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Factors Affecting U.S. Demand for Reduced-Fat Milk

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U.S. fluid milk consumption has changed dramatically since the early 1970s. Whole milk accounted for over 81% of commercial fluid milk disappearance in 1970. By 1993, this percentage was less than 39%. A three-equation fluid milk demand system is estimated for fluid milks that vary by fat content. The household panel data set used includes over 4,300 households who recorded fluid milk purchased for at-home consumption over a 12-month period. Given that many of these households did not consume one or more of the three milk types, the econometric model explicitly incorporates the censored nature of these commodity demands. Own and cross-price and substitution elasticities are estimated along with effects of household demographic characteristics.

Key words: censored regression, fluid milk, demand system, translog utility function

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Introduction

With increased health concerns about dietary fat intake, changes in the structure of U.S. fluid milk demand have been dramatic. In 1970 whole milk accounted for over 81% of commercial fluid milk disappearance. By 1993 this percentage had decreased to less than 39% with reduced-fat varieties accounting for the remainder. Figure 1 shows per capita fluid milk disappearance for 1970-93. Per capita reduced-fat milk consumption has exceeded whole milk consumption since the mid-1980s. Total per capita consumption of fluid milk decreased 20.9% from 254.9 pounds per capita in 1970. In response to this decline, the milk industry has adopted strategies to attempt to increase fluid milk consumption. The fluid milk processor-funded naitional fluid milk promotion order and its fluid milk processor education program have as their primary objective changing consumer attitudes about milk as a healthy beverage. Dairy producer-funded organizations such as Dairy Management Inc. and the California Milk Processor Board have also increased their fluid milk promotion efforts (*Dairy Field*).

Research to determine the causes for changes in fluid milk consumption patterns has focused on attitudinal factors (Miles, Schwager, and Lenz; Shepherd) or used econometric methods with price, expenditures, and household demographic characteristics as explanatory variables (Heien and Wessells 1988, 1990; Cornick, Cox and Gould; Reynolds). We follow the second type of analysis by using a demand systems approach to determine household demand for three types of milk: whole, 2%, and *other* reduced-fat milks. We improve upon previous econometric analyses of U.S. household fluid milk consumption by (*a*) using a random household survey covering the entire United States, (*b*) using household expenditure data encompassing a year's worth of purchases, (*c*) incorporating prices and a budget constraint directly into the demand model, and (*d*) using an econometric model which accounts for the censored nature of demand.

Previous analyses concerning dairy product demand, such as that conducted by Heien and Wessells (1988, 1990) do not have all these characteristics. In the meat demand system developed by Wales and Woodland: (*a*) price data were not available; (*b*) the household survey used in their analysis encompassed a relatively short time period; and (*c*) a limited geographic area was encompassed by the household survey data used in their analysis. Yen and Roe apply the model used here to a complete food system based on Dominican Republic data where price and quantity data are available but are based on a short survey period.

By using purchase data encompassing an entire year of household fluid milk purchases we avoid possible problems of infrequency-of-purchase or short-term deviations from equilibrium conditions and ensure that zero expenditures represent actual corner solutions (Pudney, p. 173). With a national survey we obtain sufficient variation in prices for use in our cross-sectional econometric model. The censored regression model used here builds on that developed by Lee and Pitt by adopting a more flexible functional form for the underlying utility function, the translog indirect utility function.

Description of the Econometric Model

Consumption analyses based on time-series or aggregated-household data can reasonably incorporate the assumption that consumers respond to changes in prices, income, household composition, and other exogenous variables in a smooth continuous manner. In contrast, for disaggregated demand analyses such as being conducted here, the analyst should examine whether there exists distinct intensive and extensive consumption responses. For example, with a drop in a commodity's price, current consumers of a normal good have an incentive to increase their consumption. This situation represents an intensive response which has typically been analyzed with regression-based methodologies. For persons who are not current consumers of the commodity, a price reduction may induce them to enter the market and purchase the commodity, an extensive response. Given the discrete nature of the response to previous nonconsumers, and in contrast to the smooth adjustment process shown by current consumers, traditional regression methods may not be appropriate (Wales and Woodland, p. 263; Pudney, p. 138-39).

Within a single commodity framework, Heckman two-stage, tobit, double-hurdle, and infrequency-of-purchase models are commonly used approaches to account for the above (Blaylock and Blisard; Blisard and Blaylock; Blundell and Meghir; Deaton and Irish; Gould; Jones; Yen; Yen and Su). Accounting for censoring within a systems framework is becoming more common (Lee and Pitt; Yen and Roe). These system approaches can be separated into two distinct types: those that do and do not explicitly incorporate a budget constraint.

Without a budget constraint, equations used to explain consumption of a separable commodity group can be treated as a group of correlated censored regressions (e.g. correlated tobit equations). Pudney reviews the general framework of such models. Gould, Cornick and Cox apply such a system in their analysis of U.S. cheese purchases.

Chiang and Lee develop a two-step procedure for estimating a random utility model that encompasses the discrete choice of whether or not to consume a particular commodity and the (nonnegatively) constrained quantity consumption decision. In this two-step procedure, a *multivariate* probability distribution incorporates the effect of censoring one commodity on other commodities in the system. Heien and Wessells (1990), Gao and Spreen, and Nayga in their household based analyses of food demand use *single-dimension* Heckman-type sample selection correction factors to control for the 0/1 purchase decision. Though attractive because of the ease with which their models can be estimated, correction factors obtained from *univariate* probit equations do not capture cross-commodity censoring impacts.

A shortcoming of the above models is that they have not explicitly been derived within a utility maximization framework. Wales and Woodland develop two approaches to modeling censored commodity demand based on both traditional Kuhn-Tucker conditions and those of Amemiya. In their model, a direct utility function is maximized subject to budget and nonnegativity constraints. With the incorporation of these constraints, cross-equation restrictions must be placed on the demand (expenditure) functions and associated error covariance matrix.

Lee and Pitt use the dual to the Wales and Woodland approach where an indirect utility function is used to derive demand characteristics. Under their model, consumers are assumed to compare virtual (reservation) prices to actual market price in making purchase decisions. In this application, virtual prices represent the price level at which the consumer would be on the margin of consuming nonpurchased goods (Neary and Roberts; Pudney, p. 164-69).

Following Lee and Pitt, we assume that an individual household maximizes utility, $U(@)$, which is a continuously differentiable quasi-concave increasing function. Decision variables are consumption levels of N goods, x_i (i =1,...,N) which are chosen subject to a household's budget constraint. The indirect utility function can be represented as:

(1)

$$U^{*}(\; ; 2 , g) = \underset{X}{Max} \left[U(X ; 2 , g) \,|\, <'X \; \# \; 1 \, ; \; < \, / \; \frac{P}{M} \right] ,$$

where P is an(N x 1) vector of market prices; M is total expenditure; X an (N x 1) vector of commodities consumed; θ a vector of unknown coefficients; < an (N x 1) vector of standardized prices; and ε an (N x 1) vector of random errors where ε~ N(0,Σ). Because (1) does not contain a set of nonnegativity constraints, X can be thought of as a vector of latent decision variables. Using Roy's Identity, latent demand equations for the N commodities can be estimated (Lee and Pitt, p. 1237).

If the utility function is quasi-concave, continuous, and strictly monotonic, if the first r (r < N) goods which are not consumed (i.e., $x_1 = x_2 = \ldots x_r = 0$), virtual prices $\pi_n(<_{r+1},\ldots,<_N)$ can be obtained using Roy's Idendity:

(2)
$$\frac{MU^{*}\left(\; 1\left(\; ^{*}_{n}\right) \ldots B_{r}\left(\; ^{*}_{N}\right), <^{*}_{N} \,|\, 2 \, , \, , \right)}{M<_{n}} = 0 \qquad (n = 1, \ldots, r) \; ,$$

where $\pi_n(<^{*}_{N})$ is the virtual price of the nth good and; $<^{*}_{N}$ is the set of relative market prices of the positively consumed goods r + 1 to N (Pudney, p.166-167).

Consumers are assumed to compare virtual and market prices when determining whether to consume the nth commodity. If a commodity's virtual prices is less than market price, the consumer will not consume this commodity. That is

(3)
$$B_{n}\left(\; ^{*}_{N}\right) \# \; <_{n} \; Y \; x_{n} = 0 \qquad (n = 1 , \ldots , N) \; .$$

In order to implement the above, a functional form for the underlying indirect utility function must be chosen. Although not used within a censored demand system framework, we adopt the indirect translog utility function suggested by Jorgensen. We assume that preferences are randomly distributed over the population. As such, marginal utility consists of both deterministic and random components. The indirect utility function can be represented as:

(4) $$\ln U^* = \ln \nu^{/}(\alpha + \epsilon) + ½ \ln \nu^{/} \beta_{PP} \ln \nu + \ln \nu^{/} \beta_{DP} D \ .$$

where D a (d x 1) vector of household demographic characteristics, and α, β_{PP}, and β_{PD} are (N x 1), (N x N) and (N x d) paramater matrices, respectively and $\epsilon$is defined above. With this utility function, characteristics of the associated demand fucntions can be obtained by using the logarithmic form of Roy's Identity:

(5) $$w_n = \frac{\dfrac{\partial \ln U^*}{\partial \ln \nu_n}}{\sum_{n=1}^{N} \left(\dfrac{\partial \ln U^*}{\partial \ln \nu_n} \right)} \Rightarrow W = \frac{\alpha + \beta_{PP} \ln \nu + \beta_{PD} D + \epsilon}{i^{/}\alpha + i^{/}\beta_{PP} \ln \nu + i^{/}\beta_{PD} D + i^{/}\epsilon} \ ,$$

where w^n is the nth budget share (n = 1,...,N), i is an (N x 1) vector of ones and W an (N x 1) vector of budget shares (Jorgenson, p.1018).

The general nonhomothetic translog system of demand equations represented by (5) are homogeneous of degree zero in unknown parameters thus requiring a normalization of parameters. As Berndt, Darrough, and Diewert note, to interpret (4) as an indirect utility function we impose the constraints:

(6) $$i^{/}\alpha = -1 \quad and \quad i^{/}\epsilon = 0$$

(Jorgenson, p. 1020; Berndt, Darrough and Diewert, p. 654; Jorgenson, Lau and Stocker, p. 167). Also, following Jorgenson and Jorgenson, Lau and Stoker, conditions for exact aggregation of individual budget shares require that these shares be linear functions of demographic characteristics and total expenditures. This implies that we impose the constraints that:

(7) $$i'\beta_{pp}\, i \;=\; 0 \quad and \quad i'\beta_{PD} \;=\; 0 \;.$$

Given (6) and (7), parameters for one share equation can be estimated from the remaining N - 1. Thus one share equation is omitted from the estimation process and the share equations in (5) can be simplified:

(8) $$W \;=\; \frac{\alpha \;+\; \beta_{PP} \ln P \;-\; \beta_{MP} \ln M \;+\; \beta_{DP} D \;+\; \epsilon}{-1 \;+\; i'\beta_{PP} \ln P} \;.$$

From (8), a typical element of the matrix of uncompensated own- and cross-price effects is

(9) $$\frac{\partial x_n}{\partial \nu_m} \;=\; \frac{1}{\nu_n \nu_m}\left[\left(\frac{\beta_{nm} \;-\; w_n \sum_{n}^{N} \beta_{nm}}{-1 \;+\; i'\beta_{PP} lnP}\right) \;-\; \gamma_{nm} w_n\right] \quad (n,m \;=\; 1,\ldots,N) \;,$$

where γ_{nm} = 0 if $n \neq m$, 1 otherwise, and ν_i are relative prices defined in (1) (Jorgenson, Lau, and Stoker, p.173). Caves and Christensen (p. 427) show that the substitution elasticities (Δ_{ij}) for this demand system are

(10) $$\Delta_{mm} \;=\; \frac{-\beta_{mm} \;-\; w_m \;+\; w_m^2}{w_m^2} \quad and \quad \Delta_{mn} \;=\; -\left(\frac{\beta_{mn}}{w_m w_n}\right) \;.\; +\; 1 \qquad m \;\neq\; n$$

These substitution elasticities provide a unit free measure of the ease with which two commodities substitute for one another along a particular indifference curve.

If all goods are consumed, the system of share equations in (8) can be estimated using standard seemingly unrelated regression procedures. However, when a significant percentage of households do not consume each commodity, alternative estimation methods need to be used. We can define demand regime 1 as one where good 1 is not consumed while the remaining N - 1 goods are consumed is zero, that is, $w_1 = 0$, $w_n > 0$ ($n = 2,\ldots,N$). Using (3) the virtual price for good 1 is

$$\ln \pi_1 = -\frac{\left(\alpha_1 + \sum_{j=2}^{N} \beta_{1j} \ln p_j - \beta_{M1} \ln M + \beta_{D1} D + \epsilon_1\right)}{\beta_{11}}, \tag{11}$$

where β_{M1} and β_{D1} are coefficients. Substituting this virtual price for the nonobserved market price, the remaining N-1 nonzero expenditure shares can be obtained (Lee and Pitt, p. 1240). The consumption switching condition for regime 1 is

$$\epsilon_1 \geq -\left(\alpha_1 + \sum_{j=1}^{N} \beta_{1j} \ln p_j - \beta_{M1} \ln M + \beta_{D1} D\right). \tag{12}$$

Using this switching condition, the likelihood function (L^1) for observations represented by the first demand regime is

$$L^1 \equiv \Gamma^1 \left(X_1 \mid \theta \right) = \int_S^{\infty} J_1(x, \epsilon_1)\, \varphi\left(\epsilon_2, \ldots, \epsilon_{N-1} \mid \epsilon_1\right) \phi\left(\epsilon_1\right) d\epsilon_1 \tag{13}$$

$$\text{and } S = -\left(\alpha_1 + \sum_{j=1}^{N} \beta_{1j} \ln p_j - \beta_{M1} \ln M + \beta_{D1} D\right).$$

$J_1(x, \epsilon_1)$ is the Jacobian transformation from $(\epsilon_2,\ldots,\epsilon_{k-1})$ to $(x_2,\ldots,x_{k-1})$; φ the conditional density function; and ϕ the normal density function. This likelihood function is simply the joint distribution of the set of virtual prices and goods consumed (Pudney, p. 167). The likelihood function in (13) can be extended to the remaining demand regimes where the appropriate likelihood function for each regime is composed of appropriate partially integrated univariate and mulitivariate density functions similar to (13) (Lee and Pitt, p.1241). With R demand regimes and S total households, the combined likelihood function (L) is

$$(14) \qquad L = \prod_{s=1}^{S} \prod_{c=1}^{R} \left[\Gamma_s^c \left(X_s \mid \Theta \right) \right]^{I_s(c)} ,$$

where $I_s(c)$ =1 if the consumption pattern for household *s* is the demand regime *c*, 0 otherwise; $\Gamma_s^c(X_s \mid \Theta)$ denotes the likelihood function for the cth demand regime and sth household, and $\Theta$the vector of estimated paramaters.

Description of the Household Survey Data

We apply the above theoretical model to an analysis of U.S. fluid milk consumption. The milk purchase data usedre obtained from April 1991-March 1992, U.S. consumer panel maintained by Nielsen Marketing Research (NMR). Only fluid milk purchased for at-home consumption is included in this data set. A household in the panel records milk purchase data including: purchase date, UPC code, expenditures, and quantity purchased for each type of milk purchased on each purchase occasion. This recording process is conducted at home with UPC scanners. This data are transmitted to NMR on a regular basis. For each milk type, price paid is calculated as the ratio of expenditure on this milk by quantity purchased. Households notify NMR if no purchases have occurred during the previous week because of not purchasing during a given week or the result of being away from home due to vacation, business trip, or some other reason. For this analysis we include households that reported continuously over the 52 weeks. This does not mean that households in the panel purchased each week, but during weeks where milk was not purchased for at-home consumption, NMR was given this information. A total of 4,303 annual household observations are used in the analysis.[1]

For consuming households, mean milk purchases over the survey period is 37.5 gallons with mean expenditure $84.55. We differentiate among three types of milk: whole, 2%, and other reduced-fat (skim and 1%) milk. Table 1 provides a description of consumption patterns for households consuming these milks. More than 25% of households consume all three milk types, while more than 30% consume only one type. For households consuming all milk types, total consumption was 43.6 gallons. This is significantly larger than households consuming one or two types of milk. Mean household size for households consuming only one milk variety was 2.81 members with mean number of children 0.70 . This compares to 2.50 members and 0.57 children for households consuming all three milks.

Exogenous Variables Used in the Econometric Model

Previous household level analyses of milk demand have found that household income, ethnicity, food stamp program participation, composition of household members, region of residence, seasonality, number of adult equivalents, number of meals served, and household size affecting milk consumption (Blaylock and Smallwood; Haines, Guilkey, and Popkin; Heien and Wessells 1988, 1990; Huang and Rauniker; Popkin, Guilkey, and Haines; Rauniker and Huang; Reynolds). A limited number of demographic variables are included in the NMR data set including household size and age composition, ethnicity of male and female heads, age of male

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[1] The 52-week requirement (including no purchase notification) initially resulted in a sample size of over 8,600 households out of an initial sample of over 11,000. With the complexity of the econometric model, we selected a 50% random sample of these households to be used in the empirical application.

and female heads, state and county of residence, categorical household pre-tax income, educational attainment of male and female heads, employment status of male and female heads, marital status of male and female heads, and home ownership characteristics.[2] Given the complexity of the econometric model, not all demographic variables are included in the final analysis. Sample means of exogenous variables used are presented in table 2.

We identified the location of each household and generated eight regional dummy variables.[3] To control for household size, composition, and income, we calculate the variable *PCTPOV*. This variable is the ratio of household income to poverty threshold income as defined by the Bureau of the Census, multiplied by 100 (U.S. Department of Commerce). Poverty thresholds are used to estimate the number of individuals and families in poverty and are dependent on the number and age distribution of household members. To estimate the effect of household member age structure on milk demand, *PERLT13* is used to capture the special needs associated with children and *PERGT65* to control for the cohort effect of older individuals who grew up during a time when whole milk was the more common milk consumed. The effect of ethnicity on milk demand is accounted for by the variable *NONWHITE* which equals 1 if the

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[2] Household pretax income in the data set is reported in 16 categories ranging from less than $5,000 to more than $100,000. To convert these categorical data to continuous we assumed the midpoint of each category to be household income. For households with income above $100,000 in 1991, an income of $150,000 was assumed.

[3] The allocation of states to each region can be obtained from the authors upon request. For estimation purposes, the *PAC_REG* variable was omitted from the analysis.

meal planner was identified as being Black, Hispanic or Asian.[4] Previous analysis of nutrition knowledge and dietary fat intake have identified education an important explanatory variable (Carlson and Gould; Gould and Lin). The effect of education and the ability to understand the health implications of dietary fat are accounted for by including of the dummy variable, *COLLEGE*, which was set equal to 1 if the meal planner had completed at least 4 years of college.

Econometric Results

The regime specific likelihood functions represented by (13) are combined into an overall lieklihood function represented by (14) and applied to the NMR data to obtain milk demand parameter estimates via the use of share equations in (8). Estimation was conducted using the maximum likelihood module, MAXLIK, within the GAUSS software package. All estimated cross-commodity coefficients (β_{ij}) and coefficients of the Σ matrix (σ_{ij}) are statistically significant at the 0.001 level. Thirteen demographic variables are used to capture nonrandom differences in preferences across households, resulting in 36 demographically related parameters (including those from the omitted equation) with 21 statistically significant. Estimated coefficients and associated standard errors can be obtained from the authors upon request.

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[4] The meal planner was assumed to be the female head, if present. As noted by an anonymous reviewer, the aggregation of all "non-Whites" into one category may hide differences in these ethnic groups relative to the White population. The reasons for collapsing the ethnic categories were to reduce computation time and to overcome the problem of not having a large enough sample of Asian households.

We use a likelihood-ratio test to examine the statistical significance of specific groups of demographic characteristics affecting milk demand. The results of these tests are presented in table 3. With a χ^2 statistic of 263.2, the null hypothesis that milk demand is not dependent on demographic characteristics is rejected at the 0.001 level. Household composition, region of residence, ethnicity, income, and education also significantly impact milk demand.

Uncompensated price, expenditure and Allen-Uzawa elasticities evaluated at mean values of independent variables are presented in table 4. All cross-price elasticities are statistically significant and indicate that these milks are substitutes for each other. The estimated own-price elasticities are negative and to other analyses. Heien and Wessells (1990), using the 1977-78 Household Food Consumption Survey and an AIDS model, obtain a total milk own-price elasticity of -0.770. In single-equation double-hurdle models of fluid milk demand, Reynolds used 1986 Canadian Family Food Expenditure Survey and obtained similarly large own-price elasticities of -0.713 for total fluid milk, -0.903 for whole milk, -0.814 for lowfat milk, and -1.89 for skim milk. Boehm and Babb using weekly household diary data estimate single-equation OLS methods to examine conditional milk demand. They obtained own-price elasticity estimates of -1.66 for whole milk, -0.83 for 1% milk, -1.33 for 2% milk, and -1.82 for skim milk. The expenditure elasticities are statistically significant and relatively close to 1.[5]

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[5] The milk demand included in this analysis is at-home consumption. The above elasticities may be significantly altered if away-from-home consumption is included in the analysis. We are unaware of the availability of away-from-home fluid milk purchase data in which to address this issue.

The Allen-Uzawa substitution elasticities shown were statistically significant at the 0.001 level and support the substitute relationship shown by the above cross-price elasticities. Similar to our analysis of the price elasticities, we can compare substitution elasticities across household type. In figure 2 we provide a relative comparison of substitution elasticities for various households with total sample mean elasticities the point of comparison. For example, households located in the Northeast exhibited a whole/2% milk elasticity of substitution value more than 35% greater than that received for the entire sample. In comparison, households with limited income and nonminority households have elasticity values less than 80% of that received for the entire sample.

Summary and Areas of Future Research

The recognition of censored commodity consumption patterns within demand system models are beginning to receive more attention. This is especially important given increased availability of disaggregated commodity data sets (Capps; Cotterill). In our analysis of fluid milk demand we adopt the censored demand system approach suggested by Lee and Pitt. Given the unique nature of the yearlong panel data set used here, we avoid the empirical problem of having to distinguish between nonconsumption and infrequency-of-purchase which is encountered when analyzing consumption data obtained over short survey periods such as in USDA's Nationwide Food Consumption Survey (one week) and the diary component of the Bureau of Labor Statistic's Consumer Expenditure Survey (two weeks).

The three milk types investigated are substitutes. All own- and cross-price elasticities were statistically significant and less than one. One limitation of this analysis is the lack of inclusion of attitudinal or nutrition knowledge variables such as that used by Miles, Schwager, and Lenz and by Gould and Lin. In spite of this limitation, this study represents one of the few econometric studies of fluid milk demand which explicitly incorporates substitution possibilities across milk types and the fact that not all types are consumed by a particular household.

With a public health objective of reducing the fat intake of individuals, the results provide some hope for a continuation of the shifting of consumption away from whole and towards reduced-fat varieties given that whole milk exhibits relatively high price elasticities; all milks were found to be substitutes; and there are significant differences in the effect of demographic characteristics on milk demand. For example, with the three milks analyzed here, there appears to be a cohort effect of age and whole milk demand. Only whole milk demand is affected by the percentage of family members over 65 years of age. Thus, whole milk demand can be expected to continue to diminish.

The model developed here allows policy makers to identify how segments of the population view the substitutability of fluid milk of varying fat contents. The differences in substitution elasticities across population subgroups (figure 2) may assist policy makers in targeting health information to specific subgroups to more effectively achieve the goal of reducing dietary fat intake. The estimate differences in substitution elasticities may also be useful to such organizations as the National Fluid Milk Processor Board and Dairy Management Inc, to identify substitution possibilities among alternative milk types that may occur in reaction to their promotion activities especially as they relate to the "healthfulness" of milk as a beverage alternative.

A methodological limitation of the model used here is the need to evaluate multi-dimensional integrals of probability density functions which makes estimation very difficult for households that are nonconsumers of more than two or three commodities. An obvious extension of this model would be to allow for greater number of commodities to be identified. A recent attempt to overcome this limitation is that of Perali where single-equation tobit models are estimated on a random subsample of a large number of replicates of the underlying data and a minimum chi squared method is used to estimate conditional demand equations (Perali, p. 116). Although this methodology has initially extended the number of commodities included in the censored system, it is still extremely computer intensive. An area for further investigation is the use of numerical approximating algorithms to approximate higher order integrals as suggested by Preckel and Liu and by Arndt, Liu, and Preckel. This method may allow for more commodities to be included with less than a proportional increase in computational requirements.

Finally, a natural extension of the analysis is the inclusion of other nonmilk commodities. Unfortunately, the data set used here did not contain information for nondairy foods. With a more complete enumeration of the consumer's food budget, one could evaluate substitution possibilities between fluid milk and other foods, especially as it relates to public health policy objectives of reducing total dietary fat intake.

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Table 1. Milk Consumption Patterns by Consuming Households

Household Type	No. of Consuming Households	Amount Consumed (Gallons)	Std. Dev.
Consume all milks	1096		
Whole		9.6	18.6
Skim		16.0	23.6
Lowfat		17.9	27.4
Total		43.6	43.6
Only whole milk	420	27.3	31.2
Only skim milk	411	26.3	35.4
Only lowfat milk	480	29.4	34.2
Whole and skim milk	291		
Whole		17.1	23.8
Skim		15.1	25.0
Total		32.2	30.9
Whole and lowfat	621		
Whole		14.0	25.4
Lowfat		22.1	30.4
Total		36.0	36.6
Skim and lowfat	984		
Skim		15.9	31.5
Lowfat		16.7	24.9
Total		32.6	37.9
All households	4303		
Whole		8.7	19.7
Skim		6.9	25.5
Lowfat		16.9	26.5
Total		32.6	36.7

Source: Nielsen Marketing Research

Table 2. Means of Exogenous Variables Used in Econometric Model

Variable	Variable Name	Units	Mean	Std. Dev.	Population Mean
Household Characteristics:					
Income as percent of poverty threshold	*PCTPOV*	%	352.3	227.7	------[a]
Percent of household members < 13 yrs.	*PERLT13*	%	10.3	18.9	------[b]
Percent of household members > 65 yrs.	*PERGT65*	%	23.3	40.0	------[b]
Meal Planner Characteristics:					
Non-White	*NONWHITE*	0/1	11.7	------	------[c]
Completed College	*COLLEGE*	0/1	27.3	------	22.0
Region of Residence:					
Northeast	*NE_REG*	0/1	5.0	------	5.4
South Atlantic	*SA_REG*	0/1	17.0	------	16.2
Middle Atlantic	*MA_REG*	0/1	17.1	------	17.6
East North Central	*ENC_REG*	0/1	19.0	------	17.0
West North Central	*WSC_REG*	0/1	9.2	------	7.3
East South Central	*ESC_REG*	0/1	5.4	------	6.1
West South Central	*WSC_REG*	0/1	9.6	------	10.5
Pacific/Mountain	*PAC_REG*	0/1	17.7	------	19.9

Source: Nielsen Marketing Research; U.S. Department of Commerce

[a]Population mean values could not be calculated. Sample mean income is $36,013 compared with a population mean of $37,400.

[b]The distribution of household members across age groups could not be obtained. Sample mean household size is 2.64 compared to a population mean of 2.75. The sample percentage of households without children under 18 years of age is 65.7% compared to 64.0% for the U.S. population as a whole.

[c]Given the definition of *NONWHITE* used here, a comparison with the U.S. population is not possible. In our sample, households classified as "White" are 91.5% of the sample compared to 85.6% for the U.S. The percent of sample households that are black or Hispanic is 6.4% and 4.8%, respectively compared to population values of 11.6% and 6.7%.

Table 3. Results of Likelihood Ratio Tests For Importance of Selected Demographic Characteristics

Demographic Variables	χ^2-Statistic (d.f.)[a]
All demographic Characteristics	263.2 (24)
Household composition	21.5 (4)
Region of residence	139.6 (14)
Education	14.5 (2)
Ethnicity	31.7 (2)
Income as percent of poverty	19.9 (2)

[a]Significant at the 0.001 level

Table 4. Estimated Price, Substitution, and Expenditure Elasticities for Whole, Skim/1%, and 2% Milk

Commodity	Price Elasticity			Substitution Elasticity			Expend. Elasticity
	Whole	Skim/1%	2%	Whole	Skim/1%	2%	
Whole milk	-0.803 (0.096)	0.294 (0.050)	0.414 (0.057)	-5.949 (0.432)	1.861 (0.164)	2.091 (0.158)	1.006 (0.015)
Skim/1%	0.242 (0.044)	-0.593 (0.078)	0.253 (0.057)	-------	-3.158 (0.206)	1.565 (0.132)	0.983 (0.020)
2%	0.252 (0.039)	0.190 (0.043)	-0.512 (0.057)	-------	-------	-2.647 (0.155)	1.009 (0.013)

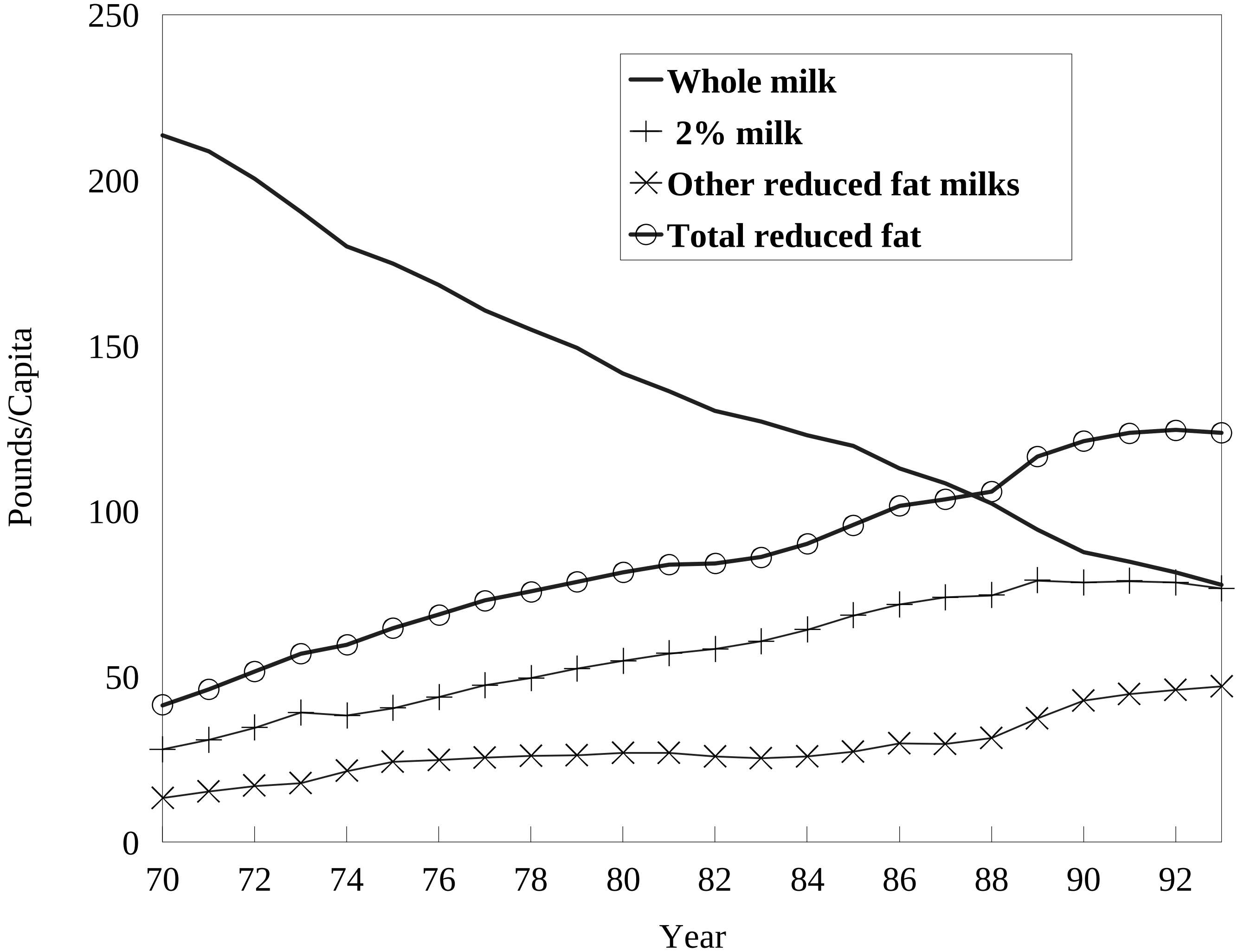
Note: Standard errors are in parenthesis.

Figure 1. U.S. per capita fluid milk disappearance
Source: Putnam and Allshouse

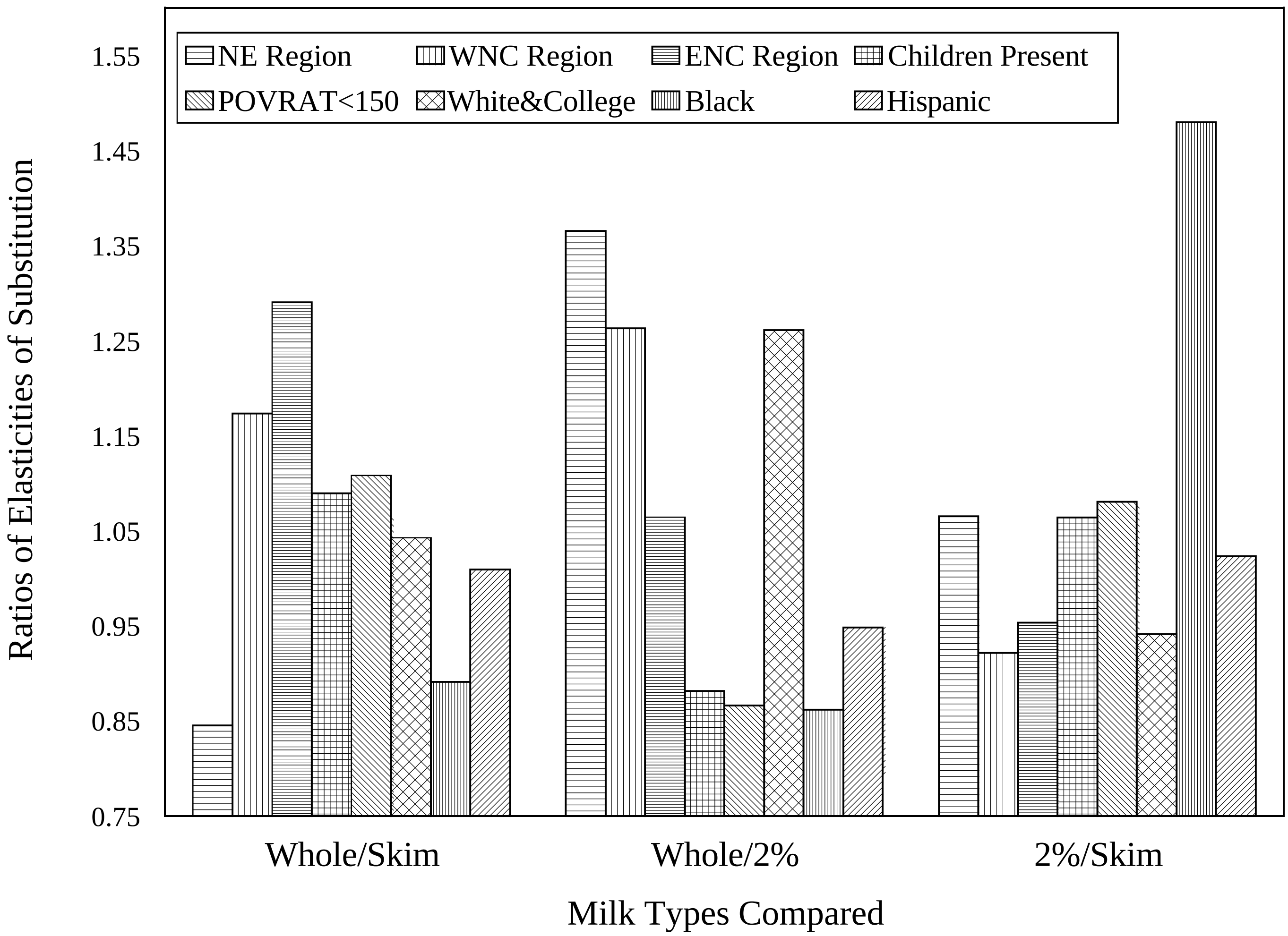
Note: This data is for pounds of nonflavored milk varieties.

Figure 2. Ratio of Allen-Uzawa elasticities of substitution for various sample sub-groups relative to entire sample elasticity value

Note: These are ratios of substitution elasticities evaluated at subgroup means compared to entire sample.



Whole milk
2% milk
Other reduced fat milks
Total reduced fat
Pounds/Capita
0
50
100
150
200
250
70
72
74
76
78
80
82
84
86
88
90
92
Year


NE Region
WNC Region
ENC Region
Children Present
POVRAT<150
White&College
Black
Hispanic
1.55
1.45
1.35
1.25
1.15
1.05
0.95
0.85
0.75
Ratios of Elasticities of Substitution
Whole/Skim
Whole/2%
2%/Skim
Milk Types Compared