

Unraveling Demand for Dairy-Alternative Beverages in the United States: The Case of Soymilk

Senarath Dharmasena and Oral Capps, Jr.

Soymilk is one of the fastest growing categories in the U.S dairy alternative functional beverage market. Using household-level purchase data from Nielsen's 2008 Homescan panel and the Tobit econometric procedure, we estimate conditional and unconditional own-price, cross-price, and income elasticities for soymilk, white milk, and flavored milk. Income, age, employment status, education level, race, ethnicity, region, and presence of children in a household are significant drivers of demand for soymilk. White milk and flavored milk are competitors for soymilk, and soymilk is a competitor for white milk. Strategies for pricing and targeted marketing of soymilk are also discussed.

Key Words: censored demand, dairy alternative beverages, flavored milk, functional beverages, Nielsen Homescan data, soymilk, Tobit model, white milk

There are many types of nonalcoholic beverages available in the United States today compared to a decade ago. The functionality and health dimensions of beverages have changed over the years. In addition to providing conventional hydration and refreshment functions, many beverages now are fortified with vitamins, minerals, protein, antioxidants, and favorable fatty acids (Beverage Marketing Corporation 2010b, 2011, 2012).

Currently, calcium- and vitamin-fortified nondairy beverages are entering the market to compete with white and flavored milk, providing consumers with functional alternative beverages specifically for people who must avoid

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Senarath Dharmasena dedicates this paper to his wife, Inoka Chandrasena.

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dairy products (primarily because they are lactose intolerant). To strengthen the position of these calcium-fortified dairy-alternative functional beverages (DAFBs) in the U.S. market, new dietary guidelines developed under *ChooseMyPlate.gov*, a program of the U.S. Department of Agriculture (USDA), placed calcium-fortified soy beverages in the dairy group, which was introduced as a side dish (USDA 2011). USDA's inclusion of calcium-fortified soy beverages raised eyebrows among U.S. dairy producers and marketers, who have a keen interest in how such beverages compete with dairy products.

According to a report by *Food Business News* (2013), roughly 5 percent of the products launched in the dairy beverage category in 2012 were DAFBs. Soy was the primary or secondary ingredient in 78 percent of those new products, but the report noted growing interest in DAFBs made from almonds, rice, oats, barley, hazelnuts, and walnuts.

According to Beverage Marketing Corporation (2010a), soymilk DAFBs were among the fastest growing categories in the general beverage market in the United States. Other DAFBs (almond milk, rice milk, and coconut milk) saw similar growth. Expansion of the DAFB market has been attributed to claims and consumer perceptions that such nondairy alternatives are a healthier choice, introduction of a flurry of soy and almond milk brands, appealing and convenient packaging, and a plethora of available flavors. Soy beverage retail sales topped \$1 billion in 2011 and have continued to grow since as producers added soymilk products in flavors such as chocolate, vanilla, and strawberry to compete directly with flavored dairy milk products (Soyfoods Association of North America 2013). In terms of brands, in 2010 Silk soymilk had the largest market share (62 percent), followed by Rice Dream (6 percent), 8th Continent (6 percent), Lifeway (2 percent), and Odwalla (1 percent) (Beverage Marketing Corporation 2010a).

In such a competitive and dynamic market, information on price sensitivities, substitutes and complements, and demographic profiles associated with consumption of DAFBs is important for manufacturers, retailers, advertisers, nutritionists, and other stakeholders (such as public health officials). We are aware of no prior studies of demand for DAFBs. Therefore, our study of soymilk is the first to examine market competitiveness and demographic factors that determine U.S. consumer demand for DAFBs. A thorough analysis of demand for soymilk is important because it dominates the DAFB market. The general objective of this study is to develop models that uncover demand for DAFBs for a diverse set of consumers. Specifically, we identify (i) conditional and unconditional factors that affect the volume of soymilk, white milk, and flavored milk purchased; (ii) conditional and unconditional own-price, cross-price, and income elasticities of demand for soymilk, white milk, and flavored milk; and (iii) retail-level pricing strategies for these beverages in the competitive marketplace.

Data and Methodology

Household purchases of soymilk, white milk, and flavored milk (both expenditures and quantities) and socioeconomic demographic characteristics were generated from Nielsen's Homescan panel data for calendar year 2008 (61,440 households), the most recent year that was available to us. While 58,268 of the households purchased white milk, only 7,729 purchased soymilk; 16,468 households bought flavored milk. We standardized the quantity data as liquid ounces, and the expenditures are expressed in dollars. Then, taking the

ratio of expenditure to volume, we generated unit values (price in dollars per ounce) for each beverage category.

We test a number of hypotheses regarding purchases of white milk, soymilk, and flavored milk: (i) flavored milk and white milk are substitutes for soymilk and so have positive cross-price elasticities; (ii) consumption of each beverage increases with level of education because highly educated consumers are likely to be more knowledgeable about beverages they consume; (iii) high-income households consume more of each beverage; (iv) the presence of children in a household increases consumption of each beverage, and the age of the children present affects the quantity consumed; (v) members of full-time-employed households consume a greater share of milk away from home; (vi) households location in the western United States consume more soymilk than households in other parts of the country; (vii) in terms of racial demographics, whites consume more white milk and flavored milk than other racial groups, and Hispanics consume the least white milk, soymilk, and flavored milk.

Zero-purchase observations are common in micro-level data (data gathered at the consumer level—individuals or households) in that some consumers may not purchase some beverages during the sampling period, and we thus faced a potentially censored data sample. Application of ordinary least squares (OLS) to estimate a regression with a limited dependent variable (such as in a censored sample like ours) gives rise to biased estimates even asymptotically (Kennedy 2003). Removing all observations associated with zero purchases and estimating regression functions strictly for non-zero purchases creates a bias in the estimates (Kennedy 2003). Tobin (1958) and Heckman (1979)¹ suggested alternative models to deal with this *sample selection bias* when estimating regression models in the presence of censored data. We chose Tobin's (1958) model to obtain both conditional and unconditional elasticity estimates. We also used decomposition of the coefficient estimates from the Tobit model, as suggested by McDonald and Moffitt (1980), to further analyze changes in the probability of being above the limit (the limit being zero in this analysis) and in the value of the dependent variable if it is already above the limit.

We observe no unit value or price for the transactions associated with zero quantities and hence zero expenditures. However, since we use the price for each beverage category as explanatory variables in the Tobit model, we have to impute prices for the zero-expenditure observations. This is accomplished through an auxiliary regression in which observed prices for each beverage are regressed on household income, household size, and the region in which the household is located.² These variables are used extensively in the literature on imputed prices (Kyureghian, Capps, and Nayga 2011, Alviola and Capps 2010). The parameters estimated from the auxiliary regression are then used

¹ The Heckman (1979) model speaks only to conditional demand estimates although the first-stage probit analysis provides information on the probability of the product being purchased.

² A reviewer questioned the consistency of the observed and imputed prices. Below we provide summary statistics for observed prices and imputed prices for each beverage category. Based on those observations, the prices and standard deviations are consistent for both the within-sample estimates and the out-of-sample price imputations.

	Observed Price (dollars per ounce)		Imputed Price (dollars per ounce)	
	Mean	Standard Deviation	Mean	Standard Deviation
Soymilk	0.0504	0.0174	0.0501	0.0029
White milk	0.0316	0.0104	0.0332	0.0028
Flavored milk	0.0490	0.0283	0.0520	0.0065

to impute prices for the zero-expenditure observations. This technique is well-established in the literature and is commonly used to deal with imputing (or forecasting) missing prices and price endogeneity issues (e.g., Capps et al. 1994, Alviola and Capps 2010, Kyureghian, Capps, and Nayga 2011, Dharmasena and Capps 2012). We address variability of demand for beverages with different levels of quality via an income variable in the auxiliary regression. Likewise, we include a household size variable to account for differences in socioeconomic-demographic conditions and the effect of those differences on price and another variable for differences associated with the region. Once the price for each type of beverage (soymilk, white milk, and flavored milk) was imputed,³ we used those prices and the other explanatory variables to estimate the Tobit model. Table 1 provides descriptions of the explanatory variables used in the analysis.

The Tobit Model

The stochastic model underlying the Tobit analysis can be expressed as

$$(1) \quad y_i = \begin{cases} \mathbf{X}_i\beta + u_i, & \mathbf{X}_i\beta + u_i > 0 \\ 0, & \mathbf{X}_i\beta + u_i \leq 0 \end{cases}$$

where $i = 1, 2, 3, \dots, N$ is the number of observations, y_i is the censored dependent variable, \mathbf{X}_i is the vector of explanatory variables, β is the vector of unknown parameters to be estimated, and $E[u_i|\mathbf{X}_i] = 0$ and $u_i \sim N(0, \sigma^2)$. The unconditional expected value for y_i is expressed in equation 2 and the corresponding conditional expected value for y_i is shown in equation 3. The normalized index value, z , equals $\mathbf{X}\beta / \sigma$. Also, $F(z)$ is the cumulative distribution function (CDF) associated with z and $f(z)$ is the corresponding probability density function.

$$(2) \quad E(y) = \mathbf{X}\beta F(z) + \sigma f(z)$$

$$(3) \quad E(y^*) = \mathbf{X}\beta + \sigma(f(z) / F(z))$$

The unconditional marginal effect is represented by

$$(4) \quad \partial E(y) / \partial \mathbf{X} = \beta F(z).$$

The conditional marginal effect is shown by

$$(5) \quad \partial E(y^*) / \partial \mathbf{X} = \beta(1 - z \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2}).$$

McDonald and Moffitt’s (1980) decomposition relating changes in the conditional and unconditional expectations to each other are shown in equation 6.

³ A reviewer questioned the potential for multicollinearity between predicted prices and a household’s income, size, and region. The collinearity diagnostics we performed, including variance inflation factors, condition indices, and variance proportion decompositions (Belsley, Kuh and Welsch, 1980), indicated that there was no degrading multicollinearity.

$$(6) \quad \partial E(y) / \partial \mathbf{X} = F(z) \left(\frac{\partial E y^*}{\partial \mathbf{X}} \right) + E(y^*) \left(\frac{\partial F(z)}{\partial \mathbf{X}} \right)$$

In other words, the total change in the unconditional expected value of the dependent variable, y , is represented by the sum of (i) the change in the expected value of y being above the limit weighted by the probability of being

Table 1. Description of the Explanatory Variables Used in the Tobit Analysis

Explanation
Price of soymilk, price of flavored milk, price of white milk (all in dollars per ounce)
Household income (dollars)
<i>Age of household head less than 25 years</i> (base category)
Age of household head between 25–29 years
Age of household head between 30–34 years
Age of household head between 35–44 years
Age of household head between 45–54 years
Age of household head between 55–64 years
Age of household head 65 or older
<i>Household head not employed for full pay</i> (base category)
Household head part-time employed
Household head full-time employed
<i>Education of household head less than high school</i> (base category)
Education of household head high school only
Education of household head undergraduate only
Education of household head some post-college
<i>Region East</i> (base category)
Region Central (midwest)
Region South
Region West
<i>Race white</i> (base category)
Race black
Race Asian
Race other (non-black, non-white, non-Asian)
<i>Non-Hispanic ethnicity</i> (base category)
Hispanic ethnicity
<i>No child less than 18 years</i> (base category)
Presence of children less than 6 years
Presence of children 6–12 years
Presence of children 13–17 years
Presence of children less than 6 and 6–12 years
Presence of children less than 6 and 13–17 years
Presence of children 6–12 and 13–17 years
Presence of children less than 6, 6–12, and 13–17 years
<i>Household head both male and female</i> (base category)
Household head male only
Household head female only

Note: The base categories for the dummy variables are printed in italics.

above the limit and (ii) the change in the probability of being above the limit weighted by the expected value of y being above the limit.

Empirical Estimation

Our Tobit models employ single equations.⁴ We tried several functional forms (linear, quadratic, and semi-log) and found that the semi-log model (we used logged price variables in the model) outperformed other functional forms in terms of model fit, significance of the variables, and results of loss metrics such as Akaike, Schwarz, and Hannan-Quinn information criteria. Hence, we used the semi-log functional form to calculate the conditional and unconditional marginal effects associated with each explanatory variable. The level of significance used in this study is 0.05 (p-value of 0.05).

The unconditional marginal effect for the price variable in the semi-log model is

$$(7) \quad \partial E(y) / \partial p = \frac{\beta}{p^U} F(z)$$

where p^U is the average of the unconditional price for all of the observations for each beverage. The conditional marginal effect for the price variable in the linear-log model is

$$(8) \quad \partial E(y^*) / \partial p = \frac{\beta}{p^C} \left(1 - z \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right)$$

where p^C is the average price in the censored sample (the conditional price) for each beverage considered. We calculate the unconditional (equation 9) and conditional (equation 10) income effects for each beverage in the linear-log model as follows.

$$(9) \quad \partial E(y) / \partial I = \frac{\beta}{I^U} F(z)$$

$$(10) \quad \partial E(y^*) / \partial I = \frac{\beta}{I^C} \left(1 - z \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right)$$

I^U is unconditional mean income and I^C is conditional mean income. Equations 11, 12, and 13 represent the model for estimating unconditional elasticities.

$$(11) \text{ Own-price:} \quad \varepsilon_{ii}^U = \frac{\beta}{p_i^U} F(z) \frac{p_i^U}{Q_i^U}$$

$$(12) \text{ Cross-price:} \quad \varepsilon_{ij}^U = \frac{\beta}{p_j^U} F(z) \frac{p_j^U}{Q_i^U}$$

$$(13) \text{ Income:} \quad \varepsilon_I^U = \frac{\beta}{I_i^U} F(z) \frac{I_i^U}{Q_i^U}$$

⁴ We looked at correlation of errors resulting from single-equation estimates and found that the cross-equation error correlations were very small. As a result, we did not pursue estimation of a system of equations using seemingly unrelated regression, which takes cross-equation errors into account.

Equations 14, 15, and 16 represent the model for estimating conditional elasticities.

$$(14) \text{ Own-price: } \quad \varepsilon_{ii}^C = \frac{\beta}{P_i^C} \left(1 - z \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right) \frac{P_i^C}{Q_i^C}$$

$$(15) \text{ Cross-price: } \quad \varepsilon_{ij}^C = \frac{\beta}{P_j^C} \left(1 - z \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right) \frac{P_j^C}{Q_i^C}$$

$$(16) \text{ Income: } \quad \varepsilon_I^C = \frac{\beta}{I_i^C} \left(1 - z \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right) \frac{I_i^C}{Q_i^C}$$

The decomposition described in equation 6 can be manipulated to obtain the following expression, which sheds light on changes in the probability of being above the limit (for the conditional sample) for consumption of each beverage category in response to a change an explanatory variable; in other words, $\partial F(z) / \partial \mathbf{X}$.

$$(17) \quad \partial F(z) / \partial \mathbf{X} = \frac{1}{E(y^*)} \left[\frac{\partial E(y)}{\partial \mathbf{X}} - F(z) \left(\frac{\partial E y^*}{\partial \mathbf{X}} \right) \right]$$

Empirical Results and Discussion

Table 2 presents summary statistics of prices, expenditures, incomes, and market penetration in the U.S. at-home market for soymilk, white milk, and flavored milk for calendar year 2008. Only 12.58 percent of the households purchased soymilk. The vast majority bought white milk (95.42 percent market penetration), and 26.8 percent purchased flavored milk. Average quantities purchased per household per year were 4.63 gallons of soymilk, 27.2 gallons

Table 2. Summary Statistics of Price, Quantity, Expenditure, Income, and Market Penetration of Soymilk, White Milk, and Flavored Milk Consumption in U.S. At-Home Markets in 2008

	Soymilk	White Milk	Flavored Milk
Market penetration (percent)	12.58	95.42	26.80
Average price (dollars per gallon)	6.04	3.57	4.85
Average conditional quantity (gallons per household per year)	4.63	27.2	3.17
Average conditional expenditure (dollars per household per year)	27.96	97.09	15.38
Average unconditional quantity (gallons per household per year)	0.58	25.80	0.85
Average unconditional expenditure (dollars per household per year)	3.52	92.08	4.21

of white milk, and 3.17 gallons of flavored milk. Average prices per gallon were \$6.04 for soymilk, \$3.57 for white milk, and \$4.85 for flavored milk.

The results of the Tobit regressions are shown in Table 3. Regarding demand for soymilk, household income and the price of soymilk, white milk, and flavored milk are important economic determinants of soymilk purchases. In addition, soymilk demand is influenced by demographic factors—the age, gender, employment status, and education of the household head; the household's region, race, and Hispanic status; and the presence of children in a household and the age of any children present.

Statistically significant determinants of demand for white milk are its price; the price of soymilk and flavored milk; the household's income, region, and race; the household head's employment status, education, age, and gender; and the presence of children in the household.

The only price variable that significantly affects demand for flavored milk is its own price. Significant demographic drivers of demand for flavored milk are the age, education, and gender of the head of the household; the household's region, race, and Hispanic status; and the presence of children and the age of any children present in the household.

It is important to note that, unlike coefficients from conventional regression models (without censoring), Tobit model coefficients are not directly interpretable. In other words, the coefficients associated with each explanatory variable must be transformed into meaningful marginal effects. Tobit model coefficients can be used to generate two types of meaningful marginal effects—unconditional marginal effects shown in equation 4 (derived using the unconditional expected value from equation 2) and conditional marginal effects depicted in equation 5 (derived using the conditional expected value from equation 3). Unconditional marginal effects for consumption of beverages take into account both households that bought a particular beverage and those that have yet to buy (or did not purchase) the beverage. Conditional marginal effects on consumption of beverages only take the households that actually bought the beverage into account.

Median unconditional marginal effects for each explanatory variable are shown in Table 4. For brevity, we do not discuss the details of the median unconditional marginal effects here. They generally follow the median conditional marginal effects, which are reported in Table 6. The only difference is that the unconditional marginal effects are smaller than the conditional marginal effects.

Table 5 reports median changes in the probability of consumption of each type of milk for changes in each explanatory variable (see equation 17).

For soymilk, the median change in probability of consumption when the household head is 65 years of age or older is -0.05 . Thus, a household headed by someone elderly is 5 percent less likely to consume soymilk than the base case of a household headed by a person younger than 25. The figures in Table 6 for marginal effects demonstrate that households in which the head is 65 or older consume 70 ounces less soymilk (at the median) per year. Full-time employment decreases the likelihood of soymilk consumption relative to the base case of part-time employment. According to the conditional marginal effects, households with full-time employment drink 11 ounces less soymilk per year. Households in which the head has some undergraduate or post-graduate education have a 2–3 percent higher probability of purchasing soymilk than households in the base case of less than a high school education. College-educated households drink 29 ounces more soymilk per year and post-graduate-educated households

Table 3. Tobit Regression Results for Soy milk, White Milk, and Flavored Milk

Variable	Soy milk			White Milk			Flavored Milk		
	Estimate	Std Error	p-Value	Estimate	Std Error	p-Value	Estimate	Std Error	p-Value
Intercept	-2,672.0268	296.9842	< 0.0001	-10,143.0000	476.3492	< 0.0001	-3,414.0345	197.7071	< 0.0001
Log price soy milk	-1,260.0311	56.4160	< 0.0001	200.8191	117.9418	0.0886	-5.2917	49.0673	0.9141
Log price white milk	803.8080	38.2391	< 0.0001	-3,619.4876	51.5021	< 0.0001	-15.6306	23.6947	0.5095
Log price flavored milk	100.2505	42.8839	0.0194	-385.2163	53.7461	< 0.0001	-853.7970	18.2890	< 0.0001
Log household income	120.2176	18.0962	< 0.0001	1.0911	0.4323	0.0116	-0.3040	0.1904	0.1103
Age of household head 25-29	-234.2444	177.0692	0.1859	101.7221	258.3341	0.6938	-34.8354	106.7495	0.7442
Age of household head 30-34	-136.6016	169.8762	0.4213	235.0039	249.4899	0.3462	-21.4992	103.0316	0.8347
Age of household head 35-44	-253.2787	166.5204	0.1283	441.2824	244.5403	0.0711	11.7962	101.0569	0.9071
Age of household head 45-54	-274.8960	166.0476	0.0978	556.4868	243.9139	0.0225	15.0915	100.8545	0.8811
Age of household head 55-64	-257.5287	166.2297	0.1213	332.3119	244.1626	0.1735	-83.5376	101.0367	0.4083
Age of household head 65 or older	-382.5150	167.3041	0.0222	351.0286	245.2510	0.1523	-306.9108	101.7070	0.0025
Employment status part-time	87.9236	30.0629	0.0034	-98.6657	40.6284	0.0152	7.3209	17.5498	0.6766
Employment status full-time	-64.6420	26.7426	0.0156	-397.9781	35.0462	< 0.0001	12.3937	15.1306	0.4127
Education high school	-88.1445	68.5169	0.1983	-76.7998	85.7577	0.3705	30.5518	37.2066	0.4116
Education undergraduate	159.0966	66.9065	0.0174	-164.4896	84.2350	0.0508	-80.5632	36.6653	0.0280
Education post-college	231.4564	72.7243	0.0015	-219.3606	93.5424	0.0190	-251.0607	41.4572	< 0.0001
East	-145.7810	33.7740	< 0.0001	72.5586	46.4668	0.1184	61.4313	21.1130	0.0036
Midwest	-244.0475	34.0139	< 0.0001	200.0533	46.0776	< 0.0001	146.8886	19.5608	< 0.0001
South	-248.3142	29.2975	< 0.0001	180.9586	41.1583	< 0.0001	88.6233	18.6672	< 0.0001

Continued on following page

Table 3. (continued)

Variable	Soymilk			White Milk			Flavored Milk		
	Estimate	Std Error	p-Value	Estimate	Std Error	p-Value	Estimate	Std Error	p-Value
Black	359.6594	33.0944	< 0.0001	-1,327.5764	48.9013	< 0.0001	-309.4472	23.3439	< 0.0001
Asian	258.3444	60.0023	< 0.0001	-710.9594	90.1477	< 0.0001	-240.6159	42.0349	< 0.0001
Other	161.3821	53.8110	0.0027	-451.6395	77.2626	< 0.0001	-32.2585	33.7790	0.3396
Hispanic	193.3763	49.1722	< 0.0001	-51.5146	71.1847	0.4693	-87.6359	31.5405	0.0055
Children less than 6 years	127.3306	55.2279	0.0211	1,716.2647	79.0094	< 0.0001	265.1160	32.3450	< 0.0001
Children 6-12 years	-124.2500	47.1874	0.0085	1,032.6322	62.3932	< 0.0001	330.4722	25.1449	< 0.0001
Children 13-17 years	-36.8813	41.5422	0.3746	1,526.6399	55.4840	< 0.0001	265.9960	22.5530	< 0.0001
Children under 6 and 6-12 years	56.7680	63.8986	0.3743	2,329.8163	89.4605	< 0.0001	387.1387	35.4241	< 0.0001
Children under 6 and 13-17 years	-332.4013	156.7669	0.0340	2,280.2864	193.3857	< 0.0001	434.3757	73.9970	< 0.0001
Children 6-12 and 13-17 years	-171.3732	59.9933	0.0043	2,532.5129	78.0858	< 0.0001	356.2139	30.9163	< 0.0001
Children under 6, 6-12, and 13-17	453.1132	132.5566	0.0006	3,045.9931	202.8663	< 0.0001	482.2837	76.9397	< 0.0001
Female head only	-64.3224	28.0483	0.0218	-1,241.9199	36.3970	< 0.0001	-143.1470	16.3613	< 0.0001
Male head only	-339.8012	40.3899	< 0.0001	-1,129.7801	50.0214	< 0.0001	-167.7441	23.2881	< 0.0001
Sigma	1,563.8795	14.3523	< 0.0001	3,313.1084	9.8139	< 0.0001	1,098.4616	6.5136	< 0.0001
Log-likelihood	-80,684.5	-553,353.5	-153,433.3						
Pseudo R-square	0.0104	0.0138	0.0181						

Note: The significance of the estimated coefficients is based on a p-value of 0.05.

drink 43 ounces more. Regionally, households in the East, Midwest, and South are 1–3 percent less likely to purchase soymilk than households in the West and consume 27–46 ounces less soymilk. Households classified as black, Asian, and other consume a significantly larger volume of soymilk (30–66 ounces more with a 2–4 percent greater probability) than households classified as white (the base case). Also, Hispanic households are more likely to purchase soymilk than non-Hispanic households and consume about 36 ounces more soymilk (at the median). Overall, the presence of children in a household increases the probability of soymilk consumption 6 percent relative to households without children. Households with children purchase about 84 ounces more soymilk per year. Households in which the head is male purchase about 63 ounces less soymilk per year relative to the base case of households headed by a male and a female.

We turn now to the results for white milk. Households in which the head is 45 to 64 years of age purchase significantly more white milk (209–350 ounces / 1.63–2.73 gallons or 2–4 percent more probability) than households in the

Table 4. Median Unconditional Marginal Effects of each Demographic Variable for Soymilk, White Milk, and Flavored Milk Demand

Variable	Soymilk	White Milk	Flavored Milk
Age of household head 25–29	-25.1509	84.9229	-7.0434
Age of household head 30–34	-14.667	196.1968	-4.3469
Age of household head 35–44	-27.1946	368.4054	2.3851
Age of household head 45–54	-29.5157	464.5841	3.0513
Age of household head 55–64	-27.6509	277.4313	-16.8904
Age of household head 65 or older	-41.0707	293.0569	-62.0542
Employment status part-time	9.4404	-82.3713	1.4802
Employment status full-time	-6.9406	-332.2528	2.5059
Education high school	-9.4641	-64.1165	6.1773
Education undergraduate	17.0822	-137.3245	-16.289
Education post-college	24.8515	-183.1336	-50.7619
East	-15.6525	60.5757	12.4208
Midwest	-26.2034	167.0149	29.6994
South	-26.6616	151.0737	17.9187
Black	38.6167	-1,108.33	-62.5671
Asian	27.7385	-593.5459	-48.6501
Other	17.3276	-377.0522	-6.5223
Hispanic	20.7629	-43.0071	-17.7191
Children less than 6 years	13.6715	1,432.83	53.6037
Children 6–12 years	-13.3407	862.0951	66.8181
Children 13–17 years	-3.956	1,274.52	53.7817
Children under 6 and 6–12 years	6.0952	1,945.05	78.2755
Children under 6 and 13–17 years	-35.69	1,903.70	87.8263
Children 6–12 and 13–17 years	-18.4004	2,114.27	72.0228
Children under 6, 6–12, and 13–17	48.6509	2,542.95	97.5128
Female head only	-6.9063	-1,036.82	-28.9429
Male head only	-36.4846	-943.1992	-33.9161

Notes: Unconditional marginal effects are in liquid ounces; 128 liquid ounces equal one gallon.

base case (heads of household younger than 25). Households characterized by full-time employment purchase less white milk—about 250 ounces (1.95 gallons, which amounts to a 3 percent smaller probability) than households characterized by part-time employment. Higher levels of education are associated with decreased consumption of white milk. Undergraduate education is associated with a 103-ounce reduction in white milk consumed per year and post-graduate education is associated with a 138-ounce decline relative to the base case of less than a high school education. Households in the Midwest and South purchase 126 and 114 ounces more white milk, respectively, than households in the West. Our results are similar to those of Gould (1996), who also studied the effect of a household head's level of education and region on purchases of milk.

Black households are 10 percent less likely to purchase white milk than white households and buy 6.5 gallons less per year. Asian households are 5 percent less likely and buy 3.5 gallons less per year while other types of households are 3 percent less likely and buy 2.2 gallons less per year. Households in which

Table 5. Median Change in the Probability of being above the Limit for Change in each Demographic Variable for Soymilk, White Milk, and Flavored Milk Demand

Variable	Soymilk	White Milk	Flavored Milk
Age of household head 25–29	-0.0318	0.0074	-0.0104
Age of household head 30–34	-0.0186	0.0172	-0.0064
Age of household head 35–44	-0.0344	0.0322	0.0035
Age of household head 45–54	-0.0373	0.0407	0.0045
Age of household head 55–64	-0.0350	0.0243	-0.0249
Age of household head 65 or older	-0.0519	0.0257	-0.0914
Employment status part-time	0.0119	-0.0072	0.0022
Employment status full-time	-0.0088	-0.0291	0.0037
Education high school	-0.0120	-0.0056	0.0091
Education undergraduate	0.0216	-0.0120	-0.0240
Education post-college	0.0314	-0.0160	-0.0748
East	-0.0198	0.0053	0.0183
Midwest	-0.0331	0.0146	0.0438
South	-0.0337	0.0132	0.0264
Black	0.0488	-0.0971	-0.0922
Asian	0.0351	-0.0520	-0.0717
Other	0.0219	-0.0330	-0.0096
Hispanic	0.0263	-0.0038	-0.0261
Children less than 6 years	0.0173	0.1255	0.0790
Children 6–12 years	-0.0169	0.0755	0.0984
Children 13–17 years	-0.0050	0.1117	0.0792
Children under 6 and 6–12 years	0.0077	0.1704	0.1153
Children under 6 and 13–17 years	-0.0453	0.1668	0.1294
Children 6–12 and 13–17 years	-0.0233	0.1854	0.1061
Children under 6, 6–12, and 13–17	0.0615	0.2228	0.1437
Female head only	-0.0087	-0.0908	-0.0426
Male head only	-0.0461	-0.0826	-0.0450

Table 6. Median Conditional Marginal Effects of each Demographic Variable for Soymilk, White Milk, and Flavored Milk Demand

Variable	Soymilk	White Milk	Flavored Milk
Age of household head 25–29	-43.4220	64.0041	-8.6890
Age of household head 30–34	-25.3219	147.8682	-5.3625
Age of household head 35–44	-46.9504	277.6572	2.9423
Age of household head 45–54	-50.9576	350.1445	3.7642
Age of household head 55–64	-47.7382	209.0925	-20.8368
Age of household head 65 or older	-70.9070	220.8691	-76.5526
Employment status part-time	16.2984	-62.0810	1.8260
Employment status full-time	-11.9827	-250.4104	3.0914
Education high school	-16.3394	-48.3229	7.6205
Education undergraduate	29.4918	-103.4978	-20.0948
Education post-college	42.9052	-138.0229	-62.6220
East	-27.0235	45.6542	15.3228
Midwest	-45.2392	125.8747	36.6384
South	-46.0301	113.8602	22.1053
Black	66.6702	-835.3184	-77.1853
Asian	47.8894	-447.3396	-60.0167
Other	29.9155	-284.1741	-8.0462
Hispanic	35.8463	-32.4133	-21.8590
Children less than 6 years	23.6033	1,079.8800	66.1278
Children 6–12 years	-23.0323	649.7379	82.4295
Children 13–17 years	-6.83671	960.5702	66.3473
Children under 6 and 6–12 years	10.5231	1,465.9300	96.5638
Children under 6 and 13–17 years	-61.6174	1,434.7700	108.3461
Children 6–12 and 13–17 years	-31.7675	1,593.4700	88.8503
Children under 6, 6–12, and 13–17	83.9938	1,916.5600	120.2958
Female head only	-11.9235	-781.4228	-35.7051
Male head only	-62.9891	-710.8639	-41.8403

Notes: Conditional marginal effects are in liquid ounces; 128 liquid ounces equal one gallon.

there is solely a male or female head purchase about 6 fewer gallons of white milk per year (a decrease in probability of about 10 percent) than the base case household, which has a male and a female head. Our results for associations between consumption of milk and age, gender, and racial group are on par with what Storey, Forshee, and Anderson (2006) found when analyzing data from the U.S. 1999–2002 National Health and Nutrition Examination Survey (NHANES).

Households in which children are present are 22 percent more likely to purchase white milk than those without children and consume about 15 gallons more white milk per year. This result supports Siega-Riz, Popkin, and Carson (1998), which found that households with children consumed more milk than those without because of the kinds of foods children typically eat for breakfast.

Finally, for flavored milk, households headed up by older individuals (65+) are about 9 percent more likely to purchase (76 ounces low) flavored milk than households in the base case (headed by people younger than 25). Higher levels of education again reduce the amount of milk consumed. Undergraduate education reduces consumption of flavored milk by 20 ounces per year and

the likelihood of purchase by 2 percent while post-graduate education reduces consumption by 63 ounces per year and the likelihood of purchase by 7 percent relative to the base case. Households in the East, Midwest, and South purchase 15, 37, and 22 fewer ounces of flavored milk per year than households in the West. In terms of racial categories, households classified as black consume 77 fewer ounces of flavored milk per year and are 9 percent less likely to purchase it. Asian households consume 60 fewer ounces per year and are 7 percent less likely to purchase flavored milk. Hispanic households purchase 22 fewer ounces of flavored milk than non-Hispanic households, and households in which children are present consume 120 ounces (about one gallon) more and are about 14 percent more likely to purchase flavored milk than those without children. Male-only and female-only household heads are associated with consumption of significantly less flavored milk (42 and 36 ounces respectively) relative to the base (a male and a female head in a household). These findings are congruent with recent work by Dharmasena, Capps, and Clauson (2009) and Dharmasena and Capps (2011).

Unconditional and conditional own-price, cross-price, and income elasticities of demand calculated at the sample mean are shown in Table 7. Again, the unconditional elasticity estimates are consistently larger than the conditional elasticities for the same variables. That is, when we pool households that buy with households that may potentially buy a beverage type, the demand and income elasticities are relatively more elastic; they show larger own-price and income responses and a greater degree of substitutability between beverages.

For brevity, we discuss only the conditional elasticities in detail. The conditional own-price elasticity of demand for soymilk is -0.30 . Thus, consumers are highly insensitive to own-price changes (or people who buy soymilk are exceedingly loyal to that product). The conditional cross-price elasticities of soymilk with white milk and flavored milk are 0.19 and 0.02 respectively, demonstrating that white milk and flavored milk are substitutes for soymilk. The conditional own-price elasticity of demand for white milk is -0.53 and denotes the inelastic

Table 7. Unconditional and Conditional Own-price, Cross-price, and Income Elasticities of Demand for Soymilk, White Milk, and Flavored Milk Demand

	Soymilk	White Milk	Flavored Milk
Unconditional Own-Price, Cross-Price, and Income Elasticities			
Soymilk	-1.68	1.07	0.13
White milk	0.05	-0.86	-0.09
Flavored milk	-0.01	-0.03	-1.39
Income	0.16	0.02	-0.03
Conditional Own-Price, Cross-Price, and Income Elasticities			
Soymilk	-0.30	0.19	0.02
White milk	0.03	-0.53	-0.06
Flavored milk	-0.002	-0.01	-0.32
Income	0.03	0.01	-0.01

Notes: The numbers printed in bold are statistically significant at a p-value of 0.05. Given the extreme nonlinearity of equations involved in calculating conditional and unconditional marginal effects, the significance of elasticity estimates is based on the significance of the underlying parameter estimates used to generate elasticities (see Table 3 for significant variables of the Tobit estimates for soymilk, white milk, and flavored milk).

nature of white milk consumption. This estimate is in line with prior estimates of own-price elasticity for white milk (e.g., Kinnucan et al. 2001, Yen et al. 2004, Zheng and Kaiser 2008, Dharmasena and Capps 2012). The conditional cross-price elasticity of white milk with respect to soymilk is 0.03, indicating that soymilk is a substitute for white milk.⁵ However, the conditional cross-price elasticity of white milk with flavored milk is -0.06 , indicating complementarity between white milk and flavored milk. For flavored milk, the conditional own-price elasticity of demand is -0.32 . The conditional income elasticities of demand are 0.03 for soymilk and 0.01 for white milk so both are normal goods.

Several retail pricing strategies can be formulated based on the estimates of the own-price and cross-price elasticities and the conditional demographic marginal effects.⁶ A retail-level sales revenue function relating revenue from the three beverage categories (soymilk, white milk, and flavored milk) can be expressed as

$$(18) \quad Total\ Sales = p_{sm} \times q_{sm} + p_{wm} \times q_{wm} + p_{fm} \times q_{fm}$$

where p_{sm} is the price of soymilk, q_{sm} is the quantity of soymilk sold, p_{wm} is the price of white milk, q_{wm} is the quantity of white milk sold, p_{fm} is the price of flavored milk, and q_{fm} is the quantity of flavored milk sold. Differentiating total sales (equation 18) with respect to the price of soymilk gives rise to

$$(19) \quad \partial Total\ Sales / \partial p_{sm} = \frac{1}{p_{sm}} [S_{sm}(1 + \epsilon_{sm,sm}) + \epsilon_{wm,sm} \times S_{wm} + \epsilon_{fm,sm} \times S_{fm}].$$

In this expression, S_{sm} is soymilk sales, $\epsilon_{sm,sm}$ is the own-price elasticity of demand for soymilk, S_{wm} is white milk sales, $\epsilon_{wm,sm}$ is the cross-price elasticity of white milk with respect to soymilk, S_{fm} is flavored milk sales, and $\epsilon_{fm,sm}$ is the cross-price elasticity of demand for flavored milk with respect to soymilk. Accordingly, the total change in sales for all three beverage categories with respect to a change in the price of soymilk is dependent not only on sales of the three products but also on respective own- and cross-price elasticity estimates. Consumers of soymilk are relatively insensitive to changes in price (the conditional own-price elasticity of demand -0.30), and white and flavored milks are substitutes for soymilk (they have positive cross-price elasticities). Thus, when we hold all else constant, equation 19 shows that an increase in the price of soymilk would result in a gain in revenue for retailers. However, since the unconditional own-price elasticity of demand for soymilk is elastic (-1.68), an

⁵ A reviewer questioned the economic significance of small cross-price elasticities such as the one for soymilk with respect to white milk, which is estimated to be 0.03. The economic significance of this small cross-price elasticity is demonstrated by calculating the change in volume of consumption of white milk that would result from a 1 percent change in the price of soymilk. The number of households consuming white milk in the 2008 Nielsen at-home sample was 58,626 (95.42 percent of 61,440 households), and the increase in consumption for those households would be 478 gallons per year, which represents an approximate annual change in expenditures of \$175,000 if the prices for white milk and flavored milk do not change and the change in expenditure per household per year is approximately \$3. Similar arguments apply to the other cross-price elasticity measures.

⁶ Since elasticities are estimated at the sample mean, a reviewer pointed out that our retail-level pricing strategies are relevant only within some epsilon region of the demand curve and that further research may be necessary to account for potentially heterogeneous elasticities in various parts of nonlinear milk demand curves. We acknowledge this limitation.

increase in the price of soymilk would dissuade potential soymilk buyers, *ceteris paribus*, thereby reducing potential retail revenue. Consequently, if a retailer's objective is to convince consumers who have not bought soymilk to buy it, the retail strategy must incorporate price promotions. If a retailer's objective is to gain greater revenue from soymilk sales, the retailer could increase the price of white and flavored milk, which are competitors (substitutes) for soymilk and thus, *ceteris paribus*, increase soymilk sales and hence revenue. A similar argument can be applied to changes in the price of white milk and flavored milk as well.

Soymilk promotions could target households in which heads of the households are younger than 25 and who are college- or post-college-educated and households that include children. Furthermore, soymilk promotion is likely to have the largest impact on households in the West, households characterized as Hispanic, and households classified as black and Asian. Since white, eastern, southern, and Midwestern households have historically bought less soymilk, marketing and promotion strategies could be directed to those potential buyers as well. Older heads of households (65+) also have tended to buy less soymilk. Given how rapidly the number of seniors will be increasing in the future, they represent a potential as-yet-untapped market for additional revenue.

Conclusions and Implications

The nonalcoholic beverage market has been evolving rapidly during the past decade. Increasingly, beverages provide more than hydration and refreshment. They are fortified with vitamins, minerals, protein, antioxidants, and favorable fatty acids, making them rich in health and functional dimensions. Calcium- and vitamin-fortified milk alternatives made from soy, almonds, coconut, and a host of other tree nuts now compete with dairy milk in the U.S. beverage market, and soymilk has been one of the fastest growing products among dairy-alternative beverages.

Using household-level purchase data for soymilk, white milk, and flavored milk and associated demographic characteristics from the 2008 Nielsen Homescan panel, we estimate models to uncover demand for these three beverage categories by a diverse set of consumers. Given that censoring (zero expenditures or purchases) is inherent to the purchase data, we use the Tobit procedure to identify conditional and unconditional factors that affect the volume of soymilk purchased and then calculate conditional and unconditional own-price, cross-price, and income elasticities for soymilk, white milk, and flavored milk. In addition, we shed light on potential retail-level pricing strategies for soymilk in the highly competitive beverage market.

We find that the demographic characteristics of households examined in this study all have some impact on demand for soymilk, white milk, and flavored milk. The age, gender, employment status, and education of the head of the household are significant determinants of demand for soymilk. In terms of characteristics of the household, the geographic region in which it is located, the household's racial identity (including whether it is Hispanic), and the presence of children all influence demand. The conditional own-price elasticity of demand for soymilk is estimated to be -0.30 . Estimates of cross-price elasticities for soymilk with respect to white milk and flavored milk reveal that both are substitutes for soymilk. The income elasticity of demand demonstrates that soymilk is a normal good.

For white milk, the impact of identification as Hispanic is particularly large. The estimated conditional own-price elasticity of demand for white milk is -0.53 . The cross-price elasticities reveal that soymilk competes with (is a substitute for) white milk and that flavored milk is a complement. For flavored milk, the effects of age and employment of household heads are particularly important determinants. The estimated conditional own-price elasticity of demand for flavored milk is -0.32 .

We suggest several retail pricing strategies based on the results of our estimations. Retail-level price promotions could motivate purchases of soymilk by those who currently do not buy it. However, the inelastic conditional own-price elasticity of demand for soymilk suggests that retailers could gain greater revenue by increasing the price of soymilk. Marketing strategies should aim to increase sales of soymilk by both current and potential consumers. Dairy milk marketers must pay attention to soymilk as a rapidly emerging competitor and design price and marketing strategies to increase consumption of white milk among those who already purchase it.

Note that the retail-level marketing recommendations we posit may be relevant only for small changes in prices and that further research may be necessary to account for potentially heterogeneous elasticities in various parts of milk demand curves.

References

- Alviola, P.A., and O. Capps, Jr. 2010. "Household Demand Analysis of Organic and Conventional Fluid Milk in the United States Based on the 2004 Nielsen Homescan Panel." *Agribusiness* 26(3): 369–388.
- Belsley, D.A., E. Kuh, and R.E. Welsch. 1980. *Regression Diagnostics Identifying Influential Data and Sources of Collinearity*. Hoboken, NJ: John Wiley & Sons.
- Beverage Marketing Corporation. 2010a. *Soy Beverages in the United States*. New York, NY.
- _____. 2010b. *Beverage Marketing Corporation Multiple Beverage Marketplace Reports*. New York, NY.
- _____. 2011. *Beverage Marketing Corporation Multiple Beverage Marketplace Reports*. New York, NY.
- _____. 2012. *Beverage Marketing Corporation Multiple Beverage Marketplace Reports*. New York, NY.
- Capps, O. Jr., R. Tsai, R. Kirby, and G. Williams. 1994. "A Comparison of Demand for Meat Products in the Pacific Rim Region." *Journal of Agricultural and Applied Economics* 19(1): 210–224.
- Dharmasena, S., and O. Capps, Jr. 2011. "Is Chocolate Milk the New-Age Energy/Sports Drink in the United States?" *Journal of Agricultural and Applied Economics* 43(3): 461.
- _____. 2012. "Intended and Unintended Consequences of a Proposed National Tax on Sugar-Sweetened Beverages to Combat the U.S. Obesity Problem." *Health Economics* 21(6):669–694 (DOI: 10.1002/hec.1738).
- Dharmasena, S., O. Capps, Jr., and A. Clauson. 2009. "Nutritional Contributions of Nonalcoholic Beverages to the U.S. Diet: 1998–2003." *Journal of Agricultural and Applied Economics* 41(2): 546.
- Food Business News*. 2013. "More Ingredients Are Being Used for Dairy Alternatives." January 7.
- Gould, B.W. 1996. "Factors Affecting U.S. Demand for Reduced Fat Milk." *Journal of Agricultural and Resource Economics* 21(1): 68–81.
- Heckman, J.J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1): 153–161.
- Kennedy, P. 2003. *Limited Dependent Variables. A Guide to Econometrics*. Cambridge, MA: MIT Press.
- Kinnucan, H.W., Y. Miao, H. Xiao, and H.M. Kaiser. 2001. "Effects of Advertising on U.S. Nonalcoholic Beverage Demand: Evidence from a Two-Stage Rotterdam Model." In M.R.

- Baye and J.P. Nelson, eds., *Advertising and Differentiated Products* (Advances in Applied Microeconomics, Vol. 10). Cambridge, MA: Emerald Group Publishing.
- Kyureghian, G., O. Capps, Jr., and R. Nayga. 2011. "A Missing Variable Imputation Methodology with an Empirical Application." *Advances in Econometrics* 27A:313-337.
- McDonald, J.F., and R.A. Moffitt. 1980. "The Uses of Tobit Analysis." *Review of Economics and Statistics* 62(2): 318-321.
- Siege-Riz, A.M., B.M. Popkin, and T. Carson. 1998. "Trends in Breakfast Consumption for Children in the United States from 1965-1991." *American Journal of Clinical Nutrition* 67(4): 7485-7565.
- Soyfoods Association of North America. 2013. "Soy Information: Sales and Trends." Washington, DC. Available at www.soyfoods.org/soy-information/sales-and-trends (accessed February 12, 2013).
- Storey, M.L., R.A. Forshee, and P.A. Anderson. 2006. "Beverage Consumption in the U.S. Population." *Journal of the American Dietetic Association* 106(12): 1992-2000.
- Tobin, J. 1958. "Estimation of Relationships for Limited Dependent Variables." *Econometrica* 26(1): 24-36.
- U.S. Department of Agriculture. 2011. "What Foods Are Included in the Dairy Group?" web page. Available at www.choosemyplate.gov/foodgroups/dairy.html (accessed September 9, 2011).
- Yen, S.T., B-H. Lin, D.M. Smallwood, and M. Andrews. 2004. "Demand for Nonalcoholic Beverages: The Case of Low-Income Households." *Agribusiness* 20(3): 309-321.
- Zheng, Y., and H.M. Kaiser. October 2008. "Advertising and U.S Nonalcoholic Beverage Demand." *Agricultural and Resource Economics Review* 37(2): 147-159.