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Will Changing Demographics Affect U.S. Cheese Demand?

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U.S. cheese consumption has grown considerably over the last three decades. Using a censored demand model and Nielsen Homescan retail data, this study identifies price and non-price factors affecting the demand for differentiated cheese products. Own-price and expenditure elasticities for all of the cheese products are statistically significant and elastic. Results also reveal that a strong substitution relationship exists among all cheese products. Although demographic influences are generally smaller than those related to prices and expenditures, empirical findings show that household size, college educated female heads of household who are age 40 and older, residing in the South, Central, and Western regions of the United States, as well as Black heads of household, have positive statistically significant effects on consumers' cheese purchases.

Key Words: cheese form, cheese purchase, demand elasticities, demographic and economic factors, Nielsen Homescan data

JEL Classifications: C25, D12, Q11

Today's cheese producers and consumers face a much different market dynamic than existed in even the recent past. The proliferation of differentiated cheeses (and other food products as well) has created segmented markets where knowledge of how consumer demands are influenced by demographic and economic factors becomes important. Among the many factors that influence cheese consumption are (1) increased availability of cheese varieties, (2) expanded cheese use by fast food and pizza restaurants, (3) increased use of cheese as an ingredient by both food manufacturers and home cooks, (4) increased consumption of "cheese-rich" ethnic foods such as Italian and Mexican dishes (Manchester and Blayney, 1997), and (5) changes in consumer demographics.

In grocery stores and other retail outlets, cheese products are sold in many forms, including natural cheese in consumer-sized cuts, bagged shredded cheese, and processed cheese slices. The existence of these product forms and their relative price differences suggest that consumer preferences are not homogeneous across product forms and that they should be considered in analyses of cheese demand. Consumer preferences among cheese product forms are influenced by demographics, including race, ethnicity, and age.

Emphasis on the nutritional benefits of milk and dairy products has also likely contributed to changes in cheese consumption. Cheese retains its calcium content and is recommended

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for good health and nutrition (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2005). The 3-Every-Day program is an effort designed to encourage people to consume three servings of low-fat cheese, yogurt, or fluid milk in efforts to improve calcium and other nutritional intakes.

Cheese production and sales are key economic components of the U.S. dairy industry. Milk production has risen steadily over time in the United States, reaching approximately 188.9 billion pounds in 2008. Milk used for processed fluid beverage milk products has been essentially flat over time at about 55 billion pounds (U.S. Department of Agriculture–Economic Research Service), so the increasing milk production is being used for manufactured products (cheese and butter) and cultured products such as yogurts. Cheese production (not including cottage cheese) absorbed about 82 billion pounds (65%) of approximately 127 billion pounds of milk entering the manufactured products production channel in 2008, and is clearly a key factor in determining the outlook for the U.S. dairy industry.

Economic theory informs us that demand for normal goods will increase as income or household income increases. However, according to Engel's law, the proportion of income spent on food should fall as income rises even if food expenditures increase. Demand elasticities provide insights on how the responses of consumers to changes in demographics, prices, and incomes affect product demands. Empirical estimates of these demand parameters help characterize analyses of the cheese markets. For example, economic data show that per capita personal income has increased annually over the past 8 years (U.S. Department of Commerce–Bureau of Economic Analysis, National Economic Accounts, 2010). Although income elasticities are different from expenditure elasticities commonly estimated in demand studies, many estimates of expenditures suggest cheese is a normal good, so if consumers' food expenditure rises, it is expected that total cheese purchases will also rise. Regarding population demographics, non-Whites are forecast to increase more rapidly than Whites (U.S. Department of Commerce–U.S. Census Bureau, 2008), which will have a positive impact on natural cheese purchases.

A number of studies have considered the importance of product form as a demand-determining factor (e.g., Bergtold, Akobundu, and Peterson, 2004; Heien and Wessells, 1988, 1990; Huang, 1993; Maynard, 2000; Maynard and Liu, 1999; Park et al., 1996). In addition to cheese forms, there have been a number of other studies that have analyzed cheese products from many different perspectives (e.g., Dong and Kaiser, 2005; Gould, 1992; Gould, Cornick, and Cox, 1994; Gould and Lin, 1994; Schmit et al., 2002, 2003; Yen and Jones, 1997). The study most comparable to the present study is Maynard (2000), who examines seven different cheese forms using Nielsen 1996–1998 Homescan data. The present study is unique because of (1) analyzing cross-sectional data collected over 12 months for the year 2006, (2) using a censored demand system, (3) assessing impacts of 14 demographic variables on the demand for different cheese forms, and (4) estimating both conditional and unconditional price elasticities. The purpose of this study will be to examine U.S. cheese demand, where five cheese categories are identified: natural, cottage, processed, shredded, grated and other, and to determine the roles of demographic factors such as age, race, and ethnicity on cheese demand.

Previous Related Studies

Using Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS) model and data from the 1987–1988 Household Food Consumption Survey, Heien and Wessells (1988) obtain own-price elasticity estimates of –0.52 and –1.10 for cheese and cottage cheese, respectively. In a later study, Heien and Wessells (1990) derived an own-price elasticity of –0.37 for cheese and –0.03 for cottage cheese using microdata and a censored regression approach.

Bergtold, Akobundu, and Peterson (2004) estimated unconditional own-price and expenditure elasticities for processed foods using the flexible and separable translog multi-stage demand system. Within dairy products, elasticities for cheese (not shredded), shredded cheese, imitation cheese, and cheese spreads yield estimates

of –0.70, –0.95, –1.84 to –1.90, and –1.88 to –1.90, respectively. These own-price elasticities are substantially higher than those obtained in studies where more aggregated groupings were included, as in the studies by Heien and Wessells (1988, 1990), Huang (1993), and Park et al. (1996); while in general, the Bergtold, Akobundu, and Peterson (2004) study also yielded lower expenditure elasticities. The authors attribute elasticity estimates greater in absolute value to the use of scanner data and a more disaggregated set of food products.

Maynard (2000) uses a double-log model to estimate seven demand equations for chunk, sliced, grated, shredded, snack, cubed, and other cheese products, using weekly scanner data. Results yielded own-price elasticity estimates for these respective cheese products of –1.70, –1.22, –0.15, –0.98, –0.45, –3.95, and –2.70, which were equal to or greater than the range of estimates determined by Bergtold, Akobundu, and Peterson (2004).

Maynard and Liu (1999) investigated expectations of increasingly elastic dairy product demand and, given the range of models available to derive elasticity estimates, evaluated the sensitivity of estimates to the type of demand model used. Their study used Nielsen retail scanner data and incorporated three models to estimate own-price elasticities: the double-log, static linear (LA) AIDS, and National Bureau of Research (NBR) differentiated models. Elasticity ranges across the models were widest for the various cheese types, with the NBR model resulting in the most elastic estimates. The elasticity for sliced cheese ranged from –2.08 to –1.64 for the NBER and double-log models, respectively, resulting in the smallest disparity between models. The range of elasticities was greatest for chunk/loaf and shredded cheese, with the static LA/AIDs and double-log models generating the most inelastic estimates for each respective product range. The elasticity for snack cheese was the smallest of all cheeses when estimated with the double-log model (–0.58), and across all models was the largest with the static LD/AIDS model (–1.68).

The General Accounting Office conducted an analysis of the impacts of dairy compacts on the U.S. dairy industry, deriving a baseline, or no compact, scenario. Medium-term, 5 year, wholesale demand elasticities for dairy cheeses were estimated at –0.16, –0.25, and –0.45 for American, Italian, and other cheeses, respectively (U.S. General Accounting Office, 2001).

Schmit et al. (2003) estimated the demand of different cheese types while evaluating the impact of advertising on U.S. household cheese purchases. Their study used data from the Nielsen Homescan Panel of U.S. households, and found higher price sensitivity for natural than processed cheese, with purchase probability elasticities of –0.53 and –0.36 for natural and processed cheese, respectively, and a total cheese elasticity of –0.35.

Huang, Jones, and Hahn (2007) used the AIDS model to estimate elasticities of store and national brands of shredded, sliced, and chunk cheeses in small and large sizes. Their study also compared cheese purchases in stores located in lower and higher income areas. Both lower and higher-income area stores demonstrated more elastic demand for national brands than for store brand cheeses. Additionally, national brands were not only shown to have higher elasticities than store brands, but also exhibited a wider range of estimates. Shoppers of the lower-income stores were more price sensitive for all products except store brands of small and large sliced cheese (–1.93 and –1.77), national brands of sliced cheese in the large size (–3.05), and national brands of chunk cheese in small package sizes (–1.23). The most inelastic estimates across all income stores and brand types were for snack cheese.

Additional studies have also evaluated the effects of factors such as shifting demographics on dairy product demand (Gould and Lin, 1994; Park et al., 1996; Schmit et al., 2002; Schmit and Kaiser, 2004, 2006). Schmit and Kaiser (2004), for example, determined that a growing Hispanic population and increases in per capita spending on food away from home were the primary contributors to increasing per capita cheese demand, yielding respective elasticities of 0.27 and 0.43 using a time-varying parameter model. Using the censored autocorrelated regression approach, Schmit et al. (2003) determined household age composition to be a primary factor in the demand for cheese, as the proportion of children under 17 and a younger

head of household, or meal planner, were factors in increased cheese purchases. Unconditional elasticities of 0.35 and 0.40 for natural and processed cheese, respectively, were also estimated using household size as a demographic variable. Using a two-step panel data approach, Schmit et al. (2002) determined a household-size elasticity of 0.68 for processed cheese. The age of the female head of household also resulted in an elasticity estimate of –0.45 for processed cheese. Among other factors, such as changing eating patterns and evolving promotion and advertising, there has also been the expectation that changing demographics will result in increasing price elasticities for cheese products (Maynard and Liu, 1999). In the study by Park et al. (1996), the price elasticities for cheese from non-poverty-status households and poverty-status households was estimated at –0.24 and –0.01, respectively.

Demand System Specification and Econometric Procedure

Our sample contains zero purchases of the cheese products, a situation that presents a problem for analysis of a system of demands and should be properly addressed to avoid biased model estimates. In general, not every product in a specified demand system is purchased by any given household. Data aggregation, for example, from the original transaction base to an annual base, is not always helpful, especially for a large demand system, along with the fact that valuable information on variations is compromised in such aggregation. Therefore, a censored demand model that addresses zero purchases is adopted in this study.

There is a large menu of censored estimators for demand systems, and they all have shortcomings. The Kuhn-Tucker procedure of Wales and Woodland (1983) and the virtual-price approach of Lee and Pitt (1986) are statistically incoherent (Ransom, 1987) and produce inconsistent estimates when the concavity restriction of the utility function is violated. The concavity restriction required for statistical coherency (van Soest and Kooreman, 1990) is difficult to impose for flexible functional forms.

The Tobit system estimator (Amemiya, 1974), used in Yen, Lin, and Smallwood (2003), does not suffer from the issue of statistical incoherency, but the adding-up restriction is compromised. The lack of adding-up also occurs with 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), and a semiparametric extension (Sam and Zheng, 2010); and other two-step estimators (Heien and Wessells, 1990; Meyerhoefer, Ranney, and Sahn, 2005; Perali and Chavas, 2000). Wales and Woodland (1983) suggested a mapping mechanism to achieve adding-up in the Tobit system of Amemiya (1974), which was later implemented by Dong, Gould, and Kaiser (2004).

In this study, we follow Dong, Gould, and Kaiser (2004) in implementing the Tobit system estimator along with the mapping rule suggested by Wales and Woodland (1983). Given the complicated mapping rule from the latent share to the observed share, symmetry cannot be guaranteed for the observed share, though it is imposed on the latent share. Another potential limitation is that not all purchases may be reported, and the resulting measurement error could bias the parameter estimates. Our empirical analysis is based on the assumption that cheese products are weakly separable from all other consumer goods. Following Dong, Gould, and Kaiser (2004), the latent share system of the AIDS model (Deaton and Muellbauer, 1980) is expressed as

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

where S^{*} is an M-vector of latent expenditure shares on cheese products, P is an M-vector of prices, and $Y = y^{*}/P^{*}$ is the total cheese expenditures (y^{*}) deflated by a translog price index (P^{*}), and ε is an M-vector of error terms. Demographic characteristics, an N-vector D, are incorporated by transforming the intercept A in Equation (1) such that $A = \beta D$. The parameters are β ($M \times N$), θ ($M \times 1$), and γ ($M \times M$). Given the budget constraint, the adding-up restriction requires that the latent shares sum to 1. This adding-up condition can be attained through parameter restrictions $\iota'\beta = [1,0,\cdots, 0]$, $\iota'\theta = 0$, $\iota'\gamma = [0,0,\cdots, 0]$, where ι is an M-vector of

ones. Other theoretical constraints such as homogeneity and symmetry can also be imposed on Equation (1). For example, we impose symmetry on γ, and homogeneity is then automatically satisfied under adding-up and symmetry (Deaton and Muellbauer, 1980).

The adding-up restriction implies that the joint density function of ε is singular, so estimation must be based on $M-1$ latent share equations. We drop an equation from the system and an element from the error vector ε, and assume the resulting error vector is distributed as an $(M-1)$ dimensioned normal with zero means and a finite and positive definite covariance matrix.

The mapping of the latent shares vector (S^*) to the observed share vector (S) must take into account that the elements of S lie within the unit simplex and sum to unity for each observation. One such mapping is introduced by Wales and Woodland (1983):

$$(2)\qquad \begin{aligned} S_i &= S_i^* / \sum_{j\in J} S_j^* \quad \text{if} \quad S_i^* > 0 \\ &= 0 \qquad\qquad\quad \text{if} \quad S_i^* \le 0, \quad i=1,\ldots,M, \end{aligned}$$

where $J \equiv \{j : y_j^* > 0\} \cap \{1,\ldots,M\}$, which is the set of subscripts for all positive shares. The mapping of S^* to S in Equation (2) has the property that the resulting density function is invariant with respect to the element of S^* excluded. Assuming that at least one cheese product is purchased, the likelihood contribution can be written according to the observed purchase pattern (sample regime) for each household. Consistent and efficient model estimates can be obtained by maximizing the sum of log likelihood contributions over the sample, with multiple probability integrals evaluated with a probability simulator (Hajivassiliou, 1993). Details can be found in Dong, Gould, and Kaiser (2004).

Elasticities are evaluated based on the expected expenditure share values. Expected values of observed expenditure shares can be obtained by summing the product of each regime's probability and the expected conditional share values over all possible regimes. Define observed share vector

$$(3)\qquad R_k = (S_1 = \ldots = S_k = 0; \quad S_{k+1} > 0, \ldots, S_M > 0),$$

for a sample regime in which the first k goods are censored and the rest are positive. Regime R_k is actually the sum of all the purchase patterns with k zero-valued shares. The expected value of the jth observed expenditure share is

$$(4)\qquad E(S_j) = \sum_{i=k+1}^{M} \eta_{R_k} E(S_j^*/R_k),$$

where η_{R_k} is the probability that regime R_k occurs. The expected share value conditional on purchase regime R_k is

$$(5)\qquad \begin{aligned} E(S_j/R_k) &= E[(S_j^*/R_k)/\sum_{i=k+1}^{M} E(S_j^*/R_k)] \quad \text{if } j > k \\ &= 0 \qquad\qquad\qquad\qquad\qquad\qquad\quad \text{if } j \le k \end{aligned}$$

From Equation (4) the impacts of changes in prices, demographic characteristics and total expenditures on cheese demand can be obtained, which requires evaluation of $M-1$ dimensioned integrals. With $2^M - 1$ purchase regimes, these integrals would need to be evaluated a large number of times. Following Dong, Gould, and Kaiser (2004), we simulate the elasticities using the procedure developed by Phaneuf, Kling, and Herriges (2000) for a censored demand system applied to recreation choices. Assume we have R replicates of the error vectors ε in Equation (1). The rth simulated latent share vector, S_r^*, evaluated at the sample means of exogenous variables ($\bar{D}$, $\bar{P}$, $\bar{y}^*$ and $\bar{P}^*$), is

$$(6)\qquad S_r^* = \beta\bar{D} + \gamma \ln \bar{P} + \theta \log(\bar{y}^*/\bar{P}^*) + \varepsilon_r,$$

where ε_r is the rth replicate of ε. The rth replicate of the ith observed share is then

$$(7)\qquad \begin{aligned} S_{ir} &= S_{ir}^* / \sum_{j\in J} S_{jr}^* \quad \text{if} \quad S_{ir}^* > 0 \\ &= 0 \qquad\qquad\quad \text{if} \quad S_{ir}^* \le 0. \end{aligned}$$

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

$$(8)\qquad E(S) = \frac{1}{R}\sum_{r=1}^{R} S_r.$$

With a small change in price j, ΔP_j, the elasticity vector with respect to this price change is

$$(9)\qquad \psi_j^Q = -\Lambda_j + \frac{\Delta E(S)}{\Delta P_j}\frac{P_j + \Delta P_j/2}{E(S) + \Delta E(S)/2},$$

where Λ_j is a vector of 0's with the jth element equal to 1, and $\Delta E(S)$ is the change in the

simulated $E(S)$, given the change of price, ΔP_j. Elasticities with respect to total expenditure and demographic variables can be simulated as

$$(10) \qquad \eta_j^Q = \frac{\Delta E(S)}{\Delta X} \cdot \frac{1}{E(S) + \Delta E(S)/2},$$

where ΔX represents the change of total expenditure or demographic variables. Further, compensated elasticities can be derived by regular means, using Slutsky's equation.

Data

The 2006 Nielsen Homescan data contain demographic and food purchase information for a nationwide panel of representative households. Each household in the panel is given a handheld device to scan at home all food items purchased at any retail outlet. Some households record only Universal Product Code (UPC) coded foods, while others record both UPC-coded and random-weight items. The UPC barcode is a familiar entry on consumer goods and is one of the principal technological developments, along with store computers, that made modern scanner data possible. In this study, we used a subset of 7,223 households that recorded both UPC-coded and random-weight products. Each purchase record contains data on product characteristics, quantity purchased, price paid with and without promotions (such as coupons), date of purchase, store, and brand information. Each panel household provides information on the size and composition of the household, household income, and origin, age, race, gender, and education and occupation of household members. Market location data are also available for each household. Projection factors (sample weights) are provided by Nielsen to be used to generate national estimates.

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

Table 1 shows the sample statistics for the six cheese categories. Over 81% of the households used in the 2006 Nielsen Homescan data purchased some type of natural or processed cheese. A large portion of consumers' household expenditure for cheese is spent on natural and processed cheeses. The quantity and price–or both–for natural and processed cheeses are higher relative to the quantities and prices of the other cheese categories.

Table 2 shows the definitions and sample means of demographic variables used in the censored demand analysis. A total of 18 variables are used in the analysis, including household size (continuous) and dummy variables representing children present in household, female[1] age categories (18–39, 40–64, and ≥65), regions (Central, East, South, and West), female educational attainment (less than high school diploma, high school diploma, some college, and college), and race and ethnicity (White, Black, Asian, Hispanics, and other race). Reference categories that are dropped in the estimation procedure to avoid singularity for this analysis are female head of household ages 18–39, Eastern region, less than high school diploma, and other race.

The average household size for the 2006 Nielsen data are 2.34 persons. For age, 64% of the female heads of household were between 40 and 64-years-old. More households in the Southern region participated in the Nielsen Homescan survey than any other region in the United States. Forty-one percent of the female

[1] Nielsen data are divided into female and male for several demographic categories including head of household, age, occupation, education, etc. The person participating in the Nielsen survey is asked the question, "who is the head of household." Head of household is self defined by the person participating in the survey. The head of household can be a single person or two persons, regardless of whether the person or persons are single or married. While the Nielsen data provide information on both males and females, single or married persons as head of households, we decided to focus on female heads of households because they are still the persons who do the majority of the shopping for the household, regardless of their occupational status or income.

Table 1. Sample Statistics of Quantities, Expenditures, and Prices (Sample Size = 7,223 households)

Variable	Mean	SD	% Households Consuming
Quantities (lbs per household over 12 months)			
Natural cheese	7.15	10.17	81
Cottage cheese	4.84	11.36	50
Processed cheese	8.68	10.56	91
Grated cheese	4.46	7.24	71
Shredded cheese	0.56	1.23	41
Other cheeses	1.69	3.94	47
Expenditures (dollars spent per household over 12 months)			
Natural cheese	25.99	35.10	
Cottage cheese	8.13	19.57	
Processed cheese	24.60	30.17	
Grated cheese	15.46	23.42	
Shredded cheese	3.11	6.50	
Other cheeses	7.11	15.89	
Prices (dollars spent per lb over 12 months)			
Natural cheese	4.16	1.33	
Cottage cheese	1.79	0.47	
Processed cheese	3.29	1.30	
Grated cheese	4.03	1.21	
Shredded cheese	6.08	1.37	
Other cheeses	5.93	2.54	

heads of household were college educated and 76% of all heads of households were White.

Results

Summary of Estimated Demand System Price and Demographic Coefficients

Table 3 shows the estimated price and demographic coefficients of the censored demand system using the GAUSS software system and BHHH maximum likelihood procedure (Berndt et al., 1974). All own- and cross-price coefficients are found to be statistically different from zero at the 1% level of significance, as are all but one (processed cheese) of the expenditure coefficients. For example, the natural cheese coefficient estimate is the largest of all own-price parameters. Natural cheese and processed cheese cross-price coefficient estimate is larger than the other cross-price coefficient estimates. A total of 84 demographic parameters are estimated, 42 (or half) of which are statistically significant. Household size, for example, influences the purchase of processed cheese.

In this study most of the coefficient estimates are highly statistically significant. These coefficients are used in Equations 9 and 10 to derive the price, expenditure, and demographic elasticity estimates reported in Tables 4, 5, and 6. Discussions of these elasticity estimates are presented in the next three sections followed by the conclusions.

Conditional Compensated Price Demand Elasticities

How changes in prices or consumers' expenditure on cheese alter the type and form of cheese demanded is one of the primary questions the authors set out to answer in the analysis. Table 4 presents the compensated price elasticities for the six cheese forms, all of which are statistically significant at the 1% level of significance, except for one that is significant at the 5% level. All own-price elasticities are negative. The

Table 2. Definitions and Sample Statistics of Explanatory Variables

Variable	Definition
Continuous explanatory variable	
Household size	The number of members present in the household
Binary explanatory variables (yes = 1; no = 0)	
Children present	There is a child present in the household
Age of female household head	
18–39 years[a]	Female household head is between 18 and 39-years-old
40–64 years	Female household head is between 40 and 64-years-old
65 years or older	Female household head is at least 65 years-old
Region	
Central	Household resides in the Central region of the United States
South	Household resides in the Southern region of the United States
West	Household resides in the Western region of the United States
East[a]	Household resides in the Eastern region of the United States
Educational level	
<High school[a]	Female head has less than a high school education
High school	Female head has a high school education
Some college	Female head has some college education
College	Female head has a college degree
Race	
White	Race of the household is White
Black	Race of the household is African-American
Hispanic	Race of the household is Hispanic-American
Asian	Race of the household is Asian-American
Other[a]	Race of the household is other American

Variable	Mean	Standard Deviation
Continuous variable		
Household size is the number of members in household	2.34	(2.64)
Dummy variables (% of households)		
Children present in home	22	
Female head of household ages 18–39[a]	13	
Female head of household ages 40–64	64	
Female head of household ages 65 or older	23	
Central region	17	
Southern region	38	
Western region	23	
Eastern region[a]	22	
Female head of household w/ less than HS education[a]	4	
Female head of household w/ HS diploma	24	
Female head of household w/ some college	31	
Female head of household w/ college degree	41	
White head of household	76	
Black head of household	13	
Asian head of household	3	
Hispanic head of household	7	
Other race head of household[a]	1	

[a] Reference category.

Table 3. Parameter Estimates from the Censored AIDS Model for Cheese Demand

Variable	Natural Cheese	Cottage Cheese	Processed Cheese	Grated Cheese	Shredded Cheese	Other Cheese
Total expenditure	0.022***	0.026***	–0.036***	0.005	–0.010***	–0.007***
Price coefficients						
Natural cheese	–0.382***					
Cottage cheese	0.086***	–0.311***				
Processed cheese	0.120***	0.093***	–0.375***			
Grated cheese	0.100***	0.070***	0.076***	–0.296***		
Shredded cheese	0.040***	0.039***	0.028***	–0.029***	–0.149***	
Other cheese	0.036***	0.025***	0.058***	0.022***	0.014***	–0.155***

Variable	Intercept	Household Size	Children Present in Home	Female Head of Household Ages 40–64	Female Head of Household Ages 64 +	Central Region	Southern Region	Western Region
Natural cheese	0.256***	–0.009*	0.019	0.018	0.017	–0.047***	0.005	0.009
Cottage cheese	–0.209***	–0.009***	0.000	–0.008	0.027***	–0.026***	–0.063***	–0.022***
Processed cheese	0.305***	0.024***	–0.009***	–0.037***	–0.038***	0.019	0.018***	–0.035***
Grated cheese	0.286***	0.001***	0.009	–0.050***	–0.108***	0.039***	0.038***	–0.006
Shredded cheese	0.245***	0.001	–0.009	–0.002	0.004	–0.021***	–0.032***	–0.018***
Other cheese	0.118***	–0.008***	–0.012***	0.006***	0.023***	0.036***	0.035***	0.072***

Variable	Female Head of Household w/ HS Diploma	Female Head of Household w/ Some College	Female Head of Household w/ College Degree	White Head of Household	Black Head of Household	Asian Head of Household	Hispanic Head of Household
Natural cheese	0.022	0.026	0.043***	0.024	0.055***	0.023	0.031
Cottage cheese	0.010	0.002	–0.003	0.003	–0.002	–0.012	–0.016
Processed cheese	–0.046***	–0.053***	–0.083***	0.018	0.002	–0.007	0.017
Grated cheese	0.011	–0.002	–0.020	–0.021	0.030*	–0.010	–0.003
Shredded cheese	–0.030	0.029***	–0.022***	–0.009	–0.024***	–0.010	–0.017
Other cheese	0.032***	0.056***	0.084***	–0.015***	–0.060***	0.016	–0.013

***, * Indicate statistical significance at the 1% and 10% level, respectively.

Table 4. Conditional Compensated Price Elasticities for Cheese Demand

Variable	Natural Cheese	Cottage Cheese	Processed Cheese	Grated Cheese	Shredded Cheese	Other Cheese
Natural cheese	–1.54***	0.25***	0.67***	0.44***	0.08***	0.10***
Cottage cheese	0.77***	–2.49***	0.83***	0.55***	0.18***	0.16***
Processed cheese	0.56***	0.20***	–1.32***	0.36***	0.05**	0.15***
Grated cheese	0.76***	0.34***	0.72***	–2.07***	0.11***	0.15***
Shredded cheese	1.04***	0.73***	0.95***	0.73***	–3.74***	0.29***
Other cheese	0.38***	0.08***	0.64***	0.33***	0.05***	–1.48***

***, ** indicate statistical significance at the 1% and 5% level, respectively.

estimated own-price elasticities, particularly for cottage cheese (–2.49), grated cheese (–2.07), and shredded cheese (–3.74), reveal that sizeable changes in quantity demanded of these cheese forms could potentially result from a 1% change in their prices. All compensated cross-price elasticities are positive, implying net substitution relationships among the six cheese forms. Net substitution among natural cheese and shredded cheese is of particular interest in that a 1% increase in the price of natural cheese will cause almost a proportionate increase in the demand for shredded cheese. From a practical perspective, these findings indicate that in the absence of an initial desired cheese form or in the case where there is a price increase beyond what consumers are willing to pay for the initial desired cheese form, another available cheese form will be purchased.

Conditional Uncompensated Price Demand Elasticities and Expenditure Elasticities

Table 5 shows the estimated uncompensated price elasticities and expenditure elasticities for the six cheese forms. All uncompensated own-price elasticities are statistically significant at the 1% level and elastic: −1.55 for other cheese, −1.63 for processed cheese, −1.84 for natural cheese, −2.25 for grated cheese, −2.59 for cottage cheese, and −3.77 for shredded cheese. Other studies that also found one or more own-price elasticities for cheese forms to be elastic include Heien and Wessells (1988), Maynard and Liu (1999), Maynard (2000), and Bergtold, Akobundu, and Peterson (2004). According to the estimated elasticities, consumers are more responsive to changes in the price of shredded cheese than they are to other cheese forms. The form least responsive to a price change is other cheese, which still yields a change in quantity demanded proportionally greater (155%) than the change in its price.

The cross-price relationships among the six cheese forms, for the most part, suggest they are gross substitutes. All but two of the cross-price elasticities are statistically significant. Estimated expenditure elasticities are all positive and statistically significant at the 1% level. Of the six cheese forms, natural, cottage, and grated cheeses show the greatest levels of responsiveness to changes in cheese expenditures,

Table 5. Conditional Uncompensated Price and Expenditure Elasticities for Cheese Demand

Variable	Natural Cheese	Cottage Cheese	Processed Cheese	Grated Cheese	Shredded Cheese	Other Cheese	Expenditure Elasticity
Natural cheese	–1.84***	0.16***	0.31***	0.25***	0.04***	0.04***	1.05***
Cottage cheese	0.45***	–2.59***	0.45***	0.35***	0.13***	0.08***	1.13***
Processed cheese	0.29***	0.12***	–1.63***	0.19***	0.01**	0.08***	0.94***
Grated cheese	0.46***	0.25***	0.38***	–2.25***	0.07***	0.08***	1.02***
Shredded cheese	0.80***	0.66***	0.68***	0.58***	–3.77***	0.23***	0.82***
Other cheese	0.10***	0.00	0.31***	0.15***	0.01	–1.55***	0.98***

***, ** indicate statistical significance at the 1% and 5% levels, respectively.

Table 6. Conditional Cheese Demand Elasticities with Respect to Demographic Variables

Variable	Household Size	Children Present in Home	Female Head of Household Ages 40–64	Female Head of Household Ages 65 +	Central Region	Southern Region	Western Region
Natural cheese	0.057***	0.036	0.025	0.012***	–0.018	0.000	0.009
Cottage cheese	0.111***	0.006	–0.025	0.034***	–0.022***	–0.128***	–0.021***
Processed cheese	–0.097***	–0.022	0.043***	0.020***	0.005	0.005	–0.014***
Grated cheese	–0.005	–0.035	–0.140***	–0.105***	0.026***	0.054***	–0.006
Shredded cheese	–0.031	–0.170	–0.032	0.018	–0.066***	–0.230***	–0.072***
Other cheese	–0.083***	–0.043	0.016	0.024***	0.017***	0.035***	0.057***

Variable	Female Head of Household w/ High School Diploma	Female Head of Household w/ Some College	Female Head of Household w/ College Degree	White Head of Household	Black Head of Household	Asian Head of Household	Hispanic Head of Household
Natural cheese	0.013	0.023	0.052***	0.034	0.013*	0.002	0.004
Cottage cheese	0.011	0.006	0.002	0.003	–0.006	–0.004	–0.005
Processed cheese	–0.021***	–0.032***	–0.060***	0.021	–0.003	0.001	–0.001
Grated cheese	0.011	–0.002	–0.032	–0.072	0.015	–0.001	–0.003
Shredded cheese	–0.129***	–0.165***	–0.155*	–0.129	–0.065***	–0.013	–0.014
Other cheese	0.028	0.064***	0.128***	–0.041	–0.031***	–0.002	0.004

***, * indicate statistical significance at the 1% and 10% levels, respectively.

with expenditure elasticities greater than unity, followed by other cheese (0.98), processed cheese (0.94), and shredded cheese (0.82). These expenditure elasticities reveal that there is a direct relationship between expenditures on cheese forms and the demand for cheese forms.

Impact of Conditional Demographic Elasticities Estimates

Table 6 shows elasticity estimates of demographic variables for at-home cheese demand. Fourteen demographic variables are analyzed in the censored demand model, namely, household size; children present in home; female head of households ages 40–64 and ages ≥65, respectively; individuals living in the Central, Southern, and Western regions of the United States, respectively; female head of households who earned a high school diploma, some college experience, and who received a 4-year college degree, respectively; and female head of households who were White, Black, Asian and Hispanic, respectively.

Our findings reveal that of the six cheese categories, demographics had statistically significant impacts on natural, cottage, processed, and grated cheeses. Specific demographic factors that have positive impacts on cheese demand include household size and age of female heads of households. Central and Southern region locations, college graduates, and Blacks have positive effects on cheese demand relative to their reference variables. Shredded cheese has the largest statistically significant demographic elasticities, but they are negative, which means that a percentage increase in the proposed demographics elasticities will lead to a decrease in at-home cheese demand. However, one of the objectives of this study is to identify whether demographic factors have an impact on at-home cheese demand.

Findings from Schmit et al. (2002) indicate that household size and age of female head elasticities for at-home processed cheese were 0.680 and –0.449 for processed cheese. A similar study conducted by Schmit et al. (2000) shows that the household size elasticities were 0.088 for shredded cheese and 0.136 for processed cheese. In contrast to the Schmit et al. (2000) study, our findings reveal that household size has a negative, statistically insignificant impact on at-home grated and shredded cheese demands, but that female heads of household ages 40–64, and 65 or older have positive impacts (0.043 and 0.020) on processed cheese demand (contrary to that shown earlier by Schmit et al. (2002)). Another study by Schmit et al. (2003) found that household size elasticities for natural and processed cheeses were 0.349 and 0.399, respectively. In the present study, household size elasticities for natural and processed cheeses had different impacts on at-home cheese demand. Household size in this study had a positive impact on at-home natural cheese demand, but was smaller in comparison with the Schmit et al. (2003) findings, and a negative impact on processed cheese demand. Based on the results from previous studies, it appears for the most part that household size is affecting the demand for cheese less than it did in past years.

Female heads of households age 65 and older had a positive impact on demand for four of the six cheeses. While regionally, residence in the Southern and Central parts of the U.S. positively affected the purchase of grated cheese. Other cheese purchases are influenced by the Central, Southern, and Western regional locations. Educated females who are heads of households also played a role in cheese purchases. Female heads of households who held college degrees and those who had some college experience have positively influenced the purchase of other cheeses. The purchase of natural cheese is also found to be influenced by female heads of households who held college degrees.

While there are some statistically significant demographic outcomes in the censored demand model for at-home cheese demand that we have estimated, the influence of these variables is small. The estimates derived show that the demographic values are important, but have less of an impact on consumer demand for the six cheese categories than do cheese prices and consumers' cheese expenditure.

Conclusions

The objectives of this analysis are to estimate U.S. cheese demand parameters and quantify

some of the important economic and demographic factors influencing the purchase of different cheese forms. Using Nielsen 2006 Homescan retail data, we find demographic factors are important and have mostly positive effects on consumers' cheese purchases. In particular, household size is a factor that has a positive elasticity, which means that as household size increases, the purchase of cottage and natural cheeses will also increase. However, compared with previous studies, household size has less of an impact on cheese purchases. Other demographic variables that also positively impact certain cheese purchases include female heads of household age 40 and older, residing in the South, Central, and Western regions of the United States, female heads of household with different educational attainments, and Black heads of household.

Although the elasticity estimates derived for some of the demographic factors do influence demands for certain cheese forms, their overall impacts are small relative to those estimated for cheese prices and consumer expenditures on cheese. Demographic factors are, perhaps not as important as some previous studies have found because the data used in this study are at-home cheese purchases from retail stores. Other cheese demand studies that have looked at commercial disappearance have found much larger demographic impacts. When including ingredient and restaurant cheese demand, demographics may play a more important role in determining cheese demand, e.g., evidence of greater away-from-home consumption by a particular group may have a positive impact on cheese demand.

The own-price elasticities for all cheese forms are statistically significant and conditionally elastic, with those of shredded cheese and cottage cheese being the largest absolutely, indicating that the demands for these two cheeses are more price responsive than that for the other cheeses (Tables 4 and 5). One possible reason for the small demographic elasticities is that at-home consumption price elasticities are more elastic than total cheese consumption, which includes restaurant and ingredient uses for cheese. Substitutability among the six cheese forms is an interesting and useful finding for milk producers, cheese manufacturers, and retail stores. One of the possible implications that can be drawn from the positive cross-price elasticities estimates derived in this study is that consumers will likely switch to other cheese forms if the price of their initial choice of cheese increases beyond a certain threshold (Tables 4 and 5). In addition, this study shows that the estimated expenditure elasticities for all six cheese forms are significant and positive; and that natural, cottage, and grated cheeses are highly sensitive to changes in cheese expenditures.

The results of this study, and others like it, are useful to the dairy industry as a whole and to the cheese industry in particular. Cheese consumption has had and will continue to have implications for the industry given the large (and growing) share of milk production used in the manufacture of cheese products. Cheese manufacturers and marketers can make use of the information as input into decisions related to potential production changes or to development of marketing strategies.

In most cases, demographic influences are smaller than those related to prices and expenditures (a proxy for income), but many of them do exhibit at least statistical significance that varies across cheese categories. Based on the results of this analysis, if national or even store brand cheese marketers wish to promote some particular product type, the importance of the characteristics of female heads of households and their differences across the product types could be used to develop marketing strategies. Location factors were also found to be important across the defined product types, but, perhaps surprisingly, racial/ethnic factors were not. One explanation for this result might be a confounding of the regional and ethnic characteristics. In other words, the regional variables may be capturing the role of the shares of populations based on race and ethnicity. Further analysis is necessary to examine this possibility.

Demand parameter estimates can also have important implications for policy and program analysis. Dairy policy is primarily focused on the supply side of the dairy market—most policy and programs in place are designed to influence the milk price received by producers. However, policies and programs also exist to assist consumers as they make decisions regarding

foods and food purchases, including milk and dairy product purchases. Policy makers can use the empirical information, such as elasticities from demand studies, to help make informed decisions on the implications of proposed policy and program changes.

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