Characteristics of Fluid Milk Expenditure Patterns in the Northeast Region

Robert Raunikar and Chung-Liang Huang

Expenditure patterns for whole milk and lowfat milk in the Northeast region were examined by applying the Tobit maximum likelihood procedure to the 1977–78 USDA NFCS data.

Results suggest that differing expenditure patterns exist between whole milk and lowfat milk. Household income estimates indicate significant positive effects on expenditure for lowfat milk but negative on expenditure for whole milk. Whole milk expenditure was estimated to be strongly related to the family life cycle stages through the child-raising years.

During the past two decades, significant changes have occurred in fluid milk consumption patterns as well as for foods generally. Factors contributing to these changes in the fluid milk consumption patterns include changes in prices, real income, demographics, tastes and preferences (Buse and Fleischner; Lebovit; Salathe). Recent food price variations along with inflationary pressures have contributed to observed changes in food consumption patterns. Changes in the age composition of the population and in consumers' tastes and life styles aided in altering food consumption patterns. Several changes in the population demographics have impacted on food consumption. These changes include an increasing proportion of elderly persons, a declining birth rate, an increased number of single females and working wives in the workforce, and an increasingly higher proportion of small (1- and 2-person) households.

The dairy industry responded to changes in fluid milk consumption patterns by changing production and product mix. Total milk production in the United States increased during the 1970s after declining during the 1960s (USDA). However after 1979, milk production showed a marked increase. Between 1960 and 1981, per capita consumption of fluid milk declined on a product weight basis by 56 pounds and a fluid milk equivalent basis by 100.6 pounds. Concurrent with this decline in

Authors are Professor and Associate Professor, respectively, Department of Agricultural Economics, University of Georgia College of Agriculture, Georgia Experiment Station, Experiment, Georgia 30212.

fluid milk consumption, an important change in its composition occurred. The introduction and promotion of lowfat milk during this time resulted in an increase in lowfat milk sales from less than 3 pounds to slightly over 74 pounds per capita, and a decline in plain whole milk from nearly 251 pounds to about 135 pounds per capita.

This paper identifies the effects of household income and other socioeconomic factors on household expenditures for lowfat milk and whole milk in the Northeast region of the United States. According to the U.S. Department of Agriculture 1977–78 Nationwide Food Consumption Survey (NFCS), fluid milk expenditures accounted for nearly 7 percent of total at-home food expenditures with 92 percent of the households in the survey using fluid milk at home. Thus, fluid milk's importance in the household's food basket provides the basis for its selection and, hence, the need to determine the effect of specific factors on the quantity and kind of fluid milk products.

The Model

Studies by Boehm; Boehm and Babb; Huang and Raunikar suggest that regional expenditure patterns for dairy products are quite different from that of the total U.S. A statistical model used to estimate the Engel relation for two fluid milk products in the Northeast region of the United States is specified as

$$(1) \qquad Y = X\beta + e$$

where Y is a n × 1 vector of n households' food expenditure for a particular type of fluid milk; X represents a n × k matrix of independent variables set with k being the number of independent variables. The independent variables set is specified to include household income and size, years of formal education of female household head, race and residence location of household, and family life cycle stages; β is an unknown k × 1 parameter vector; and e is a n × 1 vector of normally distributed random disturbances.

Aside from the customary socioeconomic variables, the model specified stages of family life cycle (FLC) to account for changes in demand for fluid milk consumption as changes in the stages of the family life cycle occur. The classification of FLC stages defined in the model follows that suggested by Murphy and Staples. However, the lack of comparable data from the NFCS survey data required minor classification change. The ten life cycle stages, established on the basis of age, marital status and presence of children, were Young Single, Young Married Without Children, Young Married With Children, Middle Age Married With Children, Middle Age Married Without Children, Older Married, Older Single, Young Single With Children, Middle Age Single With Children, and Middle Age Single. The age groups, based on household head's age, were young (under 35 years old), middle age (35–64 years old), and older (65 years old and over). Race, location and stages of the FLC were entered into the equation as sets of zero-one variables.

Data and Estimation

This study uses the 1977–78 NFCS, which provides at-home whole milk and lowfat milk expenditures and household characteristics. Procedures for checking data consistency and completeness were applied for data editing. As a result, 2,651 households surveyed from the Northeast region of the U.S. were used for the present analysis. Households located in the Northeast region accounted for about the same proportion of total survey sample, 25.1 percent and 24.6 percent, before and after eliminating those households with inconsistent and incomplete records, respectively.

Summary statistics of the sample data are presented in Table 1. The number of households reporting fluid milk expenditure during the survey week differed considerably by type

Table 1. Selected Sample Means and Standard Deviations, Fluid Whole Milk and Fluid Lowfat Milk Expenditure Per Household Per Week in the Northeast Region of the U.S., 1977–78.

Variable	Whole milk consuming sample	Lowfat milk consuming sample
Whole milk ($)	2.99 (2.94)[a]	1.02 (2.15)
Low fat milk ($)	0.18 (0.66)	2.10 (2.23)
Household income ($)	14,647 (10,330)	18,903 (11,916)
Household size (persons)	3.10 (1.64)	3.11 (1.59)
Education of female head (years)	11.88 (3.14)	13.19 (2.98)
White households (%)	85.91	96.77
Households consuming (%)	76.54	25.69

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

of fluid milk. The whole milk consuming households in the Northeast region had about 94.3 percent of fluid milk expenditures in the whole milk form, while the lowfat milk consuming samples show that about 67.3 percent of fluid milk expenditures were for the lowfat milk form. The proportion of whole milk consuming households was 76.5; whereas; the proportion of households consuming lowfat milk was 25.7 percent in the Northeast region. In comparison, the NFCS data indicate that the proportion of whole milk and lowfat milk consuming households in the South were 75.5 percent and 18.1 percent, respectively (Huang and Raunikar). Some similarities in fluid milk expenditure patterns appear to exist between the Northeast and Southern regions.

The application of the ordinary least squares (OLS) to estimate equation (1) based on the NFCS data yields biased and inconsistent estimates of the population parameters. This is because the dependent variable usually has a number of its observations concentrated at zero values. The Tobit maximum likelihood procedure, which allows zero-valued observations to occur with positive probabilities, provides an alternative and a solution to this estimation problem faced by the conventional procedure. The Tobit maximum likelihood procedure estimates simultaneously the aver-

age expenditure expended by households that purchased the product and the probability that households will purchase the product. The probability component is referred to as the market participation rate (Thraen, Hammond and Buxton). As will be shown later, this is a rather useful concept in demand analysis and provides important implications for marketing fluid milk.

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

$$(2) \quad \begin{aligned} Y_j &= X_{ij}\,\gamma + v_j, &&\text{if } X_{ij}\,\gamma + v_j > 0 \\ &= 0, &&\text{if } X_{ij}\,\gamma + v_j \le 0 \end{aligned}$$

where Y_j is a vector of n household's weekly whole milk or lowfat milk expenditures; X_{ij} represents a matrix of the socioeconomic characteristics of the sample households specified in equation (1); γ is an unknown parameter vector; and v_j represents a vector of censored normal error terms.

McDonald and Moffitt show that the Tobit regression coefficients which represent the marginal effects of a change in X on Y can be decomposed into two components. In short, they state that the total change in Y represents both the change in Y of those who purchased the product, weighted by the probability of being a purchaser, and the change in the probability of being a purchaser, weighted by the average expenditure of those who purchased. It follows that the elasticity of Y with respect to the ith variable of X (η_i) can be derived by

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

where $E(Y^*)$ 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 $z = X\gamma/\sigma$. Note that the first component of η_i is referred to as the conditional expenditure elasticity and the second component is referred to as the market participation elasticity (Thraen, Hammond and Buxton). More specifically, the total elasticity measures the total market adjustment to changes in the demand determinants in terms of percentage changes in average expenditure of those purchasing households and the adjustment in the proportion of purchasing households. The empirical interpretations of these elasticity measures are discussed in the following section.

Empirical Results

The estimates of the normalized coefficients obtained from the Tobit maximum likelihood procedure for the Northeast region sample for whole milk and lowfat milk are presented in Table 2. To test the null hypotheses that household expenditures for whole milk and lowfat milk are not related to FLC stages, two regression equations with FLC stages included and excluded, respectively, were estimated for each type of fluid milk. The likelihood radio test was then applied to test whether the coefficients for FLC stages are significantly different from zero at the .05 significance level. The results suggest that the null hypothesis can be rejected in the case of whole milk but not lowfat milk. Thus, in the case of lowfat milk, only the results of the constrained model (i.e., FLC stages are excluded from the set of independent variables) are reported.

As previously noted, the Tobit maximum likelihood procedure estimates the regression model which accounts for the fact that average

Table 2. Normalized Coefficients of Tobit Regression for Whole Milk and Lowfat Milk Expenditures Per Household Per Week in the Northeast Region of the U.S., 1977–78.

Variable	Whole milk	Lowfat milk
Constant	1.660**	−4.122**
Log (income)	−0.191**	0.203**
Household size	0.434**	0.065**
Education of female head	−0.026**	0.041**
Metropolitan	−0.195**	0.314**
Rural	−0.128*	0.220**
White household	−0.057	0.710**
Young single	−0.103	
Young married without children	−0.011	
Young married with children	−0.149*	
Middle age married w/o children	−0.038	
Older married	−0.171	
Older single	−0.194	
Young single w/children	0.088	
Middle age w/children	0.212*	
Middle age single	−0.042	
Predicted average expenditure ($)	2.26	0.45
Probability of milk expenditure	0.747	0.223
Sample size	2,651	2,651

* Significant at the 0.05 significance level.
** Significant at the 0.01 significance level.

fluid milk expenditure is affected by the expenditure expended by purchasing households and the probability of the occurrence of positive expenditure among the households. The estimated probability of purchasing whole milk and lowfat milk in the Northeast region are .747 and .223, respectively. These estimated probabilities approximate the actual proportion of households that report purchasing fluid milk (Table 1). The predicted fluid milk expenditure per household for whole milk and lowfat milk in the Northeast region are $2.26 and $.45, respectively (Table 2).

The marginal effects of changes in significantly socioeconomic variables on the expected value of fluid milk expenditure were derived from the Tobit maximum likelihood estimates and are presented in Table 3. The results suggest that household income has a negative effect on whole milk expenditure and a positive effect on lowfat milk expenditure in the Northeast region. The household size and race variables had the greatest impact on household expenditure for fluid milk. The household size variable is the most important factor in determining whole milk expenditure; whereas, the race variable is the most importnat factor affecting lowfat milk expenditure.

The predicted values of expected expenditure by FLC indicate that whole milk expenditure approximates an inverted U distribution as might be expected. In general, whole milk expenditure increases with each stage of the FLC through the child-raising years. When the children leave home, the expenditure level declines but at a slower rate than it grew. Thus, whole milk expenditure at the later stages remained above that of earlier stages for the same number of family members. The effects of FLC stages on whole milk expenditure patterns are summarized in Table 4.

Households in the Young Single With Children and Middle Age Single With Children stages have greater expenditures for whole milk than their counterparts without children. There appeared no significant difference in fluid milk expenditure between households classified as Young Married with Children, Older Married, and Older Single in the Northeast region (Table 4).

Elasticities, evaluated at the means, for household income and size are presented in Table 5. The empirical evidence presented in this study provides evidence of the difference in fluid milk expenditure patterns between

Table 3. Marginal Effect of Selected Significant Socioeconomic Variables on Average Fluid Milk Expenditure Per Household Per Week in the Northeast Region of the U.S., 1977–78[a]

Variable	Whole milk	Lowfat milk
	------Dollar------	
Income ($1,000)	-0.03	0.01
Household size	0.90	0.05
Education of female head	-0.06	0.03
White household	-0.12	0.56
Metropolitan	-0.40	0.25
Rural	-0.27	0.17

[a] Marginal effect is computed as $\partial E(Y)/\partial X_i = F(Z) \times \gamma_i$, where X_i is the independent variable, $F(Z)$ is the calculated probability of being a purchasing household evaluated at the sample means, and γ_i is the estimated Tobit regression coefficient.

whole milk and lowfat milk in the Northeast region. The estimated elasticities correspond to previous studies. Huang and Raunikar obtain an income elasticity of .293 for lowfat milk and a household size elasticity of .981 for whole milk for the Southern region of the U.S. Salathe estimated that the income elasticity for whole milk in the U.S. varies from -.096 to -.043 and household size elasticity varies from 1.024 to 1.090. Income elasticity and household size elasticity for other fluid milk vary from .360 to .384 and from .669 to .684,

Table 4. Fluid Whole Milk Expenditure Per Household Per Week and Probability of Expenditure in the Northeast Region of the U.S. by Stage of Family Life Cycle, 1977–78[a]

Family Life Cycle	Whole milk expenditure	Probability
Young Single	$2.13	0.726
Young Married Without Children	2.36	0.761
Young Married with Children	2.03	0.701
Middle Age Married With Children	2.34	0.758
Middle Age Married Without/Children	2.42	0.770
Older Married	1.99	0.702
Older Single	1.94	0.695
Young Single With Children	2.52	0.785
Middle Age Single With Children	2.78	0.819
Middle Age Single	2.25	0.745

[a] Expenditures are estimated for each stage of life cycle based on regression results of equation (2). All other socioeconomic variables are evaluated at the means.

Table 5. Household Income and Household Size Elasticities for Fluid Whole Milk and Fluid Lowfat Milk Expenditure Per Household in the Northeast Region of the U.S., 1977–78

	Household income elasticity[a]			Household size elasticity[a]		
	Conditional	Market participation	Total	Conditional	Market participation	Total
Whole milk	−.094	−.081	−.175	.634	.552	1.186
Lowfat milk	.081	.271	.352	.077	.258	.335

[a] Elasticities are evaluated at the means.

respectively. Based on MRCA data, Boehm estimates an income elasticity of −.07 for whole milk and .16 for two-percent milk from the U.S. sample. Differences in results between studies may be expected because of differing procedures and data. Although the OLS was used for their statistical estimation, Boehm used only consuming households; whereas, Salathe included both consuming and non-consuming households.

Decomposing total elasticity into two components provides additional information on the effects of household income and household size on fluid milk expenditure. The effects of a given percentage change in household income or household size on whole milk expenditure were about equal between the two components of the total elasticities, respectively. For example, a 10 percent change in household income will alter expenditure for whole milk about 1.75 percent in the Northeast region. Of this total adjustment, approximately .94 percent is due to adjustments in expenditure of households purchasing whole milk, and the other .81 percent is due to households entry into or exit from the market. The results obtained for the Northeast region suggest that as household income or household size changes, the resulting changes in lowfat milk expenditure are caused primarily by market participation due to households entry into or exit from the market. These results are quite similar to those findings reported for the Southern region. Entry into or exit from the markets for lowfat milk in the Southern region was estimated to account for about 77.8 percent of total adjustment to income changes (Huang and Raunikar). In their study of demand for major dairy products, Thraen, Hammond and Buxton obtain an income elasticity of .12 for fluid milk in the U.S. They estimate that, for fluid milk, the entry into or exit from the market accounted for about one-fourth of the total adjustment to a change in income. For other dairy products,

such as nonfat dry milk, their estimates suggest that market participation may account for as high as 80.0 percent of the total adjustment to income change.

Conclusion

This study examined fluid milk expenditure patterns for whole milk and lowfat milk in the Northeast region. The analysis was based on the application of the Tobit maximum likelihood procedure to the 1977–78 USDA NFCS data.

The results suggest that differing expenditure patterns exist between whole milk and lowfat milk. Household income was estimated to have significant positive effects on expenditure for lowfat milk but negative on expenditure for whole milk. Whole milk expenditure appears more likely to be associated with larger households while lowfat milk expenditure appears more likely to be associated with higher income households. Whole fluid milk expenditure patterns were estimated to be strongly related to each stage of the FLC through the child-raising years. The estimated effects of FLC and household size suggest that increased whole milk expenditure is associated with the presence of children in the larger household.

While the magnitudes of percentage changes in fluid milk expenditure in response to changes in household income and household size were approximately equal in the Northeast region, decomposition of income and household size elasticities suggest that entry into or exit from the market accounted for a much greater proportion in the total adjustment of lowfat milk expenditure than of whole milk expenditure.

This study provides results which have important economic and marketing implications for the dairy industry in the Northeast region. The observed expenditure patterns suggest that market segmentation for each type of fluid

milk can provide the dairy industry the basis for planning and developing alternative market strategies. With higher income households estimated to substitute lowfat milk expenditure for whole milk expenditure on a nearly one-to-one basis, increasing affluence of American households is not expected to expand markets. Further research is needed to determine the effectiveness of devising marketing strategies based on the socioeconomic characteristics of the consuming markets.

References

Boehm, W. T. "The Household Demand for Major Dairy Products in the Southern Region." *S. J. Agr. Econ.* 7(1975):187–96.

——— and E. M. Babb. *Household Consumption of Beverage Milk Products.* Sta. Bul. No. 75, Dept. of Agr. Econ., Agr. Exp. Sta., Purdue University, March 1975.

Buse, R. C., and A. Fleischner. "Factors Influencing Food Choices and Expenditures." *Econ. Issues* No. 68. Dept. of Agr. Econ., Univ. of Wisconsin-Madison, May 1982.

Hassan, Z. A., and S. R. Johnson. *Urban Food Consumption Patterns in Canada.* Economics Branch Publication 77/1, Agriculture Canada, Ottawa, January 1977.

Huang, C. L., and R. Raunikar. "Household Fluid Milk Expenditure Patterns in the South and the United States." *S. J. Agr. Econ.*, forthcoming.

Levovit, C. B. "The Impact of Some Demographic Changes on U.S. Food Consumption: 1965–75 and 1975–90." *Natl. Food Sit.*, USDA, ERS, NFS-156, May 1976, pp. 25–29.

McDonald, J. F., and R. A. Moffitt. "The Uses of Tobit Analysis." *Rev. Econ. Stat.* 62(1980):318–21.

Murphy, P. E., and W. A. Staples. "A Modernized Family Life Cycle." *J. Consumer Res.* 6(1979):12–22.

Salathe, L. E. *Household Expenditure Patterns in the United States.* USDA, ESCS, Tech. Bul. No. 1603, April 1979.

Thraen, C. S., J. W. Hammond, and B. M. Buxton. "Estimating Components of Demand Elasticities from Cross-Sectional Data." *Amer. J. Agr. Econ.* 60 (1978):674–77.

U.S. Department of Agriculture, ERS. *Food Consumption, Price, and Expenditures, 1960–80.* Stat. Bul. No. 694, November 1982.