of 5 brands and shelved fruit drinks (FDS) consisting of 5 brands. The average prices are derived by dividing total sales by total units. Specific brands included in the Rotterdam model and descriptive statistics are included in Table 1.

Table 1: Average Expenditure Share (w), Average Price (p), and Quantity Sold (q)

		w	p	q (units)
■	Private	0.144	1.90	451,307
	Minute Maid	0.138	2.82	305,551
	Tropicana	0.195	3.15	381,030
■	Private	0.005	1.71	20,086
	Welchs	0.022	2.08	67,449
	SunnyD	0.015	2.02	54,162
	Minute Maid	0.042	1.72	169,516
	Tropicana	0.013	2.68	28,872
■	Private	0.041	1.84	134,947
	Minute Maid	0.004	2.68	10,233
	Tropicana	0.002	3.83	3,722
■	SunnyD	0.025	1.75	117,581
	Capri Sun	0.070	1.95	209,710
	KoolAid	0.036	1.30	158,947
	Gatorade	0.199	2.03	728,563
	Powerade	0.049	1.35	233,007

Empirical Results

The maximum likelihood method used to estimate the Durbin Waston statistic associated with demand equations estimated in equation (1) detected positive autocorrelation. This problem is common when time series data are utilized. The Cochran-Orcutt iterative procedure was used to correct for first order autocorrelation,

$$w_i d(\log q_i) = \rho w_i d(\log q_{i,t-1}) + \theta_i (d(\log Q) - \rho(d(\log Q_{t-1}))) + \sum_j \pi_{ij} (d \log p_j - \rho(d \log p_{j,t-1})) \theta_j$$

where $\tilde{\pi}$ is known as the coefficient of autocovariance. This model also imposes the homogeneity and symmetry restrictions.

Econometric estimates associated with the autoregressive model are shown in Table 2. The marginal expenditure shares (θ_i) for all beverage brands are positive and significantly different from zero. Additionally, the all but two own compensated price effects are negative and significant from zero. Two brands in the shelved orange juice categories, Minute Maid and Tropicana, were not negative, but were also not significant. These two brands also possess less than one percent of the beverage market share sampled. Econometric estimates associated with the autoregressive model are shown in Table 1. The own price elasticities for the significant brands are in the elastic range, ranging from -1.10 (Gatorade) to -3.21 (Sunny Delight (FDS)) (Table 2). The income elasticities vary from 0.061 (Private (OJR)) to 2.118 (Kool Aid (FDS)), suggesting consumers perceive some beverages as necessities and others as luxury goods. Sixty-seven percent of the compensated cross price coefficients are statistically significant. Of those significant, 84 percent were positive suggesting that these products are substitutes and the remaining 12 cross price elasticities significant but negative.

Table 4: Results from Blockwise Dependence Test

	Chi-Squared Value		DF
OJR*OJS	6.97		8
FJR*FJS	200.76*		28
OJR*FJS	1632.77*		15
OJR*FJR	1462.12*		94
OJS*FJS	83.77*		14
OJS*FJR	11.98		14
OJ*FJ	0.0000*		64

* denotes significance at 1%

The Wald Test was used to test for separability within the beverage category and results from the separability tests are exhibited in Table 4. Eight partitions were examined and in all but two of the scenarios block dependence is rejected. The results from the separability test indicate the consumers that shop at this national supermarket do not select beverages based on form or type.

Concluding Remarks

The Rotterdam model developed by Theil and Barten was used to estimate the demand interrelationships among brands of refrigerated and shelved orange juice, fruit juice, and fruit drinks. Additionally, this study empirically tested for block dependence amongst the beverage categories in an effort to understand the structure of the beverage industry. This disaggregated model also provides a more detailed understanding of the demand for beverages. This study rejects the hypothesis of block dependence; specifically, (1) refrigerated juices are not separable from shelved and (2) orange juice is not separable from fruit juice and drinks. Since block dependence is rejected, it is not plausible to believe that block independence, a stronger hypothesis will hold. Thus, when analyzing the demand for beverages, brand managers should not focus solely other breakfast juices or other isotonic, but one must focus on all beverages simultaneously. Compensated price elasticities indicate that orange juices, fruit juices, and fruit drinks are substitutes. Since separability among selected fruit juice categories is rejected, future research should test separability of fruit juice, water, and carbonated drinks to fully understand the beverage industry.

References

- Barten, A. P. "Consumer Demand Functions under Conditions of Almost Additive Preferences." *Econometrica*, 1964: 1-38.
- Brown, Mark. "Demand Systems For Competing Commodities: An Application of the Uniform Substitute Hypothesis." *Review of Agricultural Economics*, 1993: 577-589.
- Brown, Mark, Jonq-Ying. Lee, and James L., Jr. Seale. "Demand Relationships Among Juice Beverages: A Differential Demand System Approach." *Journal of Agricultural and Applied Economics*, 1994: 417-429.
- Economic Research Services. 2007. Components of the Food and Beverage Manufacturing Value of Shipments, 2005. HYPERLINK "http://www.ers.usda.gov/Briefing/FoodMarketingSystem/processing.htm" <http://www.ers.usda.gov/Briefing/FoodMarketingSystem/processing.htm> (accessed August 25, 2007).
- Goldman, S. and H. Uzawa. "A Note on Separability om Demand Analysis." *Econometrica*, 1964: 387-398.

- Henien, Dale. "The Structure of Food Demand; Interrelatedness and Duality." *American Journal of Agricultural Economics*, 1982: 213-212.
- Lee, Jonq-Ying. "Demand Interrelationships Among Fruit Beverages." *Southern Journal of Agricultural Economics*, 1984: 135-144.
- Lee, Jonq-Ying, Mark Brown, and James L., Jr. Seale. "Demand Relationship among Fresh Fruit and Juices in Canada." *Review of Agricultural Economics*, 1992: 255-262.
- The Food Industry. 2006. "Beverage Trends for 2004-2005." *Food Industry Review: The Reference Resource on the U.S. Food Industry*.
- Theil, Henri. *System-Wide Explorations in International Economics, Input-Output, Analysis, and Market Research*. New York: North Holland Publishing Company, 1980.
- . *The System Wide Approach to Microeconomics*. Chicago: The University of Chicago Press, 1980.

