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A STUDY OF THE INFLUENCE OF CALCIUM AND PULP CLAIMS ON ORANGE JUICE PRICE

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Various orange juice (OJ) products are sold in retail outlets in the U.S. Hundreds of brands are available, varying by product form, additives and packaged form. OJ can be frozen concentrated, chilled, or shelf stable, and can be sold in various containers, including paper and metal cans, aseptic packages, glass and plastic containers, and paper cartons. Various container sizes are available, and product can be sold in single-container package or multiple-container packages. Based on the production process used, OJ can be classified as fresh-squeezed, reconstituted juice made from concentrate, not from concentrate, and frozen concentrate. Through blending, OJ can contain various amount of pulp and other nutritional additives.

Production Processes of Orange Juice

Generally, before oranges are processed into juice, the fruit used need to be sanitized and of high quality. In a processing plant, the fruit is unloaded onto moving belt conveyors and inspected by highly trained personnel, damaged and unripe fruit are removed. Then the fruit is transferred to the extraction room. On its way to the extraction room, a random sample is automatically taken and directed to a laboratory where the fruit is analyzed to ensure that it meets the maturity and quality requirements. In addition, the fruit is first spray-washed to remove any dirt or foreign materials, inspected, and defective fruit is removed. Then the fruit goes through a sizing operation and is sent to the proper-size extracting machine.

The extracted juice contains pulp; therefore, it needs to go through a finisher and/or a centrifuge for removal of pulp. In the juice finishing processing operations unfinished juice passing through the finisher is recovered and the solid material is discharged at the end of the finisher. The most common application of centrifuges in citrus processing is for juice defect removal and pulp and viscosity reduction. Extracted juice from finishers may contain small black particles or other undesirable visible materials that is removed by centrifugation, improving the appearance to the customer. Also, centrifugal control of the pulp level is more exact than by finishers to meet consumers' preferences for low pulp, low viscosity juices with between 6% and 12% pulp. The finished juice can be processed into frozen concentrate, fresh-squeezed OJ, or chilled OJ (not-from-concentrate or NFC OJ; and from-concentrate or RECON OJ).

When the finished juice is processed into concentrate, the juice is thermally treated in the evaporator to inactivate enzymes and microbes, concentrated to 65° Brix[1] and stored. This 65° Brix juice can be mixed with the proper amount of essence and/or fresh OJ to bring the Brix to 42.5° then the juice goes into filling machines and fills the cans. The cans are then frozen to about 0° Fahrenheit before shipping to retail outlets. The concentrate reconstituted with three parts of water, will produce OJ for final consumption.

Because of the aroma and flavor of fresh-squeezed OJ, non-pasteurized OJ is desirable for consumers. However, the shelf life of fresh-squeezed OJ is very limited (< 20 days at 1°C) and the potential for microbial spoilage is very high. The manufacturing operations from fruit washing to packaging must be exceptionally clean to minimize product spoilage and the product is kept as close to the freezing point as practical. The fresh-squeezed OJ is not pasteurized, because of flavor compounds are sensitive to thermal degradation and pasteurization does result in loss of the fresh juice flavor.

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[1] A quantitative measurement of total soluble solids, chiefly fruit sugars.

Recent citrus juice consumption statistics indicate a trend towards consumer preference for chilled NFC OJ over concentrate. The finished juice can be pasteurized and stored or packed directly. Currently, technology is available on a large scale to extract, process, and store NFC OJ in bulk aseptic refrigerated tanks, minimizing microbial spoilage potential and product quality degradation. In addition, this new technology does not require a second pasteurization treatment and preserves the chemical quality of the juice for periods of a year or more. Therefore, this technology enables providing blended juices to consumers on a year-round basis, when fruit is not being processed.

Chilled OJ can be manufactured from concentrate (RECON OJ). The concentrate from the storage tank can be blended with water, essence, flavor, pulp, and so forth and reconstituted to the preferred single-strength juice product. The final steps of this process are pasteurization at near 80°C for 15-30 seconds to kill microbes, followed by packaging in cartons or glass. However, this second thermal treatment can be deleterious to the flavor. The flavor of RECON OJ may not be of the quality of either NFC or FCOJ because of the two thermal treatments.

A major recent nutritional enhancement for OJ is added calcium. Table 1 shows that U.S. sales of calcium-enhanced OJ increased from 66 million gallons (less than 9% of total U.S. OJ sales) in 1996 to 200 million gallons (25% of total U.S. OJ sales) in 2000; an increase of more than 200 percent in five years. The retail prices of calcium-enhanced OJ were about 10% higher than the prices of other types of OJ.

As described above, there are many ways to produce OJ and the OJs found in U.S. retail markets are not all identical. Due to the differences in processing, marketing effort, locations of the retail markets, among other factors, OJs found in retail markets are not homogeneous products and can be priced differently. In the present study, we use a hedonic price framework to assess the pricing behavior of OJ in U.S. retail stores.

The Hedonic Pricing Framework

The hedonic price model developed by Rosen is used in this study to examine how OJ prices vary across various product attributes. Hedonic price are implicit prices for attributes of a differentiated product.

In Rosen's hedonic price framework, one considers markets for a class of differentiated products e described by n attributes or characteristics, $z = (z_1, \ldots, z_n)$. It is assumed that the components of z are objectively measured with consumer perceptions of the amounts of characteristics embodied in each good being identical. Each product defined by a fixed value of z has a quoted market price which can be expressed by the function $p(z) = p(z_1, \ldots, z_n)$. This function indicates the value of the differentiated product to buyers (and sellers), obtained from shopping around and comparing prices of brands with different characteristics.

Suppose the consumer has the utility function $u(x, z)$, where x is all other goods consumed. Setting the price of x equal to unity and measuring income, y, in terms of units of x, one has $y = x + p(z)$. The consumer bid (expenditure or cost) function $\theta(z; u, y)$ is the amount the consumer is willing to pay for the particular bundle of characteristics, given his/her given utility level and income. Noting that $x = y - \theta$, this bid function is defined as

(1) $$u(y - \theta, z) = u.$$

Differentiating equation (1) with respect to z_i and setting the result to zero, one has

(2) $$(\partial u/\partial x)(\partial x/\partial \theta)(\partial \theta/\partial z_i) + \partial u/\partial z_i = 0;$$

and since $\partial x/\partial \theta = -1$, one has

(3) $$\theta_{zi} = \partial \theta/\partial z_i = (\partial u/\partial z_i)/(\partial u/\partial x) = u_{zi}/u_x.$$

Thus, θ_{zi} is the marginal rate of substitution between the attribute z_i and "money," or x. In other words, θ_{zi} is the marginal implicit valuation the consumer places on the attribute z_i at a given level of utility and income.

Let M_z denote the number of units produced by a firm of some design offering specification z. Total costs for the producer are $C(M_z, z; \beta)$, derived from minimizing factor costs subject to a joint production function constraint relating M_z, z, and factors of production. The shift parameter β reflects underlying variables in the cost minimization problem, namely, factor prices and production parameters. Assume C is convex with $C(0, z) = 0$ and C_M and $C_{zi} > 0$. Each producer maximizes profit $\pi = M_z\, p(z) - C(M_z, z; \beta)$ by choosing M and z optimally, where unit revenue on design z is given by the implicit price function for characteristics, $p(z)$. The first-order condition for the optimal choice of M_z and z requires

(4) $$\partial p(z)/\partial z_i = p_i(z) = [\partial C(M, z; \beta)/\partial z_i]/M_z = C_{zi}(M, z; \beta)/M_z, \qquad i = 1, \ldots, n$$

$$p(z) = \partial C(M_z, z; \beta)/\partial M_z = C_M(M_z, z; \beta).$$

Define an offer function $\phi(z; \pi, \beta)$ indicating unit price the producer is willing to accept on various designs at constant profit when quantities produced of each model are optimally chosen. Hence, the offer price of the ith attribute must equal the per unit marginal cost of that characteristic, i.e., $p_i(z) = C_{zi}(M_z, z; \beta)/M_z$. Thus the firm maximizes profit when it charges the market price (i.e., the highest price it can) for each of the attributes of the good it produces. The maximum profit then occurs when $p(z) = C_M(M_z,$

z; β). A family of production "indifference" surfaces can be found from the necessary condition for profit maximization with respect to the output quantity M_z, yielding

(5) $$\phi = C_M(M, z; \beta).$$

Since ϕ is the offer price the producer is willing to accept on design z at profit level π, while $p(z)$ is the maximum price obtainable for those models in the market, profit is maximized by an equivalent maximization of the offer price subject to the constraint $p(z) = \phi$.

The amount the consumer is willing to pay for z at a fixed utility level and income is $\theta(z; u, y)$, while $p(z)$ is the minimum price he must pay in the market. Therefore, utility is maximized when $\theta(z^*; u^*, y) = p(z^*)$ and $\theta_{zi}(z^*; u^*, y) = p_i(z^*)$, $i = 1, \ldots, n$, where z^* and u^* are optimum quantities. In other words, optimum location on the z-plane occurs where the two surfaces $p(z)$ and $\theta(z; u^*, y)$ are tangent to each other. In this framework, the equilibrium price, $p(z^*)$, is determined by the characteristics embedded in the product.

Data

The hedonic price equation, $p(z^*)$, is applied to ACNielsen grocery store scanner sales data on all types of OJ. The ACNielsen data are from retail chains doing $2 million or greater annual business plus super centers; these chains and super centers represent roughly 60% of total U.S. OJ sales. The price data are 52-week (12/26/99 through 12/23/00) average prices for all available OJ universal product codes (UPC). OJ characteristics information for a total of 2,034 OJ UPCs are available. Of these 2,034 UPCs, only 1,401 UPCs had sales during the study period. The use of 52-week average prices instead of weekly prices would reduce the chances that promoted or featured prices that could be used in the analysis. The characteristics of OJ used in the analysis include the following:

1. Brand: the top four brands (A, B, C, and D brands), other national brands, and private labels;
2. Product category: freshly squeezed, frozen concentrated orange juice (FCOJ), refrigerated not-from concentrate (NFC) orange juice, refrigerated from concentrate orange juice (RECON), and shelf-stable orange juice;
3. Calcium claims: plus calcium, with calcium, percent of calcium, as much as milk, calcium added/fortified/rich, and not stated;
4. Pulp content claims: juicy bits, pulp added or some pulp, country style, high pulp or lots of pulp or extra pulp, home style, low pulp, no pulp or pulp free, and not stated;
5. Units per pack: actual number of units;
6. Size: the size of container in ounces;
7. Region: Northeastern, Central, Southern, and Western.

Table 2 shows the UPC sample means for the above variables by four regions. As shown in Table 2, the Southern region had the most number of UPCs and the Western region had the least number of UPCs. Private label UPCs accounted for 36% of all the UPCs in the Northeastern region and accounted for only 30.5% of the UPCs in the Western region. On the other hand, the Western region had more frozen OJ UPCs than the other three regions. The number of UPCs of chilled OJ processed from concentrate dominated the OJ category, these UPCs accounted for close to 50% of all OJ UPCs.

Fresh-squeezed OJ had the least number of UPCs, i.e., less than 10% of total UPCs. Around 15% of the UPCs had calcium claims and 20% had some pulp claims.

Based on the regional data, the top three brands, all other brands, and private labels OJ accounted for 57%, 10%, and 33%, respectively, of total OJ (in terms of gallons) sold in the U.S. As shown in Table 2, the top three brands, all other brands, and private label OJs accounted for about 16%, 51%, and 33% of the total regional UPCs, respectively. In other words, 16% of the top three brand UPCs had 57% of volume sales and the 51% other brand UPCs had only 10% of the volume sales.

Estimation and Results

The hedonic price equation, $p(z)$, is estimated for the OJ data using a semi-logarithmic functional form. Although there is no general consensus on a preferred functional form, the semi-log form was chosen because it fits the data better than the linear functional form and it is an accepted practice in the hedonic literature (Cropper, et al.; Graves et al.).

Several specifications of pulp/calcium claims and container types had been tried, based on the adjusted R^2 of regression results, the model with brand-specific pulp and calcium claims were chosen. Because of the high correlation between OJ category and container types, container type variables were not included in the final model. The following specification was used in the study

(4) $$ln\ p = \alpha_0 + \alpha_1^T \text{(brands)} + \alpha_2^T \text{(categories)} + \alpha_3^T \text{(pulp claims by brand)} + \alpha_4^T \text{(calcium claims by brand)} + \alpha_5 \text{(units per pack)} + \alpha_6 \text{(container sizes)} + \alpha_7^T \text{(regions)} + \varepsilon,$$

where αs are parameters to be estimated and ε is the disturbance term. The superscript T for α represents a row vector. The various categories are expressed as dummy variables for brands (the other brands category was used as the base for comparison), category (shelf-stable as the base), calcium claim (not stated as the base), pulp claim (not stated as the base), and region (the Western region as the base). Ordinary least squares method was used to estimate the parameters, results are presented in Table 3. The coefficient estimate of a continuous variable in a semi-log equation can be interpreted as the percentage effect on price of a small change in that variable. Note that all independent variables in (4) are dummy variables. Therefore, the coefficient estimates of these dummy variables are somewhat different from this interpretation. However, because of the coefficient estimates are small, the true percentage effect on price of a small change in these dummy variables should be very close to these estimates (see Table 1 in Halvorsen and Palmquist). Therefore, the estimates in Table 3 are used in the discussion below.

Results show that there were brand premiums. The B brand OJ had the highest brand premium of about 23.7%, which is followed by the A brand at 23.2%. The price premium for the C brand was not different from that for the Other Brands. The D brand and private labels had the lower brand premiums (about 11% lower) than that for the Other Brand OJ.

Results also show that fresh-squeezed OJ had the 31.6% price premium above shelf-stable OJ. The price premium of NFC OJ was not too different from that for shelf-stable OJ. RECON OJ had a lower price premium (27.4% lower) than shelf-stable OJ, and FCOJ had the lowest price premium, 84.8% lower than shelf-stable OJ. The differences in price premium among the chilled OJs probably can be attributed to the freshness of the juice, i.e., fresh-squeezed OJ had the highest price premium among the three types of chilled OJ, the NFC OJ had the second highest price premium and the RECON OJ had the lowest premium.

The two most common claims in the OJ manufacturing process are the calcium and pulp contents in OJ. Our specification allows one to test if these claims add to the purchase price. Results show that the coefficient estimates for the different pulp claims are statistically not different from zero except the one for private label OJ (12.5% lower than regular OJ), an indication that given other factors (such as brand, container type, etc.) held constant, pulp claims did not add to price premium. Results for the calcium claim related coefficient estimates demonstrate similar patterns, i.e., these coefficient estimates are either negative or statistically not different from zero. Again, the prices of private label OJ with calcium claims were 12.3% lower than those for the regular OJ.

Table 4 shows the gallon shares of three top brands and private label OJ that were featured or had retail in-store displays during the study period and their respective average retail prices. The first line in each row shows the gallon share of OJ sold that was featured by retailers in their advertisement or had any in-store display. The second line of each row (the numbers in parentheses) shows their respective retail average price. The statistics shown in Table 4 indicate that OJ with either pulp claims or calcium claims were more likely to be featured or to have in-store displays than the regular types of OJ. In addition, the OJ that had additional claims were sold at a lower price than the regular OJ. The combination of more featuring/display and lower retail prices for pulp/calcium claimed OJ than the regular OJ may be an indication that the pulp/calcium claimed OJs were sold at discounts to either attract customers or to expand market shares. In addition, different claims in pulp and calcium contents may offer customers more varieties to choose from and thus increases category sales.

Results also show that multi-pack OJs were sold at discounts and so did the OJs in large containers. The coefficient estimates shown at the bottom of Table 3 indicate that the Western region had the highest OJ retail prices among the four regions investigated, which is followed by the Central region, and the Northeastern and Southern regions had the lowest retail prices. Florida is the major OJ producing state in the U.S., the differences in retail prices among these regions probably reflect the differences in OJ transportation costs in these regions.

Concluding Remarks

In this study, we identified price premium for major brands of OJ. We also found a discount for private label OJ. In addition, we found that there were evidences that the prices of chilled OJ were positively related to their fresh attributes, i.e., fresh-squeezed OJ had the highest price premium, which was followed by the NFC OJ, then the RECON OJ. However, we did not find any evidence of a premium associated with pulp and calcium claims. On the contrary, we found that private label OJs with either pulp or calcium claims were sold at discounts. We further examined the retail OJ promotional information and suspect that the pulp and calcium-added claims were used to increase the sales of the brand or the OJ category.

The study also found that multi-pack and large container size was also associated with price discounts. In addition, we found that the price differences among the four geographical regions studied can be contributed to transportation cost differences.

Table 1 U.S. orange juice sales – 1996 through 2000

	Total Orange Juice			Calcium Added Orange Juice		
	Gallon Sales (mil. Gals)	Dollar Sales ($ mil.)	Price ($/gal.)	Gallon Sales (mil. Gals)	Dollar Sales ($ mil.)	Price ($/gal.)
1996	788.3	2,936.2	3.72	66.1	256.4	3.88
1997	833.4	3,152.3	3.78	90.0	369.2	4.10
1998	850.2	3,238.6	3.81	122.4	517.4	4.23
1999	836.6	3,571.2	4.27	157.3	730.5	4.64
2000	859.9	3,724.5	4.33	200.0	927.7	4.64

Source: ACNielsen. Retail chains doing $2 million or greater annual business plus super centers.

Table 2 UPC sample means by region

Variable	NE	Central	South	West	Total US
Number of UPCs	569	662	680	547	1401
Container Size (oz)	49.29	53.16	51.65	48.12	51.33
Units/Pack	1.23	1.11	1.18	1.18	1.17
Price ($/gal.)	5.53	5.41	5.51	6.42	5.59
Brands (% of UPCs)					
Brand A	8.8%	6.8%	7.4%	7.1%	3.8%
Brand B	5.8%	5.3%	5.0%	7.7%	3.1%
Brand C	2.3%	2.4%	3.2%	2.2%	1.8%
Brand D	1.4%	1.2%	1.5%	2.0%	0.9%
Other Brands	45.7%	53.3%	50.1%	50.5%	63.4%
Private Label	36.0%	31.0%	32.8%	30.5%	27.1%
Category (% of UPCs)					
Fresh Squeeze	8.1%	7.3%	10.1%	10.1%	8.8%
FCOJ	12.0%	12.4%	11.6%	15.7%	10.1%
RECON	45.0%	52.0%	46.2%	48.6%	55.7%
NFC	22.5%	16.8%	19.1%	13.2%	15.1%
Shelf Stable	12.5%	11.6%	12.9%	12.4%	10.4%
Pulp Claim (% of UPCs)					
Total OJ	23.0%	19.8%	21.2%	22.7%	16.3%
Brand A	4.7%	4.1%	4.1%	4.6%	2.0%
Brand B	2.6%	2.4%	2.2%	3.7%	1.4%
Brand C	1.1%	0.9%	0.9%	1.1%	0.4%
Brand D	0.4%	0.3%	0.3%	0.5%	0.2%
Other Brands	3.7%	3.5%	3.7%	5.1%	3.8%
Private Label	10.5%	8.6%	10.0%	7.7%	7.1%
Calcium Claim (% of UPCs)					
Total OJ	14.2%	15.6%	13.4%	16.5%	12.2%
Brand A	2.1%	1.8%	1.8%	2.2%	0.9%
Brand B	1.4%	1.2%	1.2%	2.0%	0.8%
Brand C	0.5%	0.6%	0.6%	0.5%	0.3%
Brand D	0.0%	0.0%	0.1%	0.2%	0.1%
Other Brands	2.5%	3.8%	2.4%	3.5%	3.1%
Private Label	7.7%	8.2%	7.4%	8.0%	7.1%

Table 3 Estimation result (log price)

Variable	Estimate	Standard Error	t-statistics	Prob > 0
Intercept	2.3069	0.0235	98.2460	0.0001
Brand *(Other Brands)*				
Brand A	0.2324	0.0380	6.1140	0.0001
Brand B	0.2366	0.0408	5.8010	0.0001
Brand C	0.0086	0.0610	0.1410	0.8878
Brand D	-0.1105	0.0597	-1.8510	0.0642
Private Label	-0.1138	0.0178	-6.4100	0.0001
Category *(Shelf Stable)*				
Fresh Squeeze	0.3156	0.0274	11.5220	0.0001
FCOJ	-0.8481	0.0259	-32.7310	0.0001
RECON	0.0064	0.0260	0.2450	0.8068
NFC	-0.2741	0.0214	-12.8390	0.0001
Pulp Claim *(Not Stated)*				
Brand A	-0.0701	0.0455	-1.5390	0.1239
Brand B	-0.0412	0.0516	-0.7990	0.4241
Brand C	-0.0715	0.0858	-0.8340	0.4044
Brand D	-0.1469	0.1156	-1.2710	0.2040
Other Brands	0.0315	0.0329	0.9550	0.3397
Private Label	-0.1251	0.0251	-4.9910	0.0001
Calcium Claim *(Not Stated)*				
Brand A	-0.0493	0.0502	-0.9830	0.3257
Brand B	-0.0491	0.0592	-0.8300	0.4068
Brand C	0.0021	0.0998	0.0210	0.9830
Brand D	-0.3042	0.2191	-1.3880	0.1652
Other Brands	-0.0942	0.0367	-2.5660	0.0104
Private Label	-0.1232	0.0262	-4.6950	0.0001
Number per Pack	-0.0226	0.0051	-4.4480	0.0001
Container Size	-0.0061	0.0002	-29.8800	0.0001
Region *(West)*				
Northeast	-0.1497	0.0180	-8.3340	0.0001
Central	-0.1239	0.0173	-7.1600	0.0001
South	-0.1416	0.0172	-8.2270	0.0001

Adjusted $R^2 = 0.6129$

Table 4 Percent of gallon sales featured or displayed and average price by pulp and calcium claims[a]

	Pulp		Calcium[b]	
	Claimed	Did not Claim	Claimed	Did not Claim
	Percent			
Total US				
Top 3 Brands	22.82	7.50	19.55	11.95
	($6.16)	($6.60)	($5.85)	($6.60)
Private Labels	28.14	16.37	26.14	17.11
	($3.81)	($4.66)	($3.73)	($4.66)
Northeast				
Top 3 Brands	25.70	7.80	20.85	13.19
	($6.05)	($7.24)	($5.85)	($6.90)
Private Labels	15.31	8.72	11.55	9.98
	($3.71)	($4.40)	($3.52)	($4.44)
Central				
Top 3 Brands	21.83	7.66	19.72	11.56
	($5.96)	($6.38)	($6.00)	($6.29)
Private Labels	15.30	11.95	17.40	10.37
	($3.80)	($4.41)	($3.74)	($4.30)
South				
Top 3 Brands	15.68	5.12	14.16	8.02
	($5.73)	($6.60)	($5.75)	($6.32)
Private Labels	11.52	6.88	10.43	7.33
	($3.79)	($4.49)	($3.71)	($4.36)
West				
Top 3 Brands	26.49	8.33	20.34	14.16
	($6.58)	($6.40)	($6.33)	($6.45)
Private Labels	9.58	7.61	9.76	6.86
	($3.77)	($4.58)	($3.88)	($4.71)

[a]The numbers in parentheses are the average retail prices of the respective orange juice categories.
[b]The top three brands of orange juice accounted for about 58% of the orange juice sold in the U.S.; therefore, the average price for calcium added orange juice is higher than the average price for the total orange juice category (see Table 1).

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