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Use of Elasticities: Implications of Market Segmentation for Fluid Milk

by

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In recent years, significant changes have taken place in food consumption patterns of American consumers. Evidence indicates that ongoing changes in U.S. household food consumption patterns occurred in response to sudden increases in food prices in the early 1970's, and the recent salient inflationary period (Salathe; Smallwood and Blaylock). Changes in household food consumption patterns during the past decades were caused not only by economic conditions, but also by demographic shifts, tastes, and preferences (LeBovit; Harmston and Hino).

Comparison of the 1972-73 Bureau of Labor Statistics Consumer Expenditure Diary Survey (CEDS) and the 1977-78 U.S. Department of Agriculture 1977-78 Nationwide Food Consumption Survey (NFCS) indicates that average household income increased from $202.85 per week to $273.04 per week, while average household size decreased from 3.01 persons to 2.95 persons. Average food expenditures by households increased 74.5 percent from $32.24 per week to $56.26 per week between the 1972-73 CEDS and the 1977-78 NFCS (Salathe; Smallwood and Blaylock). However, between 1972-73 and 1977-78, the Consumer Price Index (CPI) for all food items increased by 52.4 percent while the CPI for all items, food and nonfood, increased by 45.8 percent (USDA). During this period, real expenditures for food items increased while household real income decreased. Substantial variation in the CPI for different food items was evident; hence, the relative price level among various food items also changed. Consequently, one may expect that the mix and preference of individual food commodities may also be expected to change considerably.

Other important changes during this time in socioeconomic characteristics of the U.S. population are manifested in steadily declining birth rate, a shift in age distribution, increased female participation in the labor force and increased number of working wives. In addition, increased consciousness of dietary concern also may have influenced and changed consumers tastes and preferences as reflected in the food consumption pattern.

The objective of this study is to identify and analyze the effects of household income and other socioeconomic characteristics on U.S. household consumption of two fresh milk products. Fresh milk is selected because it represents a major food category in the U.S. household food basket. Additionally, changes in consumers' purchase and consumption of fresh whole milk and low fat milk have been evident during the past decades. Per capita sales of whole milk, on a product weight basis, declined from 205.61 to 140.71 pounds during the 1970-80 period; whereas, per capita sales of low fat milk, including skim milk, increased from 42.30 to 83.67 pounds (USDA). Thus, factors which explain the increased popularity of low fat milk among American consumers need to be identified and examined.

Model Specification and Procedure

Models for estimating the Engel relation from cross sectional data for specific food products can be represented typically as

$$(1) \qquad Y_j = X_{ij} \beta + U_j \qquad \begin{matrix} i = 1,2,\ldots,k \\ j = 1,2,\ldots,n \end{matrix}$$

where Y is a vector of n households' expenditures for a particular food; X represents a matrix of k socioeconomic characteristics of the sample households. β is an unknown parameter vector; and U represents the error vector.

The ordinary least squares (OLS) procedure is frequently used to estimate equation (1). However, analysis of cross sectional data encounters the

problem that the error term associated with the dependent variable in the econometric model is truncated normal; that is, the dependent variable has a number of its values clustered at a limiting value, usually zero. To circumvent this problem, zero observations in the sample are ususally eliminated, and hence, the analysis provides paramater estimates reflecting only the change for consuming or purchasing households. Average food consumption for the total market population represents both the average consumption of all households and the rate of their participation in the market. Analysis of household food consumption behavior should take both into account.

The OLS model in which the dependent variable is truncated normal yields biased and inconsistent estimates of the population parameters. Tobit analysis is designed to correct this estimation problem.

To apply the Tobit procedure, equation (1) is rewritten as

$$(2) \qquad Y_j = X_{ij}\,\beta + e_j, \qquad \text{if } X_{ij}\,\beta + e_j > 0$$
$$= 0, \qquad \text{if } X_{ij}\,\beta + e_j \leq 0$$

where e represents truncated normal error terms.

After obtaining the Tobit regression coefficients, adjustments are required in computing the marginal effect of a change in the ith variable of X on Y and, hence, the elasticity of Y with respect to X_i. The computations differ from the procedure used with OLS regression coefficients because the unconditional expected value E(Y) in equation (2) is no longer equal to $X\beta$, a property of OLS (Goldberger). Thus, the elasticity of the ith variable of X with respect to Y is evaluated as

$$(3) \qquad \eta_i = [\partial E(Y^*)/\partial I] \times [I/E(Y^*)] + [\partial F(z)/\partial I] \times [I/F(z)]$$

where η_i is the elasticity of the ith variable of X with respect to Y; $E(Y^*)$ is the conditional expected value for Y (the expected value of Y for observations greater than zero); and F(z) is the cumulative normal distribution

function (the probability of Y being greater than zero), with $z = X\beta/\sigma$. Note that the elasticity, n_i, has two components. The first component is referred as the conditional elasticity associated with actual consumption. The second component of equation (3) represents the elasticity of change in the probability of being a consuming household associated with a change in the ith independent variable (McDonald and Moffit).

Data

The 1977-78 NFCS provides national cross sectional household food consumption data for empirical implementation of the present study. Two types of at-home milk consumption data, whole milk and low fat milk, were selected for this analysis. A sample of 10,760 households selected from a total sample of approximately 15,000 survey households. Nearly 25 percent of the households surveyed were excluded from the empirical analysis because household income was not reported. Other households that reported inconsistent information or apparently incorrect information were also deleted.

Summary statistics of the sample data are presented in table 1. The number of households reporting fresh milk consumption during the survey week differed considerably between the two types of milk. Each subsample exhibits unique characteristics. Households in the whole milk consuming subsample, on the average, consume less fresh milk than households in the low fat milk consuming subsample. The whole milk consuming household consumes over 95 percent of fresh milk as whole milk, while the low fat milk consuming household consumes about 83 percent of fresh milk as low fat milk. A highest percentage of whole milk consuming households were located in the South. The largest proportion of low fat milk consuming households were located in the

Table 1. Selected sample means and standard deviations, fresh whole milk and low fat milk consumption per household, U.S., 1977-78.

Variable	Whole milk non-limit sample	Low fat milk non-limit sample	Total sample
Whole milk ($)	2.69 (2.54)[a]	0.48 (1.41)	1.81 (2.44)
Low fat milk ($)	0.13 (0.58)	2.37 (2.33)	0.71 (1.68)
Household income ($)	13,476.94 (9,935.25)	17,259.69 (11,638.12)	14,051.14 (10,440.25)
Household size (persons)	3.07 (1.69)	3.04 (1.55)	2.95 (1.67)
Education of female head (years)	10.59 (4.25)	12.20 (3.79)	10.85 (4.37)
White households (percent)	81.84	95.19	85.11
Black households (percent)	18.16	4.81	14.89
Northeast (percent)	28.06	21.11	24.64
North Central (percent)	19.07	35.57	24.09
South (percent)	38.39	20.65	34.17
West (percent)	14.48	22.67	17.10
Sample size	7,231	3,225	10,760

[a]Numbers in parentheses are the standard deviations.
Source: Compiled from the 1977-78 USDA Nationwide Food Consumption Survey.

North Central region. The whole milk subsample consists of more black households, larger households, households with lower education and income levels than the low fat milk subsample.

Results

The statistical model of equation (2) was estimated based on the total U.S. sample for fresh whole milk and low fat milk. Two regression equations were estimated for each type of fresh milk to test the null hypothesis that household milk consumption is not related to family life cycle stages represented by the age groups of the household head. The likelihood ratio test was used to test the null hypothesis. The results suggest that the null hypothesis can be rejected at the 0.05 significance level for the fresh whole milk equation. Thus, for low fat milk, only the results of the constrainted estimation are presented.

The regression results of the Tobit analysis suggest that the fresh milk consumption pattern was quite distinct between product types. The income coefficient for low fat milk was positive and statistically significant at the 0.05 significance level (table 2). In contrast, the income coefficient for whole milk was negative and significant. Thus, results of this study suggest that as household income increases, household consumption of whole milk and low fat milk may be expected to decrease and increase, respectively, ceteris paribus. The findings are generally in agreement with previous studies based on different sample data (Boehm; Boehm and Babb; Hassan and Johnson; Huang and Raunikar; Salathe).

In addition to household income, the variables respresenting educational attainment of female head and white household display a different pattern between whole milk and low fat milk. The effects of educational level of the

Table 2. Regression results of Tobit analysis for fresh whole milk and fresh low fat milk consumption per household in the U.S., 1977-78.

Variable	Whole milk	Low fat milk
Constant	2.384	-14.058
L_n(income)	-0.261* (-5.724)	0.719* (10.533)
Household size	0.884* (41.563)	0.278* (9.511)
Education of female head	-0.065* (-8.924)	0.140* (11.743)
North Central	-1.603* (-19.211)	1.903* (15.443)
South	-0.491* (-6.438)	-0.273* (-2.144)
West	-1.208* (-13.334)	1.460* (10.849)
Metropolitan	-0.160* (-2.150)	0.350* (3.094)
Rural	-0.044 (-0.581)	0.043 (0.362)
White household	-0.060 (-0.684)	2.416* (14.050)
Age of head <25	0.185 (1.473)	--
35≤ Age of head ≤ 44	0.157 (1.725)	--
45≤ Age of head ≤ 54	0.445* (4.874)	--
55≤ Age of head ≤ 64	0.114 (1.176)	--
Age of head ≥ 65	0.029 (0.292)	--
Standard error of estimate	2.796	3.559

[a]Numbers in parentheses are the asymptotic t-ratios.
*Significant at the 0.05 significance level.

female head suggest that as educational level increases, household consumption of whole milk decreases and consumption of low fat milk increases. Similar results were reported by Boehm for the Southern region. Assuming that higher educational levels may lead to more nutritional awareness and diet-conscious behavior, the results provide some insights which help explain the observed different consumption patterns. White households consume a relatively higher level of low fat milk than black households. However, no statistically significant difference on whole milk consumption was found between white and black households.

Regional differences in milk consumption were also evident. Northeastern households consume more whole milk than households located in other regions of the U.S; whereas, households located in the North Central region consume higher low fat milk. Among other socioeconomic variables, the analysis indicates that the highest whole milk consumption level was reached at the stage when the age of the household head is between 45 and 54 years old. This may occur because household size is usually the largest at this stage of family life cycles. The importance of household size in explaining household milk consumption is also reflected in its magnitude and statistical significance level.

Elasticities, evaluated at the means, with respect to household income and size are presented in table 3. Based on empirical evidence presented in this study, whole milk consumption will decrease by about 1 percent and low fat milk will increase only slightly above 3 percent as household income increases by 10 percent. Thus, fresh milk consumption will not be greatly enhanced by increases in household income. Furthermore, this analysis suggests that while low fat milk consumption was more responsive to change in household income,

Table 3. Household income and household size elasticities for fresh whole milk and fresh low fat milk consumption per household in the U.S., 1977-78.

	Household income elasticity[a]			Household size elasticity[a]		
	Conditional	Market participation	Total	Conditional	Market participation	Total
Whole milk	-.045	-.052	-.097	.446	.523	.969
Low fat milk	.083	.250	.333	.094	.285	.379

[a]Elasticities are evaluated at the means.

whole milk consumption was more responsive to change in household size. In terms of elasticities, the effects of changes in household income and size on low fat milk consumption were similar in magnitude; whereas, household consumption of whole milk is more likely to increase as household size increases in comparison with income increases, Ceteris paribus. The presence of children in the larger households may account for unique consumption patterns.

The results appear consistent with previous studies. Estimating fresh milk consumption as a group, Smallwood and Blaylock report household income and size elasticities of .048 and 1.036, respectively. Salathe estimates income elasticity for whole milk varies from -.096 to -.043 and household size elasticity varies from 1.024 to 1.09. Income elasticity and household size elasticity for other fresh milk varies from .360 to .384 and from .669 to .684, respectively. Based on MRCA data, Boehm estimates an income elasticity of -.07 for whole milk and .16 for two percent milk. The magnitude of the elasticites reported in this study seems to lie between those reported by Boehm, Salathe, and Smallwood and Blaylock. Differences in results may be attributed partially to the procedures and data used by the different authors. Although the OLS was used for their statistical estimation, Boehm used only consuming households in his study, Salathe, Smallwood and Blaylock included both consuming and non-consuming households in their studies.

By decomposing the total elasticity into two components, the analysis provides further insights into the effects of household income and household size on fresh milk consumption. The effects of a given percentage change in household income and household size on whole milk consumption were about equal between the two components of the total elasticities, respectively. As noted

previously, a 10 percent increase in household income will decrease consumption of whole milk about 1 percent. Of this 1 percent decrease, one-half of the total adjustment results from a decrease in the amount consumed, and the other one-half of the adjustment is attributed to the decrease in the probability of consuming whole milk. The results imply that as household income or household size increases, consumption of low fat milk will increase because of the increase in the probability of being a consuming household rather than the increase in magnitude of amount consumed.

Conclusion

Fresh milk consumption patterns in the United States are examined for two product types, whole milk and low fat milk. The analysis was based on the application of the Tobit maximum likelihood procedure to 1977-78 USDA NFCS data.

Results of the analysis suggest that distinct consumption patterns exist between whole milk and low fat milk. Elasticities suggest that fresh milk consumption will increase only slightly as household becomes more affluent. Consumption of whole milk appears to be quite responsive to changes in household size. This observation coincides with the likely presence of children in the larger household and that children may prefer whole milk to low fat milk because of the richer flavor in the whole milk.

The magnitudes of percentage changes in whole milk consumption in response to changes in household income and household size were estimated to be approximately equal with regard to changes in the amount consumed and changes in the probability of being a consuming household. For low fat milk consumption, changes in household income and household size induced a greater change in the probability of being a consuming household rather than a change in the amount consumed.

The information and results presented in this study have important economic and marketing implications. On the basis of the observed consumption patterns, market segments can be defined for each type of fresh milk; hence, providing the dairy industry an opportunity for market strategy planning and development of promotional campaigns. The prosperity of the industry cannot rely on the increasing affulence of American households. Based on this study, the industry, should direct its efforts to promote milk consumption among non-consuming households, to promote whole milk among larger households, and to promote low fat milk among white households and households with higher education and income levels.

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