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An Analysis of U.S. Household Dairy Demand

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Abstract

This report examines retail purchase data for 12 dairy products and margarine from the Nielsen 2007 Homescan data. Selected demographic and socioeconomic variables included in the Nielsen data are analyzed for their effects on aggregate demand and expenditure elasticities for the selected products. A censored demand system is used to derive the demand elasticities. The resulting estimates revealed that the magnitudes of 10 of the 13 own-price elasticities have absolute values greater than 1; substitute relationships are found among most dairy categories; expenditure elasticities are 1 or greater for 7 of the 13 products; and demographic and socioeconomic variables are statistically significant contributors to dairy demand.

Keywords: butter, cheese, censored demand, elasticities, bulk ice cream, margarine, milk, Nielsen Homescan data, yogurt

*Ashley Owens was a student intern at Economic Research Service during the time that this study was in progress.

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Summary

What Is the Issue?

The measurement of the economic effects of food prices and consumer incomes on the demand for foods derived from agricultural products is important in economic analysis. Consumers allocate spending among a wide array of competing products sold at retail outlets across the country. In this technical study, the authors estimate how fluctuation in prices and household expenditures, as well as a number of demographic characteristics, affect household demand for 12 dairy products and margarine. These empirical estimates offer a glimpse of relationships among the 13 product categories—including ways that consumers use some of the products together or interchangeably—which are of interest to many in the U.S. dairy industry.

What Did the Study Find?

Using a censored demand system and Nielsen Homescan data for purchase of items in the 13 categories, the authors estimated two types of elasticities: price and expenditure. The effects of selected demographic variables, based on characteristics such as household size and composition, educational level and ethnicity of household head, regional location, and household income, are also analyzed. The analysts found that:

- Ten of the 13 products have negative own-price elasticities with absolute values greater than 1.
- Strong substitution relationships exist among most dairy product categories.
- All of the expenditure elasticities are statistically significant and positive. Changes in the overall household dairy expenditure have the largest effect on purchases of reduced-fat milk, canned milk, bulk ice cream, refrigerated and frozen yogurts, natural cheese, and cottage cheese.
- Although the influence of most demographic variables is relatively small, some of them do have statistically significant effects on consumer purchases of dairy products:
  - Single-person households and households headed by a college-educated woman have a positive, statistically significant influence on the purchase of refrigerated and frozen yogurt and reduced-fat milk.
  - Black heads of household have a positive, statistically significant effect on the purchase of bulk ice cream, sherbet/ice milk, refrigerated and drinkable yogurts, whole and canned milk, and butter. Asian heads of household have a positive, statistically significant effect on the purchase of all fluid milks, refrigerated and drinkable yogurts, and bulk ice cream.
  - Households in the Western, Eastern, and Central regions of the United States are more likely to purchase refrigerated yogurt, natural cheese, cottage cheese, and butter than those in the Southern region. Households

in the Western region are also more likely to purchase frozen and drinkable yogurts and sherbet/ice milk.

- Of the income categories analyzed, households in the two lowest categories—$20,000-$34,999 annually and $19,999 or less—have a positive, statistically significant influence on whole and reduced-fat milk purchases. Other dairy product purchases that are statistically significant and positively influenced by households with incomes of $34,999 or less include sherbet/ice milk, processed and cottage cheese, and margarine.

How Was the Study Conducted?

The authors compiled data on retail purchases of dairy products from Nielsen Homescan data for 2007. The Nielsen Homescan data provide detailed information on dairy product purchases for at-home use by U.S. households, allowing the authors to examine consumption patterns among margarine and 12 categories of dairy products: bulk ice cream, sherbet/ice milk, refrigerated yogurt, frozen yogurt, drinkable yogurt, whole milk, reduced-fat milk, canned milk, natural cheese, processed cheese, cottage cheese, and butter. The Nielsen database includes not only economic data such as product prices, but also demographic and location information. The authors used the data to derive estimates of own- and cross-price elasticities and expenditure elasticities for the 13 product categories, employing a censored demand system.

Introduction

A wide array of milk and dairy products is offered by the U.S. dairy industry to consumers. Over the past two decades, dairy demand analyses have been conducted at the aggregated and disaggregated levels, using panel and cross-sectional data. Although several methods have been used to derive dairy demand parameter estimates, one of the most popular has been the Almost Ideal Demand System (AIDS) model and its many variations. (See, for example, Chouinard et al. (2010), Huang and Lin (2000), Maynard and Veeramani (2003), Maynard and Liu (1999), and Heien and Wessells (1990)).

In this study, a censored demand system used by Dong, Gould, and Kaiser (2004) is employed to estimate the demand for four major dairy categories: fluid milk, ice cream, yogurt, and cheese. These four broad categories are disaggregated into three fluid milks, two ice creams, three yogurts, and three cheeses, plus butter and margarine. The objective of the study is to estimate demand elasticities with respect to retail prices, expenditure, and several demographic variables.

Background

While there are numerous studies focusing on aggregated dairy products, few display an analysis of the many disaggregated products for dairy goods available in retail stores. The authors make no effort to catalog the relevant earlier studies. One of the studies most comparable to the present analysis was conducted by Chouinard et al. (2010). Using weekly Information Resources Incorporated's (IRI) Infoscan™ scanner data for the years 1997 through 1999, Chouinard estimated price and income elasticities at the city level from an Incomplete Almost Ideal Demand System that is linear in income and linear and quadratic in prices. Findings showed that the own-price elasticities for 1-percent milk (–0.88), 2-percent milk (–0.79), no-fat or skim milk (–0.62), whole milk (–0.74), natural cheese (–0.72), processed cheese (–0.77), shredded cheese (–0.25), butter (–0.41), ice cream (–0.80), and flavored yogurt (–0.77) were smaller than the elasticities estimated by our censored demand system at the household level.

Maynard and Liu (1999) estimated three separate models, a quantity-dependent double-log specification, a linearized AIDS model, and a differential demand system model, using weekly national average retail scanner data from Nielsen (formerly referred to as A.C. Nielsen) for the years 1996 through 1998. Results from the linearized AIDS model, which is the model most similar to that used in the present study, revealed that own-price elasticities for flavored milk, shredded cheese, frozen yogurt, and frozen novelties were elastic. The estimates from the differential demand system also showed these dairy products to be elastic, but provided elastic results for butter and ice cream in addition.

In the two studies above, Chouinard et al. and Maynard and Liu avoided the data-censoring problem by aggregating the data from household to city or national level. Heien and Wessells (1990) applied the AIDS model to estimate a demand system that includes 11 food items, with a focus on dairy. In their study, a two-step censored regression approach was compared with an uncensored approach, using data retrieved from USDA's 1977-78 household food consumption survey (HFCS). Own-price elasticities for milk, cheese, cottage cheese, butter, margarine, and ice cream were all inelastic under the censored demand estimation, but were elastic for ice cream, cottage cheese, and butter. The uncensored demand model expenditure elasticities were lower for all items than they were for the censored demand model, ranging from 0.61 to 0.89.

A study by Boehm and Babb (1975) used two separate models without censoring to estimate price and expenditure elasticities at the market level for dairy products, using cross-sectional and time-series data from the United Dairy Industry Association. Findings from the model showed that national average own-price elasticities for whole milk (–1.70), 2% milk (–1.33), buttermilk (–1.52), cottage cheese (–1.29), processed cheese (–1.71), and canned milk (–1.33) were all elastic, while other dairy products such as ice cream (–0.42), ice milk (–0.56), American cheese (–0.44), butter (–0.76), and yogurt (–0.31) were less than 1 in magnitude. All of the expenditure elasticity estimates for the above dairy products were also less than 1.

A Censored Demand System Model with Adding-Up Constraint

The present study uses Nielsen 2007 Homescan data, which provide detailed dairy product purchases at the retail level for at-home use by U.S. households. Household demographic variables are also collected and combined with the purchase data. An analyst needs to address the data-censoring problem when using these household data, particularly for a system of demand analysis. Normally, not every product from the system will be purchased by any given household for the data survey period (1 year). Ignoring this nonpurchase issue could lead to biased parameter estimates (Wales and Woodland, 1983). To solve this censoring problem, we define the share equations as:

$$(1) \qquad S^* = A + \gamma \ln P + \xi \ln Y + \varepsilon ,$$

where S^* is a column vector of latent expenditure shares on M products. Equation 1, the AIDS model specified by Deaton and Muellbauer (1980), is derived from the price-independent generalized logarithmic (PIGLOG) utility function for a consumer. P is a column vector of the associated M product prices, and $Y = \frac{y^*}{P^*}$ is the deflated total dairy expenditure, with y^* as total expenditure and P^* as a translog price index. The ε is a column vector of M error terms.

In order to obtain the effects of household demographic variables on dairy demand, we incorporate these variables into the AIDS model through transformation of the intercept A of equation 1. We follow Abdulai (2002) by defining the intercept of equation 1 as:

$$(2) \qquad A = \beta_0 + \beta X ,$$

where X is a column vector of N demographic variables. The translog price index P^* is defined as:

$$(3) \qquad \ln P^* = \alpha_0 + A' \ln P + \frac{1}{2} (\ln P)' \gamma (\ln P) .$$

In equations 1, 2, and 3, β_0 (M x 1), β (M x N), γ (M x M), ξ (M x 1), and α_0 (a scalar) are parameters to be estimated.

The latent expenditure shares of equation 1 are derived from the utility maximization problem under the budget constraint, and they must sum to 1 (adding-up). The adding-up and other theoretical constraints, such as symmetry and homogeneity, are attained through parameter restrictions. However, no restriction is imposed to ensure that the latent shares S^* lie between 0 and 1. To account for this non-negativity and the adding-up of the observed shares S, Wales and Woodland (1983) developed a mapping rule, later used by Dong, Gould, and Kaiser (2004), which transforms the latent shares S^* to the observed shares S as:

$$(4)\qquad S_i = \begin{cases} \dfrac{S_i^*}{\sum_{j\in\Delta} S_j^*}, & \text{if} \quad S_i^* > 0, \\ 0, & \text{if} \quad S_i^* \le 0, \end{cases} \qquad (i = 1, 2, \cdots, M),$$

where the subscript Δ is a set of all positive shares' subscripts. Equation 4 guarantees that the observed shares lie between 0 and 1 and sum to unity for each observation. Given equations 1 through 4, the likelihood function for this model can be derived for estimation.[1]

[1]For more details, refer to Dong, Gould, and Kaiser for the derivation of the likelihood function and the model estimation.

Elasticity Evaluation

Given the parameter estimates, demand elasticities of the latent system defined by equation 1 can be derived using the formula provided by Green and Alston (1990). Homogeneity and symmetry are held in these elasticities. Demand elasticities of the observed system defined by equation 4 can be obtained using a simulation procedure developed by Phaneuf, Kling, and Herriges (2000) and later applied by Dong, Gould, and Kaiser. Following Dong et al., assume R equals replicates of the M error term vectors ε in equation 1. The r^{th} simulated latent share vector, S_r^*, evaluated at the sample means of the exogenous variables (indicated by a bar over a variable), is:

$$(5)\qquad S_r^* = A + \gamma \ln \overline{P} + \xi \ln \frac{\overline{Y}}{\overline{P^*}} + \varepsilon_r ,$$

where ε_r is the r^{th} replicate of ε. The r^{th} replicate of the i^{th} observed share is:

$$(6)\qquad S_{ir} = \begin{cases} \dfrac{S_{ir}^*}{\sum_{j\in\Delta} S_{jr}^*}, & \text{if} \quad S_{ir}^* > 0, \\ 0, & \text{if} \quad S_{ir}^* \le 0. \end{cases}$$

The expected observed share vector for R replicates is calculated as a simple average of these simulated values:

$$(7)\qquad E(S) = \frac{1}{R}\sum_{r=1}^{R} S_r \ .$$

If there is a small change in price j, ΔP_j, then the elasticity vector with respect to this price change is:

$$(8)\qquad \psi_j^Q = -\Lambda_j + \frac{\Delta E(S)}{\Delta E(P_j)} \cdot \frac{E(P_j) + \Delta E(P_j)/2}{E(S) + \Delta E(S)/2},$$

where Λ_j is a vector of 0's with the j^{th} element equal to 1, and $\Delta E(S)$ is the change in the simulated $E(S)$ given the change of expected price, $\Delta E(P_j)$. Homogeneity still holds in the elasticities of the observed system because the budget constraint (adding-up) is imposed in both latent and observed systems.

Most of the empirical estimations of price and expenditure elasticities reported in published analyses vary in size due to model specification. This study differs from other cross-sectional models in its ability to satisfy both non-negativity and the adding-up conditions. The Tobit system estimator (Amemiya, 1974) used by Yen, Lin, and Smallwood (2003) addressed the non-negativity, but the adding-up restriction is compromised. Other approaches, including the maximum entropy estimator of Golan, Perloff, and Shen (2001) (also a Tobit system), the sample-selection estimator (Yen and Lin, 2006), its two-step alternative (Shonkwiler and Yen, 1999), a semiparametric extension (Sam and Zheng, 2010), and other two-step estimators (Perali and Chavas, 2000; Meyerhoefer, Ranney, and Sahn, 2005; Heien and Wessells, 1990), also do not satisfy the adding-up constraint. The present study also differs in that it uses finer distinctions in the product categories selected—bulk ice cream, sherbet/ice milk, refrigerated yogurt, frozen yogurt, drinkable yogurt, whole milk, reduced-fat milk, canned milk, natural cheese, processed cheese, cottage cheese, butter, and margarine—to reduce potential aggregation biases in estimation.

Data

A demand system of 12 dairy products and margarine that were assumed separable from other food products is specified and estimated in this study. The impact of changes in retail prices, consumer expenditure, and demographic factors on these product purchases is determined. The data underlying the analysis are from Nielsen Homescan data for 2007. A sample of the U.S. population was used in the selection process of U.S. consumers who agreed to allow their grocery receipts of purchases made during a 12-month period to be scanned. Thirteen categories were established, using the descriptions of the UPC (United Product Code) and designated codes for each item. Individual overall quantities and expenditures are reported for all 13 products. Prices (unit values) are derived from observed quantities and expenditures after accounting for any coupons or promotions that might have been in effect. There are 63,061 households in this study, each of which purchased at least 1 of the 13 products in the 2007 data. The purchase record is matched to a household record that contains information on the size and composition of the household, income, age, race, gender, education and occupation of household members, and market location data. Projection factors (sample weights) are included in the Nielsen data to be used at the household level to provide estimates for the U.S. population. Although some researchers have heavily criticized the reliability of Nielsen data, the overall accuracy of self-reported data by Homescan panelists seems to be in line with many other surveys of this type (Einav, Leibtag, and Nevo, 2008).

Nielsen data contain only retail purchases for "at-home" use. Thus, one of the limitations of using the Nielsen data is that any of the 13 products consumed "away-from-home" at establishments such as fast food or dine-in restaurants, cafeterias, and schools are not included. If the products being analyzed have significant "away-from-home" purchases, estimated economic measures such as per capita consumption or elasticities must be evaluated with that in mind.

Estimation Results

Sample Statistics

According to Nielsen 2007 Homescan data, on average, consumers purchased more reduced-fat and whole milk than they did any other fluid-ounce dairy products (table 1). Among dry-ounce products, refrigerated yogurt is the one most purchased, followed by margarine and processed and natural cheese. Dairy expenditures are largest for reduced-fat milk and bulk ice cream, which account for almost 42 percent of total dairy expenditures. Natural cheese had the highest average price among the seven dry-ounce products, while drinkable yogurt had the highest average price among the six fluid-ounce products.

In addition to prices, quantities, and expenditure, demographic-variable summary statistics are also displayed in table 1. Variables used in the analysis include household size; age of female head of household and dummy variables representing children under the age of 6 years; teenagers 13-17 years; single (unmarried) head of household; White, Black, Asian, and Other (other race) heads of household; U.S. region (East, Central, Southern, and West); and female head educational attainment (up to some college), along with seven household income categories ranging from 0 to $150,000 or more per year.[2] To avoid singularity problems, the demographic dummy variables of Southern region, White head of household, and household income of $150,000 or more per year are used as the base.

[2]Female head indicates the mother of the household. If no female head is present in the household, the head will be used as a substitute.

Summary of Estimated Demand System Price and Demographic Coefficients

Tables 2 and 3 show the coefficient estimates derived from demand systems consisting of 13 different products and 18 demographic variables. A total of 338 parameters (among them 234 are demographics, 91 are prices, and 13 are total expenditures) were estimated using the GAUSS software system and BHHH maximum likelihood procedure (Berndt et al., 1974). Of the 234 demographic parameter estimates, 154 are statistically significant at the 10-percent level or better. All of the own-price coefficients are statistically different from zero at the 10-percent level of significance except for margarine. Of the 78 cross-price coefficients estimated, 58 (74 percent) were statistically significant at the 10-percent level or better. Eleven of the 13 estimated expenditure coefficients were statistically significant at the 10-percent level or better.

Table 1
Variable definitions and sample statistics (sample size = 63,061)

Variable	Mean	SD	% of households purchasing
	Quantities (oz or floz per household over 12 months)		
Bulk ice cream (floz)	591.77	801.69	89
Ice milk & sherbet (floz)	22.36	104.90	18
Refrigerated yogurt (oz)	316.61	505.48	80
Frozen yogurt (oz)	16.77	137.61	8
Drinkable yogurt (floz)	27.13	131.80	18
Whole milk (floz)	609.37	1,746.28	49
Reduced-fat milk (floz)	2,755.11	3,525.58	27
Canned milk (floz)	33.42	117.27	43
Natural cheese (oz)	121.90	173.63	86
Processed cheese (oz)	146.31	164.70	94
Cottage cheese (oz)	85.63	183.61	57
Butter (oz)	82.54	135.25	65
Margarine (oz)	153.80	196.64	74
	Expenditures (dollars spent per household over 12 months)		
Bulk ice cream	32.73	45.04	
Ice milk & sherbet	1.09	5.52	
Refrigerated yogurt	27.96	44.94	
Frozen yogurt	1.03	9.42	
Drinkable yogurt	3.34	15.80	
Whole milk	16.91	45.93	
Reduced-fat milk	70.56	84.68	
Canned milk	2.66	8.08	
Natural cheese	29.81	40.33	
Processed cheese	26.70	29.60	
Cottage cheese	9.61	20.63	
Butter	13.67	22.07	
Margarine	10.56	13.67	
	Prices (dollars spent per oz or floz over 12 months)		
Bulk ice cream ($/floz)	$0.06	$0.04	
Ice milk & sherbet ($/floz)	0.05	0.01	
Refrigerated yogurt ($/oz)	0.09	0.03	
Frozen yogurt ($/oz)	0.09	0.03	
Drinkable yogurt ($/floz)	0.13	0.04	

—Continued

Table 1
Variable definitions and sample statistics (sample size = 63,061) (continued)

Variable	Mean	SD
	Prices (dollars spent per oz or floz over 12 months)	
Canned milk ($/floz)	0.09	0.02
Natural cheese ($/oz)	0.27	0.08
Processed cheese ($/oz)	0.20	0.07
Cottage cheese ($/oz)	0.12	0.02
Butter ($/oz)	0.18	0.06
Margarine ($/oz)	0.08	0.04
	Demographic variables	
Continuous variables:		
Household size - number of members	2.43	1.31
Average age of female head of household	52.00	11.71
Dummy variables (1 = yes, 0 = otherwise) – Percent of households:		
Children less than 6 years old	9%	
Teenagers 13 – 17 years old	13	
Single person household	24	
Eastern region	17	
Central region	27	
Southern region (base)	36	
Western region	20	
Female head of household w/some college	30	
White head of household (base)	84	
Black head of household	9	
Asian head of household	2	
Other head of household	5	
Household income ≤$19,999	11	
Household income $20,000-34,999	20	
Household income $35,000-49,999	19	
Household income $50,000-69,999	20	
Household income $70,000-99,999	18	
Household income $100,000-149,999	10	
Household income ≥$150,000 (base)	2	

Note: “floz” is fluid ounce and “oz” is dry ounce. Income is per year.
Source: Authors’ calculations, using 2007 Nielsen Homescan data.

Table 2
Censored demand system parameter estimates for demographics

Variable	Intercept	Household size	Age of female head of household	Children ages 6 and younger
Bulk ice cream	0.039*	–0.005*	0.001	–0.024*
Sherbet/ice milk	–0.026*	0.001*	0.000	–0.002
Refrigerated yogurt	0.207*	–0.003	–0.001*	0.017*
Frozen yogurt	–0.017*	0.002	0.000	–0.003*
Drinkable yogurt	0.038*	–0.003*	0.000*	0.010*
Whole milk	0.335*	0.004*	–0.001*	0.076*
Reduced-fat milk	–0.379*	0.002	–0.001*	–0.035*
Canned milk	–0.023*	0.000*	0.001*	–0.001*
Natural cheese	0.367*	–0.005*	–0.001*	0.000
Processed cheese	0.311*	0.005*	–0.001*	–0.023*
Cottage cheese	–0.045*	0.003	0.001*	–0.004
Butter	0.106*	–0.003	0.001*	–0.006
Margarine	0.086*	0.003	0.001*	–0.006

Variable	Teenagers ages 13-17	Single person household	Female head of household w/ some college	Black head of household
Bulk ice cream	0.008	0.014*	–0.003	0.053*
Sherbet/ice milk	0.000	0.001	0.000	0.008*
Refrigerated yogurt	–0.006	0.024*	0.035*	0.012*
Frozen yogurt	–0.002*	0.005*	0.001*	0.000
Drinkable yogurt	–0.006*	0.005*	0.001	0.007*
Whole milk	–0.009	–0.025*	–0.035*	0.055*
Reduced-fat milk	0.032*	0.035*	0.020*	–0.093*
Canned milk	–0.001*	–0.006*	–0.001	0.020*
Natural cheese	–0.006	0.002	0.011*	–0.024*
Processed cheese	0.002	–0.017*	–0.015*	–0.025*
Cottage cheese	–0.008*	–0.003*	–0.001	–0.042*
Butter	–0.002*	–0.009*	–0.001	0.012*
Margarine	–0.001	0.025*	–0.013*	0.016

—Continued

Table 2
Censored demand system parameter estimates for demographics (continued)

Variable	Asian head of household	Other-race head of household	Eastern region	Central region
Bulk ice cream	–0.002	0.000	–0.002*	0.001
Sherbet/ice milk	0.001	0.002	0.010*	–0.004
Refrigerated yogurt	0.043*	0.013*	0.037*	0.020*
Frozen yogurt	0.002	–0.002	0.002*	–0.003*
Drinkable yogurt	0.011*	0.005*	0.001	0.000*
Whole milk	0.042*	0.039*	–0.025*	–0.075*
Reduced-fat milk	0.026*	–0.025*	–0.049*	0.008*
Canned milk	0.011*	0.005*	–0.009*	–0.002*
Natural cheese	–0.056*	0.006	0.016*	0.012*
Processed cheese	–0.035*	–0.014*	–0.022*	–0.004*
Cottage cheese	–0.031*	–0.009*	0.008*	–0.033*
Butter	–0.008	–0.009*	0.047*	0.024*
Margarine	–0.030	–0.007	–0.006	0.001

Variable	Western region	Household income ≤$19,999	Household income $20,000–$34,999	Household income $35,000–$49,999
Bulk ice cream	0.003*	0.003	0.003	0.003*
Sherbet/ice milk	0.004*	0.001	–0.004	0.004
Refrigerated yogurt	0.037*	–0.073*	–0.060	–0.054*
Frozen yogurt	0.002	–0.008*	–0.006*	–0.005*
Drinkable yogurt	0.002	–0.006*	–0.011*	–0.009*
Whole milk	–0.054*	0.081*	0.053*	0.041*
Reduced-fat milk	–0.055*	0.002	0.013*	0.007
Canned milk	–0.004*	0.003	0.000	0.001
Natural cheese	0.056*	–0.024*	–0.011*	–0.005
Processed cheese	–0.040*	0.017*	0.019*	0.023*
Cottage cheese	0.031*	0.007	0.006	0.003
Butter	0.043*	–0.046*	–0.033*	–0.025*
Margarine	–0.015	0.047*	0.036*	0.028*

—Continued

Table 2
Censored demand system parameter estimates for demographics (continued)

Variable	Household income $50,000–$69,999	Household income $70,000–$99,999	Household income $100,000–$149,999
Bulk ice cream	–0.015*	–0.017*	–0.018*
Sherbet/ice milk	0.002	0.001	0.001
Refrigerated yogurt	–0.044*	–0.032*	–0.025*
Frozen yogurt	–0.005*	–0.002	–0.003*
Drinkable yogurt	–0.009*	–0.005*	–0.005*
Whole milk	0.023*	0.007	0.003
Reduced-fat milk	0.015*	0.016*	0.014*
Canned milk	0.002	0.000	0.000
Natural cheese	0.002	0.007*	0.011*
Processed cheese	0.020*	0.019*	0.014*
Cottage cheese	0.004*	0.000*	0.003
Butter	–0.016*	–0.007	–0.001
Margarine	0.020	0.012	0.005

Notes: Level of statistical significance: * = 10% or better. Income is per year.
Source: Authors' calculations using 2007 Nielsen Homescan data.

Table 3
Censored demand system parameter estimates for price and total expenditures

Variable	Bulk ice cream	Sherbet/ice milk	Refrig. yogurt	Frozen yogurt	Drinkable yogurt
			Total expenditure		
	0.006*	–0.002*	0.003*	0.000	–0.002*
			Price coefficients		
Bulk ice cream	–0.025*				
Sherbet/ice milk	–0.003*	–0.007*			
Refrigerated yogurt	0.005*	–0.004*	–0.041*		
Frozen yogurt	0.002*	–0.001*	–0.010*	–0.013*	
Drinkable yogurt	0.002*	0.002*	0.001	–0.006*	–0.038*
Whole milk	0.008	0.004*	0.004	0.008*	0.001
Reduced-fat milk	–0.024*	0.001	0.031*	0.009*	0.016*
Canned milk	–0.001*	0.005*	0.002*	0.001	0.003*
Natural cheese	0.015*	0.002*	–0.001	0.003*	0.003*
Processed cheese	–0.015*	–0.001	0.011*	0.003*	0.006*
Cottage cheese	0.002*	0.004*	–0.012*	0.000	0.003*
Butter	0.017*	–0.001	–0.003	–0.001	0.001
Margarine	–0.017*	–0.001	0.017*	0.006*	0.007*

—Continued

Table 3

Censored demand system parameter estimates for price and total expenditures (continued)

Variable	Whole milk	Reduced-fat milk	Canned milk	Natural cheese	Processed cheese
			Total expenditure		
	–0.051*	0.065*	0.003*	0.010*	–0.024*
			Price coefficients		
Bulk ice cream					
Sherbet/ice milk					
Refrigerated yogurt					
Frozen yogurt					
Drinkable yogurt					
Whole milk	–0.179*				
Reduced-fat milk	0.118*	–0.261*			
Canned milk	0.011*	0.008*	–0.014*		
Natural cheese	0.035*	0.054*	0.001	–0.147*	
Processed cheese	–0.014*	0.016*	–0.007*	0.024*	–0.006*
Cottage cheese	0.028*	0.012*	0.005*	0.002	0.010*
Butter	0.015*	0.025*	–0.006*	0.003*	0.000
Margarine	–0.021*	–0.004	–0.007*	0.006	–0.026*

Variable	Cottage Cheese	Butter	Margarine
		Total expenditure	
	0.010*	–0.001	–0.033*
		Price coefficients	
Bulk ice cream			
Sherbet/ice milk			
Refrigerated yogurt			
Frozen yogurt			
Drinkable yogurt			
Whole milk			
Reduced-fat milk			
Canned milk			
Natural cheese			
Processed cheese			
Cottage cheese	–0.062*		
Butter	0.005*	–0.070*	
Margarine	0.004*	0.019*	0.0170

Notes: Level of statistical significance: * = 10% or better.
Source: Authors' calculations using 2007 Nielsen Homescan data.

Compensated Demand Elasticities

Two sets of demand elasticities can be derived from the censored AIDS model estimates: compensated (Hicksian) and uncompensated (Marshallian). According to economic theory, changes in both price and income can influence demand. A compensated demand curve allows income to change to "compensate" for the price change, while an uncompensated demand curve does not.

The compensated price elasticities for the 13 products are presented in table 4. Each cell shows the price elasticity for a change in the price of the product identified at the top of the column. All own-price elasticities are negative and statistically significant at the 10-percent level. The cross-price relationships estimated in large demand systems provide information about how the purchase price of one product affects the demand for another product. Of the 156 compensated cross-price elasticity estimates shown in table 4, 145 (93 percent) are statistically significant at the 10-percent level.

Table 4
Estimated compensated price elasticities

Variable	Bulk ice cream	Sherbet/ ice milk	Refrig. yogurt	Frozen yogurt	Drinkable yogurt
Bulk ice cream	**–0.77***	0.00*	0.12*	0.01*	0.01*
Sherbet/ice milk	0.05*	**–1.21***	–0.02	–0.04*	0.06*
Refrigerated yogurt	0.16*	–0.01*	**–1.08***	–0.05*	0.01
Frozen yogurt	0.17*	–0.02	–0.08*	**–1.26***	–0.10*
Drinkable yogurt	0.18*	0.04*	0.13*	–0.11*	**–1.72***
Whole milk	0.09*	0.01*	0.14*	0.03*	0.01*
Reduced-fat milk	0.09*	0.01*	0.17*	0.02*	0.04*
Canned milk	0.11*	0.12*	0.15*	0.03*	0.07*
Natural cheese	0.21*	0.02*	0.09*	0.02*	0.01*
Processed cheese	0.05*	0.00	0.17*	0.01*	0.03*
Cottage cheese	0.17*	0.05*	–0.04*	0.00	0.04*
Butter	0.34*	–0.01	0.07*	–0.01*	0.01
Margarine	0.09*	0.00	0.15*	0.01*	0.01*

Variable	Whole milk	Reduced-fat milk	Canned milk	Natural cheese	Processed cheese
Bulk ice cream	0.01	0.23*	0.01*	0.18*	0.05*
Sherbet/ice milk	0.17*	0.33*	0.16*	0.20*	0.10*
Refrigerated yogurt	0.06*	0.46*	0.02*	0.12*	0.16*
Frozen yogurt	0.22*	0.45*	0.03*	0.18*	0.16*
Drinkable yogurt	0.11*	0.56*	0.06*	0.17*	0.23*

—Continued

Table 4
Estimated compensated price elasticities (continued)

Variable	Whole milk	Reduced-fat milk	Canned milk	Natural cheese	Processed cheese
Whole milk	**–1.65***	0.73*	0.04*	0.28*	0.10*
Reduced-fat milk	0.26*	**–1.26***	0.04*	0.26*	0.12*
Canned milk	0.27*	0.55*	**–1.31***	0.12*	–0.06*
Natural cheese	0.20*	0.60*	0.02*	**–1.61***	0.23*
Processed cheese	0.02*	0.36*	–0.04*	0.26*	**–0.89***
Cottage cheese	0.31*	0.49*	0.07*	0.14*	0.20*
Butter	0.23*	0.61*	–0.06*	0.16*	0.12*
Margarine	–0.01*	0.31*	–0.01*	0.15*	0.06*

Variable	Cottage Cheese	Butter	Margarine
Bulk ice cream	0.04*	0.13*	–0.01*
Sherbet/ice milk	0.17*	0.02	0.01
Refrigerated yogurt	–0.02*	0.05*	0.14*
Frozen yogurt	0.03*	0.04*	0.19*
Drinkable yogurt	0.09*	0.07*	0.19*
Whole milk	0.12*	0.11*	–0.02*
Reduced-fat milk	0.08*	0.13*	0.04*
Canned milk	0.14*	–0.09*	–0.11*
Natural cheese	0.05*	0.07*	0.09*
Processed cheese	0.07*	0.04*	–0.08*
Cottage cheese	**–1.64***	0.10*	0.10*
Butter	0.07*	**–1.81***	0.28*
Margarine	0.04*	0.11*	**–0.90***

Notes: Level of statistical significance: * = 10% or better. Own-price elasticities are in boldface.
Source: Authors' calculations, using 2007 Nielsen Homescan data.

Uncompensated Demand Elasticities

Table 5 presents the uncompensated price elasticity estimates for the 13 product categories purchased by consumers from retail stores. All own-price elasticities are negative, statistically significant at the 10-percent level, and are relatively similar in size to the compensated own-price elasticities presented above. Among the 156 cross-price elasticity estimates, 133 (85 percent) are statistically significant at the 10-percent level or better. Expenditure elasticities are also presented in table 5. All of the expenditure elasticities are statistically significant and positive.

Seven of the 13 product categories have expenditure elasticities that are 1 or greater.

Table 5
Estimated uncompensated price and total expenditure elasticities

Variable	Bulk ice cream	Sherbet/ice milk	Refrig. yogurt	Frozen yogurt	Drinkable yogurt
Bulk ice cream	**–0.91***	–0.01*	0.01*	0.00*	–0.00
Sherbet/ice milk	–0.08*	**–1.21***	–0.12*	–0.05*	0.05*
Refrigerated yogurt	0.02*	–0.02*	**–1.19***	–0.05*	–0.00
Frozen yogurt	0.03*	–0.03*	–0.19*	**–1.26***	–0.11*
Drinkable yogurt	0.05*	0.04*	0.03	–0.11*	**–1.73***
Whole milk	–0.02*	0.01*	0.06*	0.03*	0.00
Reduced-fat milk	–0.07*	0.00*	–0.05*	0.02*	0.02*
Canned milk	–0.04*	0.11*	0.03*	0.03*	0.06*
Natural cheese	0.07*	0.01*	–0.02*	0.01*	0.00
Processed cheese	–0.07*	–0.01*	0.08*	0.00	0.02*
Cottage cheese	0.02*	0.05*	–0.15*	0.00	0.03*
Butter	0.20*	–0.01*	–0.04*	–0.02*	0.00
Margarine	–0.04*	0.00*	0.05*	0.01*	0.00

Variable	Whole milk	Reduced-fat milk	Canned milk	Natural cheese	Processed cheese
Bulk ice cream	–0.06*	–0.05*	0.00*	0.06*	–0.07*
Sherbet/ice milk	0.10*	0.08*	0.15*	0.09*	–0.01
Refrigerated yogurt	–0.01	0.18*	0.01*	0.00	0.04*
Frozen yogurt	0.16*	0.17*	0.02*	0.06*	0.04*
Drinkable yogurt	0.04*	0.30*	0.05*	0.06*	0.11*
Whole milk	**–1.70***	0.52*	0.03*	0.19*	0.01
Reduced-fat milk	0.19*	**–1.57***	0.03*	0.12*	–0.02*
Canned milk	0.20*	0.26*	**–1.32***	0.00	–0.19*

—Continued

Table 5

Estimated uncompensated price and total expenditure elasticities (continued)

Variable	Whole milk	Reduced-fat milk	Canned milk	Natural cheese	Processed cheese
Natural cheese	0.32*	0.00	0.02	**–1.73***	0.10*
Processed cheese	–0.04*	0.13*	–0.05*	0.16*	**–0.99***
Cottage cheese	0.23*	0.19*	0.05*	0.01	0.07*
Butter	0.17*	0.34*	–0.07*	0.05*	0.01
Margarine	–0.08*	0.05*	–0.02*	0.03*	–0.05*

Variable	Cottage Cheese	Butter	Margarine	Total expenditure
Bulk ice cream	0.01*	0.07*	–0.06*	1.01*
Sherbet/ice milk	0.13*	–0.04*	–0.04*	0.93*
Refrigerated yogurt	–0.06*	–0.01	0.09*	1.00*
Frozen yogurt	–0.01	–0.02*	0.14*	1.00*
Drinkable yogurt	0.06*	0.02	0.14*	0.96*
Whole milk	0.10*	0.07*	–0.06*	0.77*
Reduced-fat milk	0.04*	0.06*	–0.02*	1.14*
Canned milk	0.11*	–0.15*	–0.17*	1.06*
Natural cheese	0.01*	0.01*	0.03*	1.04*
Processed cheese	0.04*	–0.01	–0.12*	0.85*
Cottage cheese	**–1.68***	0.04*	0.05*	1.10*
Butter	0.04*	**–1.87***	0.23*	0.97*
Margarine	0.00	0.06*	**–0.95***	0.94*

Note: Level of statistical significance: * = 10% or better. Own-price elasticities are in boldface.
Source: Authors' calculations, using 2007 Nielsen Homescan data.

Estimated Elasticities of Demographic Variables

Table 6 displays the impact of demographic variables on the demand for "at-home" dairy products and margarine. Eighteen exogenous demographic variables are analyzed in the censored demand model, including household size, children under 6 years, teens age 13-17, average age of female heads of household, single person household, households living in the Eastern, Central, and Western regions of the United States, female heads of household who have some college training, Asian, Black, and Other race household heads, and six household income categories. Findings from the censored demand system show that the size of households is statistically significant and positively influences the purchase of sherbet/ice milk, drinkable yogurts, whole milk, reduced-fat milk, processed cheese, and margarine. Although there are more women in the workforce today than 20 years ago, women still do the majority of the shopping and cooking for the household (Babble, 2010; Casual Kitchen, 2010). Purchases of dairy items, including bulk ice cream, sherbet/ice milk, frozen yogurt, canned milk, cottage cheese, and butter, are all statistically significant and positively influenced by the age of the female head of household.

Single-person heads of household, along with college-educated female heads of household, positively influenced the purchase of healthy dairy products such as refrigerated and frozen yogurt and reduced-fat milk. Black heads of household have a positive, statistically significant effect on purchases of bulk ice cream, sherbet/ice milk, refrigerated and drinkable yogurts, whole and canned milk, and butter. Asian heads of household also have a positive, statistically significant effect on purchases of bulk ice cream, refrigerated and drinkable yogurts, and all fluid milks. Households residing in the Eastern, Central, and Western regions of the United States have a greater impact on refrigerated yogurt, natural and cottage cheese, and butter than other dairy products and margarine. Of the income categories analyzed, households in the two lowest categories—$20,000-$34,999 annually and $19,999 or less—have a positive, statistically significant influence on purchases of whole and reduced-fat milk. Other dairy products that are statistically significant and positively influenced by households who make $34,999 or less include purchases of sherbet/ice milk, processed and cottage cheese, and margarine. Although the influence of most demographic variables is relatively small, some of them do have statistically significant effects on consumer purchases of dairy products.

Table 6
Estimated demographic elasticities

Variable	Intercept	Household size	Age of female head of household	Children ages 6 and younger	Teenagers ages 13-17	Single-person household	Female head of household w/ some college
Bulk ice cream	–0.295*	–0.037*	0.248*	–0.006	0.002*	0.012*	–0.007*
Sherbet/ice milk	–1.256*	0.115*	0.069*	–0.002	0.000	0.003	0.000
Refrigerated yogurt	0.503*	–0.024*	–0.229*	0.007*	–0.004*	0.027*	0.060*
Frozen yogurt	–0.822*	0.005	0.027*	–0.005*	–0.006*	0.021*	0.010*
Drinkable yogurt	0.193*	0.148*	–0.405*	0.015*	–0.013*	0.023*	0.008
Whole milk	0.976*	0.045*	–0.145*	0.027*	–0.005*	–0.032*	–0.062*
Reduced-fat milk	–1.339*	0.013*	–0.053*	–0.005	0.008*	0.020*	0.016*
Canned milk	–0.981*	0.019	0.594*	–0.001	–0.004*	–0.044*	–0.013*
Natural cheese	1.394*	–0.059*	–0.264*	0.001	–0.004*	0.000	0.018*
Processed cheese	1.289*	0.069*	–0.131*	–0.009*	0.000	–0.027*	–0.035*
Cottage cheese	–0.941*	–0.079*	0.436*	–0.003	–0.011*	–0.011*	–0.006
Butter	0.814*	–0.087	0.646*	–0.005*	–0.003*	–0.030*	–0.006*
Margarine	–0.158*	0.069*	–0.131*	–0.009	0.000*	–0.027*	–0.035*

Variable	Black head of household	Asian head of household	Other race head of household	Eastern region	Central region	Western region	Household income ≤ $19,999
Bulk ice cream	0.022*	0.003*	0.000	0.001	–0.018*	–0.004*	0.001
Sherbet/ice milk	0.027*	–0.002	0.000	–0.010*	–0.005	0.015*	0.014*
Refrigerated yogurt	0.007*	0.005*	0.003*	0.028*	0.023*	0.033*	–0.037*
Frozen yogurt	0.002	0.001	–0.002*	0.008*	–0.012*	0.007*	–0.018*
Drinkable yogurt	0.013*	0.005*	0.004*	0.002	0.003	0.010*	–0.012*
Whole milk	0.025*	0.004*	0.008*	–0.018*	–0.091*	–0.046*	0.043*
Reduced-fat milk	–0.019*	0.002*	–0.002*	–0.019*	0.002	–0.025*	0.002*
Canned milk	0.049*	0.006*	0.005*	–0.036*	–0.011*	–0.017	0.009
Natural cheese	–0.009*	–0.007*	0.002*	0.013*	0.014*	0.055*	–0.012*
Processed cheese	–0.011*	–0.005*	–0.003*	–0.019*	–0.007*	–0.041*	0.012*
Cottage cheese	–0.041*	–0.008*	–0.004*	0.016*	0.098*	0.069*	0.010*
Butter	0.015*	–0.003*	–0.004	0.093*	0.080*	0.101*	–0.062*
Margarine	–0.001*	–0.005*	–0.003	–0.019*	–0.007*	–0.041*	0.012*

—Continued

Table 6
Estimated demographic elasticities (continued)

Variable	Household income $20,000–$34,999	Household income $35,000–$49,999	Household income $50,000–$69,999	Household income $70,000–$99,999	Household income $100,000–$149,999
Bulk ice cream	–0.006*	–0.007*	–0.011*	–0.012*	–0.007*
Sherbet/ice milk	0.021*	0.022*	0.012	0.007	0.004
Refrigerated yogurt	–0.054*	–0.047*	–0.038*	–0.026*	–0.011*
Frozen yogurt	–0.023*	–0.016*	–0.017*	–0.008*	–0.006*
Drinkable yogurt	–0.042*	–0.031*	–0.031*	–0.018*	–0.008*
Whole milk	0.050*	0.037*	0.021*	0.006	0.001
Reduced-fat milk	0.008*	0.004*	0.007*	0.007*	0.003*
Canned milk	0.003	0.005	0.010	0.000	0.000
Natural cheese	–0.010*	–0.003	0.002	0.006*	0.005*
Processed cheese	0.021*	–0.025*	0.021*	0.018*	0.007*
Cottage cheese	0.014*	0.007*	0.007*	0.000*	0.003*
Butter	–0.079*	–0.057*	–0.036*	–0.015	–0.001
Margarine	0.022*	0.025*	0.021*	0.018*	0.007

Note: Level of statistical significance: * = 10% or better. Income is per year.
Source: Authors' calculations, using 2007 Nielsen Homescan data.

Conclusions

This research estimated demand elasticities that can be used for policy analysis by researchers in academic institutions and policy-oriented agencies. An empirical analysis of Nielsen 2007 Homescan retail purchase data was used to estimate a censored demand system of margarine and 12 dairy products. Results indicate that dairy purchases are influenced by price, overall dairy expenditure, and demographic factors. Ten of the 12 uncompensated own-price elasticities for dairy products are statistically significant and elastic with respect to changes in retail prices. Similar findings are noted for compensated own-price elasticities.

Other findings reveal that consumers' purchases of bulk ice cream, refrigerated and frozen yogurts, reduced-fat milk, canned milk, natural cheese, and cottage cheese are sensitive to changes in overall dairy expenditures. Strong substitution relationships are found among bulk ice cream, reduced-fat milk, and natural cheese and other products in the demand system. The three fluid milks—whole milk, reduced-fat milk, and canned milk— are found to be strong substitutes for each other. Similar substitution relaionships exist among the three cheese products, natural cheese, cottage cheese, and processed cheese.

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