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DETERMINANTS OF THE DEMAND FOR FOOD FATS AND OILS: THE ROLE OF DEMOGRAPHIC VARIABLES AND GOVERNMENT DONATIONS

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ABSTRACT

A demand systems model of the fats and oils market is estimated using quarterly time series data for the period 1962-1987. Demographic scaling is used to incorporate demographic variables and per capita government butter donations into the model. From estimated conditional price elasticities, dietary fat intake elasticities are calculated for each of the demographic characteristics included in the study.

Determinants of the Demand for Food Fats and Oils: The Role of Demographic Variables and Government Donations

One of the major recommendations of the 1988 report of the U.S. Surgeon General was that Americans should change their diet so as to reduce the consumption of fat, especially saturated fat, and cholesterol (U.S. Department of Health and Human Services). As noted in this report and elsewhere, a high blood cholesterol level is one of the factors affecting the incidence of coronary heart disease. The quality and quantity of dietary fat has long been known to be an important determinant of the quantity and composition of blood cholesterol.

In general, the consumption of saturated fatty acids present in animal (meat and dairy) and some plant products (palm-kernel, palm, and coconut oils) have been recognized as increasing blood cholesterol levels (McBean; Kris-Etherton et al.; Kinsella). The consumption of polyunsaturated fatty acids found in corn, safflower and soybean oils in place of saturated fats tend to lower blood cholesterol levels. Until recently, the consumption of monounsaturated fatty acids present in olive and canola oils were thought to be neutral to blood cholesterol levels. Recent research has shown that when monounsaturated fatty acids replace saturated fatty acids they tend to reduce blood cholesterol levels as much as polyunsaturated fats (McBean, p.9).[1]

Over the 1962-1985 period, the per capita consumption of saturated fat remained relatively constant at 58-60 grams/days. In contrast, total dietary fat consumption increased from 143 grams/day in 1962 to 169 grams in 1985, an 18% increase. The two types of food that account for a majority of total fat intake are red meats and food fats and oils. In 1962, 31.3% of the total fat consumed was obtained from red meats and 39.6% from food fats and oils. By 1985 red meats accounted for 25.6% of total dietary fat while food fats and oils accounted for 47.2% (Raper and Marston). These changes reflect the increased consumption of poultry and fish in place of red means, the increased consumption of food fats and oils, and the fat characteristics of these foods (Table 1). Figure 1 shows U.S. per capita consumption of various food fats and oils over the last 25 years. This figure reflects the steady increases in the consumption of vegetable shortenings, salad and cooking oils and lower consumption levels of animal based fats and oils (i.e., butter and lard).

For the dairy industry, the decrease in the consumption of butter has occurred at the same time that there has been a dramatic decrease in the consumption of whole milk, increased consumption of reduced fat beverage milk, and increased consumption of other low-fat yogurt and cheese products (Gould, Cox and Perali). The challenge to the dairy industry is to respond to these trends in the development of new products with lower levels of fat and cholesterol. From a public policy perspective, concerns have been raised with respect to this increase in the demand for reduced fat dairy products on the level of government purchases of excess butter and full-fat cheeses. This is especially important should the pricing of fluid milk be changed to a component pricing system where the total value of milk is determined by the value of milkfat and solids-not-fat (Cheese Reporter p.1).

In order to provide information for both the dairy industry and public policy makers it is essential to understand the factors that affect the demand for the various dairy products including butter. In the present paper we concentrate on the demand for butter and develop a demand model of food fats and oils using a systems approach. The systems framework is used so as to enable us to examine the interrelationships between the demand for butter and other commodity fats and oils. The interrelationships examined include those corresponding to changes in relative prices and in the demographic profile of the U.S. population. Following the analysis of Zellner and Carmon who analyzed the displacement effect of cheese donations on commercial cheese disappearance, we include a variable in the model which accounts for government donations of butter. This variable will enable us to examine how such donations affects the commercial disappearance of butter and other sources of food fats and oils.

Description of the Demand System

Food choices are affected by demographic, social and economic factors. In the model developed here we hypothesize that the U.S. consumption of food fats and oils is determined by relative prices and tastes and preferences which are, in turn, hypothesized to be determined by socioeconomic variables. We explicitly incorporate a set of demographic variables into a demand system in which the demand for fats and oils is assumed to be separable from the demand for other foods. That is, we are implicitly assuming that the consumer first decides on the level of fat and oils expenditure and in the second stage decides on the allocation of these expenditures between the various food fats and oils sources based on relative prices and demographic characteristics.

The Almost Ideal Demand System (AIDS) model originally formulated by Deaton and Muellbauer is used as the basis for this analysis. This model is widely used due to the lack of a-priori restrictions imposed on the types of substitution characteristics between commodities and the exact aggregation properties of this functional form (Heien and Willett; Deaton and Muellbauer).

The AIDS demand model can be obtained from the following expenditure function:

$$(1)\quad \ln M(U,p) = \alpha_0 + \Sigma_k \alpha_k \ln p_k + \tfrac{1}{2}\Sigma_k \Sigma_j \delta_{kj} \ln p_k \ln p_j + U^{*}\beta_0 \prod_k p_k^{\beta_k}$$

where M is the minimum level of expenditure that is necessary to achieve utility level U^{*} at prices p_k (k=1,...,n). The demand equations are derived from equation (1) via Shephard's Lemma and in budget share form appear as:

$$(2)\quad w_i = \alpha_i + \Sigma_j \delta_{ij} \ln p_j + \beta_i \ln(M/p') \quad (i=1,\ldots,n)$$

where:

$$(3)\quad \ln p' = \alpha_0 + \Sigma_k \alpha_k \ln p_k + \tfrac{1}{2}\Sigma_k \Sigma_j \delta_{kj} \ln p_k \ln p_j .$$

The adding up restrictions implied by economic theory can be represented as:

$$(4)\ \Sigma_i \alpha_i = 1\ ;\quad \Sigma_i \delta_{ij} = 0 \quad (j=1,\ldots,n);\ \text{and}\quad \Sigma_i \beta_i = 0.$$

In addition, for the demand functions to be homogeneous of degree zero in prices it is necessary that:

$$(5)\quad \Sigma_j \delta_{ij} = 0 \quad (i=1,\ldots,n).$$

Symmetry is satisfied if:

$$(6)\quad \delta_{ij} = \delta_{ji} \text{ for all } i,j \ (i \neq j).$$

Given the objectives of this study, we choose to incorporate demographic characteristics into the above demand system. Equivalence scales are one of the traditional methods for incorporating demographic variables into demand systems. As noted by Lewbel (p.1), one problem with this approach is that it results in a demographic effect where changes in demographic characteristics are virtually equivalent to changes in prices. This restriction has been overcome through the use of demographic translating, scaling and Gorman procedures. In the present study we use demographic scaling in that we want to allow for demographic variables to affect more than the "subsistence" or "necessary" parameters of the demand system which is characteristic of the translating methodology (Pollak and Wales, 1981).

Representing the original demand system as:

(7) $D_i = D_i(P,M)$,

demographic scaling replaces this system by:

(8) $D_i = \Phi_i D_i^*(p_1\Phi_1, p_2\Phi_2, \ldots, p_n\Phi_n, M)$

$= \Phi_i D_i^*(p_1^*, p_2^*, \ldots, p_n^*, M)$

where $p_i^* = p_i\Phi_i$ are scaled prices and the Φ_i's are scaling parameters which are functions of the demographic variables, $s_1, \ldots, s_d$:

(9) $\Phi_i = \Phi_i(s_1, \ldots, s_d)$

In the present study a scaling function similar to the specification used by Ray and by Barnes and Gillingham was adopted:

(10) $\Phi_i = \prod_r s_r^{\varepsilon_{ir}}$

Incorporating this scaling function into the AIDS share equations, equation (2) is reformulated as:

(2') $w_i = \alpha_i + \Sigma_j \delta_{ij} \ln p^*_j + \beta_i \ln(M/P^*)$ $\quad$ $(i=1,\ldots,n)$

where

(3') $\ln P^* = \alpha_0 + \Sigma_k \alpha_k \ln p^*_k + \frac{1}{2}\Sigma_k \Sigma_j \delta_{kj} \ln p^*_k \ln p^*_j$.

With the incorporation of the scaling functions, the traditional homogeneity and adding up conditions still hold. In addition, equation (2') must be homogeneous of degree zero in p_i^* as well as p_i. In order to maintain homogeneity with respect to p_i, (2') must be homogenous of degree zero with respect to the demographic variables. That is,

(11) $\Sigma_i \varepsilon_{ir} = 0$ $\quad$ $(r=1,\ldots,d)$.

Similar to previous studies that have incorporated demographic variables in demand systems, it is assumed that Stone's index (using scaled prices) provides an acceptable linear approximation to $\ln P^*$ (Capps, Tedford and Havlicek; Heien and Wessells). As such we approximate equation (3') by:

(12) $\ln P^* \approx \Sigma_k w_k \ln p_k^*$.

In order to avoid simultaneity problems, we adopt the Eales and Unnevehr approach where lagged budget shares are used in equation (12).

A characteristic of the AIDS model is that both expenditure and price elasticities will change over time as the share of each commodity changes. Differentiating equation (2'), the expenditure (N_i), uncompensated price elasticities (Γ_{ij}) and compensated price elasticities (Γ^*_{ij}) can be calculated as:

(13) $N_i = 1 + \beta_i/w_i$

(14) $\Gamma_{ij} = ((\delta_{ij} - \beta_i w_{j,t-1})/w_i) - K_{ij}$

(15) $\Gamma^*_{ij} = ((\delta_{ij} - \beta_i w_{j,t-1})/w_i) - K_{ij} + w_j[1 + \beta_i/w_i]$

where K_{ij} is the Kronecker delta equal to 1 if i=j, 0 otherwise.

Pollak and Wales (1980) show that the elasticity of the demand for the i^{th} good with respect to the r^{th} demographic characteristic (E_{ir}) is a function of the uncompensated own and cross-price elasticities (Γ_{ij}) and the elasticity of the i^{th} goods scaling function with respect to the r^{th} demographic characteristic, Ω_{ir}. Thus, these demographic elasticities are given as:

(16) $E_{ir} = \Omega_{ir} + \Sigma_j \Gamma_{ij} \Omega_{jr}$.

Because the scaling functions vary across commodity type, the scaling functions can be interpreted to represent the number of commodity specific "profile equivalents" as the demographic characteristics contain more than just the number of children as in Pollak and Wales(1980). Specifically, with respect to the demand for food fats and oils in this context, we interpret preferences as depending not on the number of pounds consumed but on the number of pounds per profile equivalent, i.e., pounds/Φ_i, (where i = butter, margarine, etc.), and on the price per pound per profile equivalent, $p_i\Phi_i$

(Pollak and Wales, 1981 pp. 1535-1536).

Description of the Data

Five categories of fats and oils are delineated in the model: butter, margarine, vegetable shortenings, salad and cooking oils, and lard. The demand for these commodities are analyzed through the use of aggregate quarterly U.S. time series data for the years 1962-1987. In order to estimate this demand system, quarterly per capita consumption and price data are required. Commercial butter disappearance data is obtained from various issues of Dairy Situation (USDAa). Quarterly commercial disappearance for margarine, shortening and baking oils, and salad and cooking oils are obtained via the following:

(17) $COMMDIS_t = PROD_t + STOCK_{t-1} + IMPORT_t - EXPORT_t - STOCK_t$

where COMMDIS is commercial disappearance, PROD represents production levels, STOCK are ending stock levels, IMPORT are imports, and EXPORT represent exports of the commodity. Various issues of Current Industrial Reports: Fats and Oils Production, Consumption, and Stocks are used to obtain monthly production and stocks (U.S. Department of Commerce). Annual import and export data is obtained from Putnam(1989). For lard, various issues of the CRB Commodity Yearbook are used to obtain monthly commercial disappearance values (Buchman and Gaylann). Estimates of aggregate per capita disappearance values are obtained by dividing by quarterly population estimates obtained from published Department of Commerce sources.

Quarterly estimates of butter margarine and shortening prices are obtained from published BLS retail city average price series. For vegetable oils and lard, wholesale prices are converted to retail prices using data provided in various issues of the Fats and Oils Situation (USDAb). These data (as well as those used for estimation) are available upon request from the authors.

The demographic variables included in the demand model are: the median age of the population (AGE), the proportion of the population that is nonwhite (NONWHITE) and the median number of years of schooling completed by those over 25 years of age (SCHOOL). Quarterly data is obtained by interpolating from the annual estimates of these variables.[1] The variable DONATE, which represents per capita USDA donations of butter, is used as an explanatory variable in each of the commodity specific scaling functions. Estimates of quarterly government donations are obtained from various issues of Dairy Situation (USDAa) and other published USDA data (ASCS).[1]

In the second stage, total expenditure for fats and oils (EXPEND) is calculated as the sum of the expenditures of each of the component commodities. Commodity specific expenditure values and budget shares are obtained from the above estimates of prices and quantities.

Estimation Procedure

With the adding-up constraint (equation (4)), only four equations in the five equation system are independent. In the present study, the lard equation is dropped from the estimation. The parameters for this equation are estimated using the restrictions given in equations (4), (5) and (12). With the use of demographic scaling, the estimated model is nonlinear in the parameters and is estimated using an iterative seemingly unrelated regression procedure (SYSNLIN within the SAS system). Demographic, price and donation elasticities are calculated from the estimated coefficients and corresponding share values. Approximate asymptotic standard errors are computed via the δ-method for the demographic elasticities due to the nonlinear nature of the elasticities (Rao).

Because quarterly data are used to estimate this model, the effects of seasonality in food fats and oils consumption are accounted for through the use of several harmonic variables in each share equation.[4] Following Doran and Quilkey, and Kinnucan and Fearon, these harmonic variables are calculated as:

$$(18)\quad H_1kt = \cos(\lambda_1 t) \qquad (k=1,2)\ (t=1,\ldots,T)$$

$$H_2kt = \sin(\lambda_1 t) \qquad (t=1,\ldots,T)$$

where

$$(19)\quad \lambda_1 = 2\pi k/4 \qquad (k=1,2).$$

Estimated Coefficients and Elasticities

Table 2 presents the estimated demand system coefficients. All own price coefficients are statistically significant at the 5 percent level except for the own price of lard. Six of the 10 cross price coefficients are also significant at this level as is the butter and shortenings expenditure coefficients. Seven of the harmonic variable coefficients and nine of the estimated demographic coefficients are statistically significant at the 5 percent level. AGE is statistically different from zero at the 5 percent level in the butter, margarine and cooking oil equations. The SCHOOL coefficient is statistically different from zero in the butter, shortening, and cooking oils equations (5 percent level). The NONWHITE coefficient is statistically different from zero in the butter, margarine and cooking oils equations (5 percent level). The coefficient for the DONATE variable is statistically different from zero at the 5 percent level in the shortening equation.

As noted by Wallis, failure to fully address seasonality using seasonally unadjusted data and dummy variable or harmonic specifications (as is the case here, and in much of the extant food demand analysis using quarterly aggregate disappearance data) can result in fourth-order autocorrelation in the model's error terms.[1] The existence of fourth-order autocorrelation was examined by incorporating a variable representing residuals lagged four periods and estimated following Berndt and Savin. A log-likelihood ratio test of the null hypothesis that the autocorrelation coefficient is zero could not be rejected indicating that fourth-order autocorrelation is not a problem (Judge et al. p.758). Thus, the harmonic specification appears to adequately model the seasonality in the estimated fats and oils system.

Table 3 shows the uncompensated price and expenditure elasticities evaluated at the means of the data. All of the own price elasticities are statistically different from zero at the 5 percent level as are 15 of the 20 cross-price elasticities. In terms of the relationship between butter and margarine, the cross price elasticity of the change in butter's price on margarine demand is statistically significant at the 5 percent level and is negative indicating gross complementarity. Similar results are found by Goddard and Amuah, and by Cox for the Canadian fats and oils market. Similarly, margarine price is found to have a statistically significant (gross) effect on butter (Marshallian) demand. Except for lard and butter, all of significant elasticities indicated gross complementarity. A change in the price of butter significantly affects four of the five commodities delineated in the study (all except vegetable shortenings). The price of cooking oils significantly effects the demands for all five commodities. All (conditional) expenditure elasticities are positive and three are statistically different from one at the 5 percent level (butter, shortening and lard).[6]

We can compare the price and expenditure elasticities obtained here with those estimated in other studies. Table 4 provides such a comparison between the present study and those of Goddard and Amuah, Cox, and Huang. The studies by Goddard and Amuah and by Cox were estimated using Canadian quarterly data. To provide as close a comparison as possible, the elasticities obtained in the present study are re-estimated using means of the independent variables over the 1973-1986 period, the period over which Goddard and Amuah, and Cox estimated their model. The Canadian butter and margarine price and expenditure elasticities obtained by Goddard and Amuah, and by Cox are quite similar to those obtained in the current study. The results obtained by Huang are quite different and may reflect the use of annual time series data and a different time period for analysis.

From the price elasticities, elasticities of substitution are estimated and presented in Table 5. All of the own substitution elasticities are negative and significantly different from zero at the 5 percent level. From this table we see that butter and margarine are net substitutes as is butter and vegetable shortenings and butter and cooking oils. Margarine is a net substitute for vegetable shortenings. None of the cross-substitution elasticities for lard are statistically significant.[7]

Following equation (16) we calculate the elasticity of commodity demand with respect to changes in the three demographic characteristics (Table 3).

Fourteen of the 15 demographic elasticities are statistically different from zero at the 5 percent level or better (i.e., all but AGE/Lard). AGE has elastic and positive effects on butter, shortening, and lard demand and a negative impact on margarine and cooking oils. These results suggest the aging of the U.S. population increases (decreases) butter (margarine) demand, ceteris paribus. An intuitive interpretation of these results is that older Americans have stronger preferences for butter relative to margarine, perhaps reflecting preferences acquired prior to the recent negative health concerns for food cholesterol in the diet.[1]

The SCHOOL elasticities are statistically different from zero in all equations (Table 3). The highly elastic, statistically significant and negative (positive) SCHOOL elasticity in the butter and lard (shortening) equations indicate that increases in the average U.S. level of education have reduced (increased) butter and lard (shortening and cooking oils) demand, ceteris paribus. These results are intuitively appealing under the hypothesis that higher education levels increase dietary/health awareness and concern, hence have induced a ceteris paribus substitution away from lard (and butter) to vegetable shortenings. The NONWHITE elasticities are statistically significant at the 5 percent level for all commodities. These results indicate that increases in the proportion of the non-white population have decreased (increased) the demand for butter, shortening, and lard (margarine and cooking oils), ceteris paribus.

The estimated coefficients of the government donations variable (DONATE) enable us to analyze the elasticity of government butter donations on the demand for the five commodities included in the study. As noted above, the estimated DONATE coefficient is statistically significant only in the shortening equation (Table 2). Hence , while government butter donations are found to have small negative elasticity impacts on commercial disappearance of butter (-.003), these impacts are not statistically different from zero. The associated shortening elasticity is statistically significant and positive, though relatively small (Table 3).[9] This DONATE/Shortening elasticity (0.004) suggests that the income gained from government donations may be reallocated to the consumption of shortenings, a net substitute for butter (Table 5). Hence, as butter prices decrease for the (relatively small) recipient portion of the population (i.e., it is free to those who receive the donations, but they are a small part of the total population), the complementary price effect of butter on shortenings (-.079, Table 3) and the positive conditional expenditure elasticity (.891, Table 3) combine to yield a small but statistically significant positive impact on shortening demand. However, given the conditional nature of these second stage estimates, appropriate caution in the interpretation of these estimates is advised.

Effect of Changing Demographic Characteristics on the Intake of Total, Saturated and Unsaturated Fat

The above results provide information as to the effect of changes in demographic characteristics on the demand for various types of fats and oils. We extend these results to analyze the effect of demographic changes on the intake of total, saturated, and unsaturated fats. Given the assumed separability of the consumption of fats and oils from other commodities the "fat intake" elasticities estimated here should be interpreted as conditional, i.e., reflecting the impacts of demographic factors on the intake of fat from the fat and oils commodities. Thus, for example, the fat intake associated with meat or other dairy products are not covered by this analysis

Following Pitt and Sahn, the elasticity response of the intake of the m^{th} type of fat obtained from fats and oils to a change in the r^{th} demographic characteristic (D_{mr}) can be calculated as:

$$(20) \quad D_{mr} = (\Sigma_i a_{mi} E_{ir} Q_i) / (\Sigma_i a_{mi} Q_i)$$

where a_{mi} is the quantity of the m^{th} type of fat per unit of the i^{th} type of food, E_{ir} is the demographic quantity elasticity calculated via (16) and Q_i the predicted quantity of the i^{th} food. Approximate standard errors obtained by the δ-method are also computed to facilitate interpretation.

Table 6 presents these elasticity estimates (with associated standard errors) for the mean values of the independent variables over the entire study period as well as point estimates for three quarters. The predicted quantities for each type of fat or oil are obtained by using the estimated shares and actual prices for the three periods covered by this Table. The values of a_{mi} are obtained from Table 1.

The total fat elasticity for AGE is found to be negative and statistically significant when evaluated over the 1962-1987 period and for the three quarters evaluated. This implies that the aging of the U.S. population is associated with a statistically significant, ceteris paribus reduction of total fat intake from the commodities included in the model. In terms of the composition of this total fat consumption, a positive (negative) and statistically significant relationship between AGE and saturated (unsaturated) fat intake are obtained. As these component fat elasticities are statistically significant at all points for which they were evaluated (except saturated fat in the second quarter of 1987), these results suggest that the aging of the U.S. population is associated with ceteris paribus increases (decreases) in the amount of saturated (unsaturated) fats. These results primarily reflect the elastic impacts of AGE on butter (+), margarine (-), shortening (+), cooking oils (-) and lard (+) from Table 3, and the associated fat compositions of these commodities (Table 1).

Total fat consumption from the fat and oil commodities modeled is positively affected by increased education (SCHOOL elasticities, Table 6). Statistically significant (at the 5 percent level or better) and positive total fat intake elasticities are obtained for all time periods analyzed. The positive (and statistically significant at the 5 percent level or better) unsaturated fat SCHOOL elasticities indicate that increasing education levels of the U.S. population are associated, ceteris paribus, with changes in the composition of this increasing total fat intake. In contrast, while all SCHOOL/saturated fat elasticities are negative and relatively small, they are not statistically significant from zero. These results suggest that increasing education levels have increased consumption of unsaturated fats more than the associated decrease in saturated fats. These results are intuitively appealing under the hypothesis that, with higher education levels, the population has a greater ability to obtain information on and understand the health impacts of the consumption of certain types of fats, hence substitute away from saturated to unsaturated fats. The positive unsaturated fat SCHOOL elasticities may also reflect increased purchases of food away from home (FAFH) for those individuals with higher income levels. Much of these FAFH purchases occur in fast food establishments that use a large amount of vegetable based fats.

The changing ethnic composition of the U.S. population appeared to have little impact on the intake of total fat except for the latter part of the

1980's. In contrast, the saturated fat elasticities were negative and statistically different from zero (5 percent level) at both the mean level of independent variables and for the late 1960's and 1970's. The unsaturated fat elasticities are positive and significant at all points evaluated.

Summary and Conclusions

This research analyses the impacts of prices, fats and oils expenditures, seasonality, government donations and demographic factors on quarterly U.S. fats and oils consumption over the 1962-87 period. The demand systems approach using an AIDS with demographic scaling specification appears to perform quite well statistically and in terms of the implied elasticity results. In particular, the butter and margarine Marshallian price elasticities compare quite favorably (in signs and magnitudes) to the results of Goddard and Amuah, and Cox. The estimated impacts of the changing U.S. demographic profile (in particular, the aging of the population (AGE), increased average levels of schooling (SCHOOL), and increased proportion of the population that is non-white (NONWHITE)) on fats and oils consumption are generally statistically significant and appear quite intuitive. Thus, for example, AGE is found to have elastic, statistically significant and positive (negative) impacts on butter, vegetable shortening and lard (margarine and cooking oils) demand. SCHOOL has statistically significant and elastic negative (positive) impacts on butter, margarine and lard (vegetable shortenings and cooking oils).

One interpretation of these AGE results is that older consumers acquired strong (positive) preferences for butter (and vegetable shortening) prior to current concerns for food cholesterol in the U.S. diet. Similarly, if increasing average education levels in the U.S. population are assumed to reflect an increasing awareness of and concern for diet/health linkages, then the negative (positive) impacts of SCHOOL on butter and lard (vegetable shortening) reflect substitution away from fats and oils commodities that are relatively high in saturated fat.

The nutrient/demographic elasticities indicate that the aging of the population (AGE) is associated with statistically significant decreases in total fat intake, but with increases in the amount of saturated fats and decreases in the amounts of unsaturated fats. In contrast, increasing average education level (SCHOOL) is associated with statistically significant increases in total fat intake, but with negative (positive) impacts on the amount of saturated (unsaturated) fat from the commodities modeled. Increases in the proportion of the non-white population (NONWHITE) are found to have little impact on the total intake of fats but to increase (decrease) the intake of unsaturated (saturated) fats. We interpret these results similar to the demographic elasticities above. In particular, the fat consumption from sources other than those modeled here (e.g., meats and other dairy products) are not reflected in these results.

Government donations (DONATE) of butter are found to have statistically insignificant and small negative impacts on commercial disappearance of butter. Given the relatively small percentage of the population that receives these donations, this result is not unexpected. The results suggest that the potential reallocation of the "income transfer" generated by these donations is spent on shortenings (DONATE elasticity, 0.004, significant at the 5 percent level), but given the conditional (second stage) nature of the specification estimated, this result should be interpreted cautiously.

The inclusion of demographic information in the estimation of conditional demand systems from aggregate disappearance data is strongly supported by the results of this research. These procedures explicitly model changes in tastes and preferences associated with changes in the demographic profile, allow estimation of profile specific response parameters, and provide a natural basis for projecting demand based on demographic projections.[18] Given these results and future possibilities, it is hoped that similar procedures will be more routinely used for demand estimation from aggregate time series data.

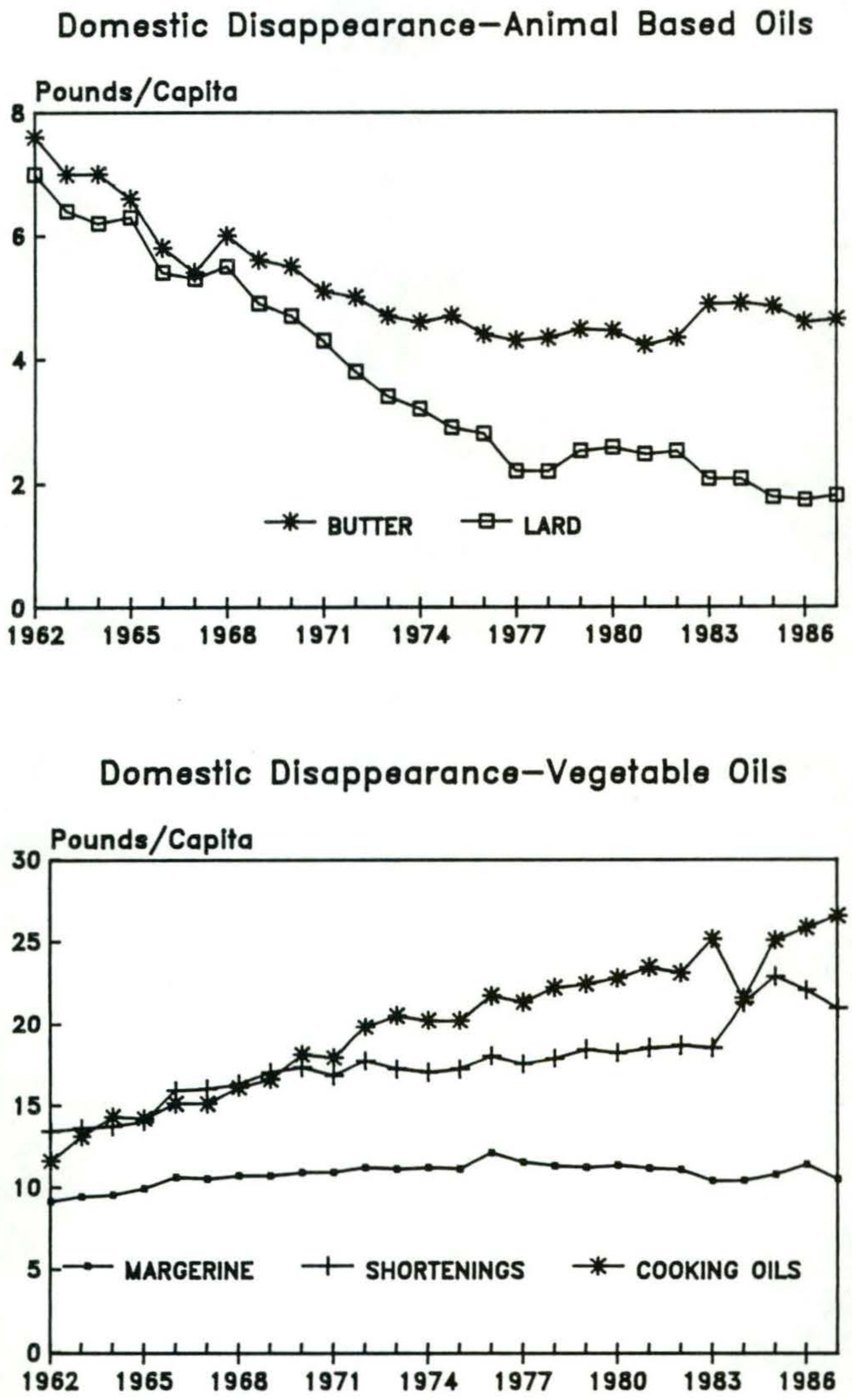

Figure 1. Per Capita Disappearance of Food Fats and Oils, 1962-1987

Table 1. Fat Composition of Various Foods.

Type of Food	Fat Content (Grams/Pound)				
	Total	Saturated	Unsaturated Fat		
	Fat	Fat	Mono	Poly	Total
Food Fats and Oils					
Butter	370	229 (62)	106 (29)	14 (4)	120 (33)
Margarine	366	72 (20)	163 (45)	115 (31)	278 (76)
Shortenings	454	114 (25)	202 (45)	118 (26)	320 (81)
Salad and Cook	454	68 (15)	195 (43)	171 (38)	366 (81)
Lard	454	178 (39)	205 (45)	51 (11)	256 (56)
Meat					
Ground Beef	96	37 (39)	41 (43)	4 (4)	45 (47)
Pork Chops	98	36 (37)	45 (46)	11 (11)	56 (57)
Ham	75	27 (36)	36 (48)	8 (11)	44 (59)
Poultry and Fish					
Chicken	41	11 (27)	16 (39)	9 (22)	25 (61)
Haddock	48	13 (27)	21 (44)	13 (27)	34 (71)

Source: Guthrie (1986), Appendix A.

Note: The salad and cooking oils coefficients pertain to soybean oil (partially hydrogenated). The shortening coefficients pertain to vegetable shortenings. The figures in parenthesis correspond to the percent of total fat. They do not sum to 100 due to the inability to correctly identify and measure all fatty acids.

Table 2. AIDS Share Equation Estimates for U.S. Fats and Oils Sector Using Quarterly Aggregate Disappearance Data, (1962-1987).

	Independent Variables														
Dependant	Price					Expen-	Harmonic Variables							Inter-	
Variable	Butter	Margarine	Short	Cooking	Lard	diture	COS1	COS2	SIN1	AGE	SCHOOL	NONWHITE	DONATE	cept	R^2
Butter	.0801	-.0219	-.0238	-.0270	-.0074	.0209	.0093	.0058	.0002	5.5383	-5.1744	-2.7120	-.0055	.4065	.915
	(.0109)	(.0063)	(.0103)	(.0082)	(.0254)	(.0097)	(.0022)	(.0015)	(.0024)	(1.2449)	(1.2212)	(.7213)	(.0043)	(.2772)	
Margarine		.1321	-.0289	-.0643	-.0170	.0010	.0064	-.0002	.0078	-3.6836	-.2396	2.0452	.0014	1.6593	.844
		(.0174)	(.0138)	(.0052)	(.0332)	(.0026)	(.0010)	(.0007)	(.0010)	(.9038)	(.7242)	(.5382)	(.0015)	(.3132)	
Shortening			.1280	-.0667	-.0086	-.0251	-.0025	-.0030	-.0018	.6708	4.4931	-.0201	.0057	-1.5213	.944
			(.0171)	(.0105)	(.0370)	(.0104)	(.0019)	(.0013)	(.0020)	(1.2442)	(1.0309)	(.6659)	(.0026)	(.4305)	
Cooking				.1723	-.0144	-.0056	-.0151	-.0033	-.0045	-3.3381	2.6732	3.0907	-.0008	-.0118	.913
				(.0098)	(.0241)	(.0056)	(.0024)	(.0017)	(.0025)	(.7672)	(.7536)	(.4436)	(.0027)	(.2538)	
Lard					.0473	.0088	.0018	.0007	-.0017	.8126	-1.7523	-2.4038	.0008	.4673	
					(.0608)	(.0216)	(.0055)	(.0037)	(.0058)	(2.7608)	(2.4926)	(1.5770)	(.0079)	(.7205)	

Note: The model was estimated via iterative seemingly unrelated regression (ITSUR) using the SYSNLIN procedures of SAS. Asymptotic standard errors are presented in parentheses.

Table 3. Uncompensated Price, Demographic and Donation Elasticities Evaluated at the Sample Means, (1962-1987).

Dependant	Price					Expen-	Demographic Variables			
Variable	Butter	Margarine	Short	Cooking	Lard	diture	AGE	SCHOOL	NONWHITE	DONATE
Butter	-.662	-.114	-.128	-.150	.040	1.094	2.654	-2.579	-1.465	-.003
	(.057)	(.029)	(.045)	(.035)	(.020)	(.040)	(.439)	(.513)	(.285)	(.002)
Margarine	-.130	-.227	-.171	-.379	-.100	1.006	-2.497	-1.118	1.008	.001
	(.037)	(.112)	(.082)	(.032)	(.022)	(.015)	(.374)	(.571)	(.221)	(.001)
Shortening	-.079	-.107	-.421	-.255	-.030	.891	1.195	2.346	-.790	.004
	(.048)	(.060)	(.096)	(.046)	(.022)	(.049)	(.435)	(.524)	(.257)	(.002)
Cooking	-.083	-.204	-.210	-.440	-.045	.982	-1.751	1.099	1.642	-.001
	(.027)	(.017)	(.035)	(.047)	(.014)	(.019)	(.260)	(.361)	(.126)	(.002)
Lard	-.146	-.285	-.164	-.264	-.277	1.136	1.574	-1.812	-2.667	-.001
	(.069)	(.061)	(.095)	(.061)	(.112)	(.056)	(.748)	(.851)	(.583)	(.003)

Note: Due to the nonlinear nature of the elasticities, approximate asymptotic standard errors computed via the δ-method are in parenthesis.

Table 4: Comparison of Alternative Fats and Oils Price Elasticity Estimates for the U.S. and Canada.

Previous Study	Dependant Variable	Price Elasticity Butter	Margarine	Short	Cooking	Expenditure Elasticity
	Butter					
U.S.						
Current		-.62	-.13	-.15	-.17	1.11
Huang		-.17	.05	-.12	---	.02
Canada						
Goddard and Amuah		-.72	-.29	-.09	-.08	1.18
Cox		-.79	-.12	-.16	-.08	1.33
	Margarine					
U.S.						
Current		-.13	-.23	-.17	-.37	1.01
Huang		.07	-.27	.19	---	.11
Canada						
Goddard and Amuah		-.26	-.60	-.04	-.07	.84
Cox		-.14	-.47	-.31	-.07	.92
	Shortening					
U.S.						
Current		-.08	-.10	-.45	-.24	.90
Huang		-.03	.03	-.22	---	.37
Canada						
Goddard and Amuah		-1.19	-.57	.72	-.74	1.77
Cox		-.15	-.24	-.26	-.21	.53
	Cooking and Salad Oils					
U.S.						
Current		-.08	-.19	-.20	-.48	.98
Goddard and Amuah		.03	.62	-.52	-.14	.01
Canada						
Cox		-.31	-.24	.02	-.57	.93

Note: Huang delineated only three categories: butter, margarine, and other oils. The other oils category is presented in the shortening rows and columns. For this table, the Current elasticities are evaluated at the mean values of the independent variables for the 1973-1986 period in order to be consistent with Goddard and Amuah and with Cox (who estimated a quarterly Canadian fats and oils model over this period). The elasticities estimated by Huang were obtained from an annual time series model of the years 1953-1981.

Table 5. Substitution Elasticities Evaluated at the Data Means, (1962-1987).

Dependant	Price				
Variable	Butter	Margarine	Short	Cooking	Lard
Butter	-1.873	.426	.538	.611	.483
	(.252)	(.160)	(.205)	(.119)	(.303)
Margarine		-.324	.266	-.214	-.537
		(.630)	(.378)	(.112)	(.361)
Shortening			-.931	.071	.427
			(.325)	(.179)	(.375)
Cooking				-.434	.285
				(.107)	(.214)
Lard					-3.144
					(1.348)

Note: Due to the nonlinear nature of the elasticities, approximate asymptotic standard errors computed via the δ-method are in parenthesis.

Table 6. Estimated Demographic Nutrient Elasticities, 1962-1987 and Second Quarter 1967, 1977, and 1987.

Variable	Type of Fat	1962-87	Second Quarter 1967	1977	1987
AGE					
	Total Fat	-.355 (.068)	-.220 (.065)	-.224 (.074)	-.688 (.094)
	Saturated Fat	.423 (.064)	.522 (.085)	.568 (.060)	.074 (.058)
	Total Unsaturated Fat	-.637 (.103)	-.495 (.094)	-.478 (.102)	-.920 (.121)
SCHOOL					
	Total Fat	.461 (.078)	.403 (.084)	.474 (.082)	.580 (.120)
	Saturated Fat	-.090 (.088)	-.127 (.120)	-.060 (.088)	.077 (.085)
	Total Unsaturated Fat	.661 (.108)	.601 (.103)	.646 (.107)	.734 (.148)
NONWHITE					
	Total Fat	.170 (.039)	.001 (.038)	.091 (.042)	.482 (.054)
	Saturated Fat	-.446 (.040)	-.593 (.049)	-.511 (.036)	-.172 (.036)
	Total Unsaturated Fat	.391 (.058)	.220 (.055)	.282 (.058)	.679 (.069)

Note: Due to the nonlinear nature of the elasticities, approximate asymptotic standard errors computed via the δ-method are in parenthesis. These elasticities are conditional on the level of total expenditures on fats and oils and refer to the dietary intake of fat from these commodities and do not include the fat intake from meat and other dairy products not included in this table.

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Footnotes

1. Besides the effect of fat intake on heart disease, research over the last decade has also linked high fat intakes to the incidence of certain types of cancer (Guthrie p. 71). As noted in the Surgeon General's report the incidence of breast, enodetrium, colon, and prostate cancers are positively related to total fat intake and to a lesser degree animal fat intake.

2. The annual estimates of each demographic variable are assumed valid for July 1 of each year.

3. Government donations are calculated via the following:

$$GD_t = GOVSTOCK_{t-1} - GOVSTOCK_t + REMOVE_t - FDONATE_t$$

where GD are government donations, GOVSTOCK are government ending stocks, REMOVE represent government net removals and FDONATE are foreign donation commitments.

4. A dummy variable specification was also evaluated to address the seasonality evident in the U.S. fats and oils consumption. Demand system parameters (price, conditional expenditure, and demographic effects) were found to be quite robust across the dummy variable and harmonic specifications. As the harmonic specification provided marginally superior explanatory power, these results are presented here.

5. "The usual interpretation of the error or disturbance term in econometric models is that it represents the effect of omitted or unobservable variables on

the dependent variable. The error term might thus be expected to display certain features of observed economic variables, in particular, when quarterly data are employed, seasonal variation. Equally, when seasonally unadjusted data are employed in order that one may attempt to explain seasonal variation in the dependent variable, along with other types of variation, by means of explanatory economic or seasonal dummy variables, then the presence of non-systematic seasonal variation, or an incomplete accounting for seasonality by the regressors, will produce seasonal effects in the error term, with the possible consequence of fourth order autocorrelation." (Wallis, p. 617)

6. The lard expenditure results appear to be in conflict with Figure 1 (i.e., we might expect lard to have a small, and perhaps negative, expenditure elasticity. Figure 1 merely plots consumption trends through time, hence it is not a reflection of the ceteris paribus Engel function.

7. When evaluated at the mean levels of the independent variables, the substitution matrix was found to be negative semi-definite.

8. As the U.S. population ages, the proportional impact of this older cohort increases. Hence, it is likely that the AGE variable in this context, reflects cohort rather than pure age effects.

9. Over the study period, the estimated butter donations averaged more than 13 percent of commercial butter disappearance.

10. For an example of demand projections using a similar methodology, see Gould, Cox and Perali.