The Demand for Fluid Milk Products
in the U.S.: A Demand Systems Approach

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Abstract

The demand for fluid milk products has changed dramatically in recent years not only in terms of lower levels consumed but also in terms of the composition of the products consumed. A time-series based demand system analysis of the market for lowfat and whole milk products is developed incorporating the effects of changes in prices and demographic characteristics. From the estimated model, the impacts of future changes in the demographic profile of the U.S. population on fluid milk demand are analyzed.

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Running Head: Demand for Fluid Milk Products
THE DEMAND FOR FLUID MILK PRODUCTS
IN THE U.S.: A DEMAND SYSTEMS APPROACH

The per capita consumption of fluid milk products has declined steadily over the last three decades from 291 lbs. in 1966 to less than 236 lbs. in 1987, a 19 percent decline. Coincident with this decline in overall fluid milk demand, there has occurred a change in this demand away from whole milk beverage products towards reduced fat milks such as lowfat and skim milk. Since 1966 lowfat milk consumption increased from less than 34 lbs. to more than 113 lbs. in 1987 while the consumption of whole milk declined from 251 to 110 lbs.1

Because of the change in fluid milk demand away from whole milk products, on a whole milk equivalent basis, the decline in milk consumption has been greater than the decline when measured on a product weight basis. Using per capita sales data, between 1954 and 1987 per capita whole milk equivalent sales decreased by 36% while total product weight fluid milk sales decreased by 17%. From 1954 to 1965 whole milk accounted for more than 84% of whole milk equivalent sales while lowfat milk represented less than 3%.2 By 1987, the consumption of lowfat milk had increased to the point where 27% of total fluid milk sales on a whole milk equivalent basis originated from the sale of lowfat milk and only 55% of total sales originated from whole milk.

This trend of increased sales of lowfat milk products has not been limited to fluid beverage milk products. Over the last decade there have been increases in the consumption of lowfat cottage cheese, frozen desserts and increased interest in reduced fat cheeses. For example, in 1987 lowfat yogurt accounted for 73% of total U.S. yogurt production, compared with 10% for nonfat yogurt and 13% for fullfat. Three years earlier, lowfat yogurt
accounted for 66%, nonfat 4% and fullfat accounted for 30% of total production (Rogers).

The changing composition of dairy products to lowfat varieties has important policy implications both at the farm level as well as for the manufactured dairy product industries. For example, if the current milk pricing system were to be changed to one of multiple component pricing which is based on milkfat, protein, and/or solids-not-fat components, the value of milkfat may be expected to decline due to the increase in the demand for lowfat products. This decline in demand for milkfat may have the effect of increasing the supply of milkfat for use in other government supported products such as butter. Currently there exist large surpluses of milkfat (Cheese Reporter, p.1). Should the increased consumption of lowfat milk continue such surplus may increase and could have important ramifications in terms of the level of government subsidy payments required to maintain the price of milk and milk based products. For example, recent increases in the federal dairy price supports stipulated an increase in the Commodity Credit Corporation (CCC) purchase price for nonfat dry milk while keeping the CCC purchase price of butter unchanged (Dairy Market News, p. 13).

The question remains as to the factors contributing to the increased consumption of lowfat milk and the impacts of continued change in these factors on the level of total milk demand, the demand for lowfat versus whole milk, and the intake of calcium, fat and other nutrients. As noted by Raunikar and Huang, Heien and Wessells, and Haidacher et al., changes in the types of milk products consumed have come about from a variety of sources including relative prices, incomes and the demographic profile of the U.S. population.
The objective of the present study is to examine the impacts of changes in the demographic structure of the U.S. on the demand for fluid milk products, specifically the demand for whole versus lowfat milk. We first examine how such changes have affected milk demand over the last 30 years. We then use projections of future demographic changes to estimate how the demand for fluid milk products will change in the future both on a per capita basis and in terms of the overall market for fluid milk products. In order to achieve these objectives we develop a demand model that specifically incorporates price and demographic variables. Unlike the cross-sectional studies of milk demand conducted by Huang and Raunikar, Blaylock and Smallwood, and Heien and Wessells, time series data covering the period 1955-1985 are used. An advantage of the use of time-series data is the inclusion of food away from home (FAFH) consumption; in contrast, the cross-sectionally based analyses consider only food at home (FAH) consumption. Problems associated with the use of time series data include collinearity among the independent variables and substantially fewer degrees of freedom.

Description of the Theoretical Model

In the present study we assume that the consumer demand for milk and other food is the result of a two stage budgeting process. In the first stage, the consumer determines the amount that is to be spent on food. In the second stage the consumer then allocates this food budget among various food commodities. Given the econometric evidence provided by Heien and Wessells that first stage food prices have little effect on second stage food demand, in the present study we limit our analysis to the second stage. Because the focus of this study is on the demand for fluid milk products, we delineate
four types of beverages and an aggregate "other food" category in the demand system.

The Almost Ideal Demand System (AIDS) model originally formulated by Deaton and Muellbauer is used in this analysis. This model is used due to the lack of a-priori restrictions on the types of substitution characteristics that can exist between commodities and the exact aggregation properties of this functional form (Helen and Willett, Deaton and Muellbauer). The AIDS demand model can be obtained from the following expenditure function:

\[ \ln M(U, P) = \alpha_0 + \sum_k \alpha_k \ln p_k + h \sum_k \sum_j \delta_{kj} \ln p_k \ln p_j + U^* \beta_0 \prod_k p_k^{\delta_j} \]

where \( M \) is the minimum level of expenditure that is necessary to achieve utility level \( U^* \) given the vector of prices \( P \) which is composed of \( n \) individual commodity prices \( (p_k, k=1, \ldots, n) \). If we let \( w_i \) represent the share of total expenditure associated with the \( i^{th} \) commodity, the demand equations can be derived from equation (1) via Shephard's Lemma and in budget share form appear as:

\[ w_i = \alpha_i + \sum_j \delta_{ij} \ln p_j + \beta_i \ln (M/P') \quad (i=1, \ldots, n) \]

where:

\[ \ln P' = \alpha_0 + \sum_k \alpha_k \ln p_k + h \sum_k \sum_j \delta_{kj} \ln p_k \ln p_j. \]

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

\[ \sum_i \alpha_i = 1; \quad \sum_i \delta_{ij} = 0 \quad (j=1, \ldots, n); \quad \text{and} \quad \sum_i \beta_i = 0. \]

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

\[ \sum_j \delta_{ij} = 0 \quad (i=1, \ldots, n). \]

Symmetry is satisfied if:

\[ \delta_{ij} = \delta_{ji} \text{ for all } i,j \ (i \neq j). \]
One of the traditional methods for incorporating demographic variables into demand systems is with equivalence scales. As noted by Lewbel, the problem with these variables is that they result in a very limited type of demographic effect where changes in demographic characteristics are virtually equivalent to changes in prices (p.1). 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 to depend on demographic variables (Pollak and Wales, 1981).

If the original demand system can be represented by:

\[ D_i = D_i(P, M) \]

demographic scaling replaces the original demand system by:

\[ D_i = \phi_i p_i = \phi_i(p_1, p_2, \ldots, p_n, M) \]

where \( p_i \) are scaled prices (i.e., \( p_i \phi_i \)) and the \( \phi_i \)'s are scaling parameters which are functions of the demographic variables, \( s_1, \ldots, s_d \):

\[ \phi_i = \phi_i(s_1, \ldots, s_d) \]

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

\[ \phi_i = \prod r \epsilon_{ir} \]

where \( \epsilon_{ir} \) is the estimated coefficient associated with the \( r \)th demographic variable in the \( i \)th scaling function.

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

\[ w_i = \alpha_i + \delta_j \ln p_j' + \beta_i \ln (M/P)^* \quad (i=1, \ldots, n) \]
where

\[(3') \ln P' = \alpha_0 + \sum_k \alpha_k \ln p_k' + \sum_j \delta_{kj} \ln p_k' \ln p_j'.\]

With the incorporation of the scaling functions the traditional homogeneity and adding up conditions hold. In addition, equation \((2')\) must be homogeneous of degree zero in the original prices. This requires that equation \((2')\) must be homogeneous of degree zero with respect to the demographic variables. That is:

\[(11) \Sigma \xi_{ir} = 0 \quad (r=1, \ldots, d).\]

This normalization allows the identification of all the demographic parameters and guarantees that:

\[(12) \Sigma \ln(\phi_i) = 0.\]

Equation \((2')\) is nonlinear in the parameters. Similar to previous studies that have incorporated demographic variables in demand systems, it is assumed that Stone’s index provides an acceptable linear approximation to \(\ln P'\) (Capps et al., Heien and Wessells). That is:

\[(13) \ln P' = \Sigma \omega_k \ln p_k'.\]

In order to avoid simultaneity problems, we adopt the Eales and Unnevehr approach where lagged share values \((w_{k,t-1})\) are used in equation \((13)\).

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 \((\Gamma_{ij})\) and compensated price elasticities \((\Gamma_{ij}')\) are calculated via the following:

\[(14) N_i = 1 + \beta_i / w_i\]
\[(15) \Gamma_{ij} = (\delta_{ij} - \beta_i w_j / w_i) - K_{ij}\]
\[(16) \Gamma_{ij}' = (\delta_{ij} - \beta_i w_j / w_i) - K_{ij} + w_j [1 + \beta_i / w_i]\]
where \( \delta_{ij} \) 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 (\( \Gamma_{ij} \)) and the elasticity of the \( i^{th} \) goods scaling function with respect to the \( r^{th} \) demographic characteristic, \( \Omega_{ir} \):

\[
E_{ir} = \Omega_{ir} + \sum_j \Gamma_{ij} \Omega_{jr}
\]

Because the scaling functions vary across commodity type the scaling functions can be interpreted to represent the number of commodity specific "adult equivalents". We refer to these measures as "profile equivalents" in the present context as the demographic characteristics contained in the scaling functions contain more than just the number of children as in Pollak and Wales (1980) (e.g., number of adults older than 65, median number of years of schooling completed, percentage of the population that is nonwhite, etc.). Following Pollak and Wales (1981) and given equation (8) we can interpret preferences as depending not on the number of gallons of milk consumed but on the number of gallons per milk equivalent profile, i.e., gallons/\( \phi \). The relevant price affecting consumption is not the price per gallon but the price per gallon per profile equivalent, i.e., \( p_{\phi} \).

Description of the Data and Estimation Procedures

Previous models of the demand for lowfat versus whole milk products have been conducted through the use of cross-sectional data. In the present study we analyze the changes in demand using time-series data from the 1955-1985 period. Five commodities are delineated within the model: whole milk, lowfat milk, fruit juices, other non-alcoholic beverages and other food. In order
to estimate the theoretical model, data are needed on the per capita quantities consumed and prices for each of these commodities. The demographic variables included in the demand model are: the proportion of the population less than five years old (POPS); the proportion of the population between the ages of 5 and 13 years of age (POPS13); the proportion of the population above the age of 65 (POP65); the proportion of the population that is nonwhite (NONWHITE); and, the median number of years of schooling completed for those over 25 years of age (SCHOOL).4

The quantity data on whole and lowfat milk consumption are measured by per capita sales data obtained from Manchester, Bunch and Simon, and DAIRYFIELD. Retail prices for whole milk, skim milk and lowfat milk are obtained from published Bureau of Labor Statistics sources. Because a retail price series for lowfat milk was not available prior to 1980, an OLS regression between monthly retail skim milk and lowfat milk prices over the 1980-1987 period was estimated.5 Using the skim milk price series and the estimated regression, a lowfat milk price series was obtained.

Per capita juice and other beverage quantities consumed are estimated from various issues of the USDA's Food Consumption, Prices, and Expenditures. Price series for the juice and other beverage commodities are estimated from the consumer price indexes for juice and non-alcoholic beverages, respectively and calculated prices for these two commodity groupings obtained from the 1965 Food Consumption Survey. Given the estimated prices and consumption levels for the four beverage commodities, expenditures for other food are obtained by subtracting these expenditures from total food expenditures. The consumer price index for food is used as a proxy for the retail price of other foods.

Because of the adding-up constraint, only four equations are
independent. The "other food" equation is dropped from the estimation process. The parameters for this equation are estimated using the restrictions given in equations (4), (5) and (11). In order to estimate the parameters of the share equations that are invariant to the omitted share equation, the modified seemingly unrelated regression procedure suggested by Chavas and Segerson is used. With the use of demographic scaling the estimated model is nonlinear in the parameters and thus is estimated using the SYSNLIN program within SAS. Demographic and price elasticities are calculated from the estimated coefficients and the predicted share values. For the demographic elasticities, approximate standard errors are computed via the \( \delta \)-method described in Rao.

Empirical Model of Fluid Milk Demand

Table 1 presents the estimated coefficients for the demand system. All of the own price coefficients are statistically significant at the 5 percent level. Seven of the 10 cross price coefficients are also significant. The expenditure coefficients are significant at the 5 percent level except in the juice equation. From these coefficients compensated price elasticities are calculated (Table 2). Fifteen of the 25 price elasticities are significant at the 5 percent level when evaluated at mean levels of the independent variables. All own price elasticities are statistically significant at the 5 percent level.

Huang estimates that the uncompensated own price elasticity for fluid milk products was -.259 based on a time-series demand systems model. Using this value and the relationship between compensated and uncompensated elasticities noted in Johnson et al., the compensated elasticity from Huang is
estimated to be -.351. In the present study, the compensated own price elasticities are -.341 and -.447 for whole and lowfat milk, respectively. In terms of the own price elasticity of fruit juices, the present study finds a lower compensated elasticity value, -.337 versus -.490.

The cross-price elasticities between lowfat and whole milk show that they are substitute products although the cross-price elasticities are not statistically significant. The cross-price elasticities between "other foods" and whole milk, juices and other beverages are statistically significant and indicates a substitution relationship. Similarly, the cross-price elasticities of juices and other beverages reflect a statistically significant substitution relationship.

Twenty-five demographic coefficients are estimated in the model. In Table 1 we see that 11 of these coefficients are statistically significant. Five of these significant coefficients appear in the whole milk equation and 3 are in the lowfat milk equation. None of the demographic coefficients are significant in the "other food" equation. The corresponding elasticities (see Table 2) for the age structure variables indicate a major difference between the effects of these variables on whole versus lowfat milk demand.

The estimated relationship between age and the consumption of whole versus lowfat milk are different from previous cross-sectional analyses. Although not directly comparable to the present study, Haines et al. in their cross-sectional analysis of women between the ages of 19-50 years show some similarity between age and the consumption of both types of milk. They found statistically significant negative relationships for those consumers who had positive levels of consumption. In contrast, in their Tobit and Probit analyses, the authors found significant negative relationships only in terms
of the consumption of whole milk.

Huang and Raunikar using cross sectional data in a Tobit analysis of the consumption of lowfat and whole milk in the U.S. and for the South found differences between family life cycle and the consumption of these two types of milk. Raunikar and Huang in their analysis of the consumption of whole versus lowfat milk in the Northeast conducted a likelihood ratio test of the null hypothesis that household expenditures for whole milk and lowfat milk were not related to family life cycle stages. The results obtained by the authors suggested that the null hypothesis could be rejected for whole milk but not lowfat milk (Raunikar and Huang, 1984 p.57).6

In terms of the net effects of changes in the education level on demand, the results are consistent with previous cross-sectional analysis of the demand for whole milk products with whole milk demand being negatively affected by increased education levels. The differences observed between the lowfat and whole milk demand with respect to education levels may reflect the increased access to nutritional information and diet-conscious behavior associated with higher education levels (Huang and Raunikar, p.30).

Previous analysis of the relationship between ethnicity and the consumption of milk products have not been consistent. In a Tobit analysis conducted using the 1977 Household Food Consumption Survey, Haines et al. found that nonwhite individuals tend to consume less lowfat milk. The same was found for the consumption of whole milk products except for Hispanic persons where a positive relationship was found. A similar Tobit analysis conducted using the 1985 Continuing Survey of Food Intake by Individuals, found insignificant ethnic coefficients for whole milk products. Huang and Raunikar found significant positive coefficients on a white household dummy
variable in terms of lowfat milk but insignificant negative coefficients in the analysis of whole milk products. Table 1 shows that significant and positive coefficients for the NONWHITE was obtained in the whole milk equation while a negative but insignificant coefficient was obtained in the lowfat milk equation. The differences between the results obtained here and those in previous cross-sectional studies may be due to the fact that the variable NONWHITE encompasses Hispanics and blacks as well as other minorities.

The Impacts of Projected Changes In Demographic Characteristics on Fluid Milk Demand

With the above elasticity estimates we can examine the implications of future changes in the characteristics of the U.S. population for fluid milk demand. Following Theil, and Heien and Wessells, the predicted quantities of lowfat and whole milk consumption can be calculated as:

\[ \ln q^{\text{p}}_{ij} = \Sigma_j \Gamma_{ij} \ln P_{jt} + \Sigma_r E_{ir} \ln s_{it} + N_i \ln M_t \]

where \( q^{\text{p}}_{ij} \) is the predicted level of the \( i \)th commodity in the \( t \)th period. Using this equation, the annual compound rate of growth between two time periods can be estimated as:

\[ R_i = 1/T \left[ \Sigma_j \Gamma_{ij} (\ln P_{jt} - \ln P_{jt-T}) + \Sigma_r E_{ir} (\ln s_{it} - \ln s_{it-T}) + N_i (\ln M_t - \ln M_{t-T}) \right] \]

where \( R_i \) is the annual compound rate of growth for the \( i \)th commodity between two time periods \( T \) years apart. In the present analysis we are concerned only with the future impacts of changes in the demographic variables. As such in equation (19) the changes in prices and income are assumed to be zero.

Projections for changes in the variables POP5, POP513, POP65, and NONWHITE over the 1990-2010 period are obtained from Spencer. Projections for changes in the median number of years of school completed are obtained from the
following regression equation estimated using a GLS estimator to correct for autocorrelation over the 1950-1985 period (with coefficient standard errors in parenthesis):

\[
\ln(\text{SCHOOL}) = 2.2311 + 0.0819 \ln(\text{TIME}) + 0.8617 e_{t-1}
\]

\[
\text{D.W.} = 2.189
\]

\[
(0.0228) \quad (0.0079) \quad (0.0857)
\]

\[R^2 = 0.952\]

where TIME was set equal to 1 for 1950.

Table 3 presents the decomposition analysis for whole and lowfat milk for the years 1985-2010. For example, over the 1985-2010 period, the annual rate of change in the per capita demand for whole milk demand resulting from changes in the proportion of the population less than 5 years of ages is projected to be -0.81 percent per year. This is the product of the elasticity of whole milk demand with respect to POP5 (-0.90 percent) and the annual rate of change of this variable (-0.91 percent). The "ALL AGE" column in this table shows the total impact of changes in the age structure of the population on fluid milk demand while the last column shows the annual rate of change in milk demand resulting from projected changes in the five demographic characteristics.

Over the 25 year period, changes in the age structure are projected to cause an average annual decline in whole milk consumption of 1.66 percent. This trend is projected to increase over time from an annual rate of -1.32 percent over the 1985-1990 period to -1.84 percent over 2000-2005. In contrast, a positive growth rate resulting from changes in the age structure is projected for lowfat milk, increasing from an annual growth rate of 1.32 percent over the 1985-1990 period to 3.55 percent during 1995-2000 with a 25 year average growth rate of 2.63 percent.8

Blaylock and Smallwood in their analysis of the impacts of demographic
changes on food demand found that changes in the age distribution had very little impact on per capita fluid dairy (milk and cream) demand over the 1980-2010 period. The differences between their results and those of the present study may be due to: the use of cross-sectional versus time-series data; the aggregation of the lowfat and whole milk demand; the inclusion of fluid milk products not incorporated in the present study; and the analysis of at home fluid milk consumption versus aggregate (FAH and FAFH) sales. When compared to the effects of the changing age structure, changes in the proportion of the population that is nonwhite, and the median school years completed on milk demand are estimated to have relatively minor impacts.

Table 3 summarizes the annual growth rates (on a per capita basis) for the effects of changes in the demographic characteristics included in this study. Adding these annual growth rates to the projected population growth rates yields an estimate of the demographically induced changes in the total demand for lowfat and whole milk. From Spencer total population estimates over the 1985-2010 period where obtained. Using the procedure outlined by Theil, the annual compound population growth rate is projected to decline from .91 percent over the 1985-1990 period to .50 percent over the 2005-2010 period (Table 4). Over the entire 25 year period, the annual growth rate is projected to be .67 percent.

The projected change in the total population reinforces the projected increase in the per capita demand for lowfat milk market and reduces the negative impacts of lower per capita consumption of whole milk. The overall demand for whole milk is projected to increase over the 1985-1995 period. Over the 1985-2010 period, total whole milk demand is projected to decline at an annual compound rate of -.50 percent while lowfat milk is projected to
increase at an annual rate of 3.56 percent.

The importance of the population increase on overall changes in the demand for lowfat milk diminishes over the 1985-2010 period. The last column in Table 4 shows the ratio of the annual rate of population growth to the growth in lowfat milk demand. This ratio decreases from .385 over the 1985-1990 period to .138 for 1995-2000 and remains relatively constant over the remaining simulation period. The average ratio over the 25 year projection period was .141. Again, these results assume that the demographic effects (i.e., estimated coefficients) do not change over the forecast period.

Conclusions

Changes in the demographic profile along with increased purchasing power have been identified as having important implications for future food consumption patterns. The present study develops a demand system incorporating demographic variables so as to better understand the current structure of the demand for fluid milk products and the implications of projected changes in the demographic characteristics of the U.S. on fluid milk demand. Such a model is important both to the development of agricultural policy as well for the development of marketing strategies associated with these commodities. With recent increases in both generic and brand specific agricultural commodity promotion, knowledge as to the impacts of demographic characteristics are essential to the appropriate segmentation of the population to target such promotion activities.

The results from the demand system estimation are used to estimate changes in the overall market demand for whole milk and lowfat milk products over the years 1985-2010 resulting from changes in the demographic
characteristics of the U.S. The results obtained point to an average annual increase in per capita lowfat milk consumption of 3.6% and a decrease in whole milk consumption of .5%. These results are important given recent debates with respect to changes in the 1985 Food Security Act and the Federal Milk Marketing Orders (GAO, McDowell et al.). Policy makers must take into consideration the increased supply of milkfat that may be generated and any modification to the methods used to determine milk prices should take into account anticipated demand shifts caused by changes in the population's demographic profile.

The present study has been concerned with an analysis of fluid milk demand. From an agricultural policy perspective, it is essential to understand what factors are affecting the utilization of milk in all of its forms. An area of future research would be to include an analysis of the effects of changes in demographic characteristics on the demand for manufactured dairy products. This is important due to the unique situation facing the dairy industry in that at the time that there has been a reduction in the demand for high fat fluid milk products, the consumption of relatively high fat cheese products has been increasing as shown by the increase in the per capita consumption of whole and part whole milk cheeses from 9.7 to 24.0 lbs. over the period 1966-1987 (Putnam). Such trends suggest that there may exist significant differences in the role of demographic and price variables in the demand for fluid milk versus manufactured dairy products.

Heien and Wessells present a model that investigates the demand for a variety of dairy products but use aggregated commodity categories and limit the demographic effects to the intercept terms of the share equations. In order to identify the unique trends associated with specific types of milk
based products, the analysis conducted in the present study should be expanded to a larger number of dairy commodity categories as well as the incorporation and evaluation of alternative methods for measuring demographic effects in demand systems.
Table 1. Estimated Coefficients of the AIDS Model

<table>
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<th>Independent Variables</th>
<th>Price</th>
<th>Dependant</th>
<th>Whole</th>
<th>Lowfat</th>
<th>Juice</th>
<th>Beverages</th>
<th>Food</th>
<th>Toys</th>
<th>POP5</th>
<th>POP513</th>
<th>POP65</th>
<th>SCHOOL</th>
<th>NONWHITE</th>
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<tr>
<td></td>
<td>(.0014)</td>
<td>(.0007)</td>
<td>(.0019)</td>
<td>(.0035)</td>
<td>(.0045)</td>
<td>(.0157)</td>
<td>(.2630)</td>
<td>(.1873)</td>
<td>(.3818)</td>
<td>(.1378)</td>
<td>(.3003)</td>
<td>(.1126)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Food</td>
<td>.02831</td>
<td>-.00228</td>
<td>-.01006</td>
<td>-.06105</td>
<td>.01070</td>
<td>.04444</td>
<td>.52821</td>
<td>.10817</td>
<td>-.18055</td>
<td>-1.3598</td>
<td>-.14737</td>
<td>.30441</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(.0057)</td>
<td>(.0033)</td>
<td>(.0027)</td>
<td>(.0045)</td>
<td>(.0232)</td>
<td>(.0214)</td>
<td>(2.545)</td>
<td>(1.440)</td>
<td>(1.638)</td>
<td>(2.1342)</td>
<td>(1.655)</td>
<td>(.1601)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Asymptotic standard errors are presented in parenthesis. POP5 is a variable representing the proportion of the population less than 5 years old, POP513 is a variable representing the proportion between the ages of 5 and 14, and POP65 is a variable representing the proportion above the age of 65. The variable NONWHITE represents the proportion of the population that is nonwhite. The median number of years of schooling completed for those over 25 years of age is represented by the variable SCHOOL.
Table 2. Compensated Own and Cross Price, Expenditure and Demographic Elasticities

<table>
<thead>
<tr>
<th>Dependant Variable</th>
<th>Whole Milk</th>
<th>Lowfat Milk</th>
<th>Other Drinks</th>
<th>Beverage</th>
<th>Other Expenditures</th>
<th>Demographic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Milk</td>
<td>-.324</td>
<td>.059</td>
<td>-.023</td>
<td>.119</td>
<td>.168</td>
<td>.658</td>
</tr>
<tr>
<td></td>
<td>(.090)</td>
<td>(.038)</td>
<td>(.025)</td>
<td>(.028)</td>
<td>(.099)</td>
<td>(.114)</td>
</tr>
<tr>
<td>Lowfat Milk</td>
<td>.270</td>
<td>-.437</td>
<td>.117</td>
<td>-.130</td>
<td>.180</td>
<td>-1.660</td>
</tr>
<tr>
<td></td>
<td>(.175)</td>
<td>(.218)</td>
<td>(.057)</td>
<td>(.062)</td>
<td>(.287)</td>
<td>(.211)</td>
</tr>
<tr>
<td>Juices</td>
<td>-.051</td>
<td>.058</td>
<td>-.327</td>
<td>-.055</td>
<td>.376</td>
<td>.539</td>
</tr>
<tr>
<td></td>
<td>(.059)</td>
<td>(.029)</td>
<td>(.146)</td>
<td>(.088)</td>
<td>(.150)</td>
<td>(.412)</td>
</tr>
<tr>
<td>Other Bev.</td>
<td>.066</td>
<td>-.016</td>
<td>-.014</td>
<td>-.193</td>
<td>.156</td>
<td>.492</td>
</tr>
<tr>
<td></td>
<td>(.015)</td>
<td>(.008)</td>
<td>(.021)</td>
<td>(.052)</td>
<td>(.056)</td>
<td>(.146)</td>
</tr>
<tr>
<td>Other Food</td>
<td>.010</td>
<td>.002</td>
<td>.010</td>
<td>.017</td>
<td>-.040</td>
<td>1.102</td>
</tr>
<tr>
<td></td>
<td>(.007)</td>
<td>(.004)</td>
<td>(.005)</td>
<td>(.007)</td>
<td>(.011)</td>
<td>(.024)</td>
</tr>
</tbody>
</table>

Note: Approximate standard errors are presented in parenthesis. Refer to Table 1 for the definition of the demographic variables.
Table 3: Decomposition of Projected Annual Rates of Change in the Demand for Whole Milk and Lowfat Milk, 1985-2010

<table>
<thead>
<tr>
<th>YEAR</th>
<th>POP5</th>
<th>POP513</th>
<th>POP65</th>
<th>ALL AGE</th>
<th>NONWHITE</th>
<th>SCHOOL</th>
<th>ALL DEMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHOLE MILK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985-90</td>
<td>-.360</td>
<td>.202</td>
<td>-1.165</td>
<td>-1.323</td>
<td>.616</td>
<td>-.011</td>
<td>-.718</td>
</tr>
<tr>
<td>1990-95</td>
<td>-1.287</td>
<td>.048</td>
<td>-.597</td>
<td>-1.836</td>
<td>.563</td>
<td>-.067</td>
<td>-1.340</td>
</tr>
<tr>
<td>1995-2000</td>
<td>-1.484</td>
<td>-.323</td>
<td>-.037</td>
<td>-1.844</td>
<td>.549</td>
<td>-.060</td>
<td>-1.356</td>
</tr>
<tr>
<td>2000-5</td>
<td>-.792</td>
<td>-.559</td>
<td>-.247</td>
<td>-1.597</td>
<td>.528</td>
<td>-.055</td>
<td>-1.124</td>
</tr>
<tr>
<td>2005-10</td>
<td>-.140</td>
<td>-.430</td>
<td>-1.151</td>
<td>-1.721</td>
<td>.493</td>
<td>-.050</td>
<td>-1.278</td>
</tr>
<tr>
<td>1985-2010</td>
<td>-.813</td>
<td>-.212</td>
<td>-.639</td>
<td>-1.664</td>
<td>.550</td>
<td>-.049</td>
<td>-1.163</td>
</tr>
<tr>
<td>LOWFAT MILK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985-90</td>
<td>.666</td>
<td>-.477</td>
<td>1.134</td>
<td>1.323</td>
<td>.086</td>
<td>.043</td>
<td>1.452</td>
</tr>
<tr>
<td>1990-95</td>
<td>2.382</td>
<td>-.115</td>
<td>.581</td>
<td>2.849</td>
<td>.078</td>
<td>.257</td>
<td>3.184</td>
</tr>
<tr>
<td>2005-10</td>
<td>.260</td>
<td>1.017</td>
<td>1.121</td>
<td>2.398</td>
<td>.069</td>
<td>.191</td>
<td>2.658</td>
</tr>
<tr>
<td>1985-2010</td>
<td>1.504</td>
<td>.502</td>
<td>.623</td>
<td>2.629</td>
<td>.076</td>
<td>.186</td>
<td>2.891</td>
</tr>
</tbody>
</table>

Note: Refer to Table 1 for the definition of the demographic variables.
Table 4: Projected Annual Compound Population Growth Rates and the Impacts on Overall Milk Demand.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Project Pop Change (%)</th>
<th>Total Demand Change Whole Milk (%)</th>
<th>Lowfat Milk (%)</th>
<th>Pop Growth/Total Lowfat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985-90</td>
<td>.909</td>
<td>.191</td>
<td>2.361</td>
<td>.385</td>
</tr>
<tr>
<td>1990-95</td>
<td>.762</td>
<td>-.578</td>
<td>3.946</td>
<td>.193</td>
</tr>
<tr>
<td>1995-2000</td>
<td>.615</td>
<td>-.741</td>
<td>4.468</td>
<td>.138</td>
</tr>
<tr>
<td>2000-05</td>
<td>.540</td>
<td>-.584</td>
<td>3.849</td>
<td>.140</td>
</tr>
<tr>
<td>2005-10</td>
<td>.500</td>
<td>-.778</td>
<td>3.158</td>
<td>.158</td>
</tr>
<tr>
<td>1985-2010</td>
<td>.665</td>
<td>-.498</td>
<td>3.556</td>
<td>.187</td>
</tr>
</tbody>
</table>

Note: The changes in total demand are due to changes in demographic characteristics and in the size of the population. The above results are conditional on 1985 actual prices and total food expenditures in that the impacts of changes in relative actual prices or changes in total food expenditures have not been incorporated.
Table A1. Means of Dependant and Independent Variables and Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Mean</th>
<th>Coefficient of Variation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Milk</td>
<td>$/.5 gal</td>
<td>.677</td>
<td>.399</td>
<td>.387</td>
<td>1.222</td>
</tr>
<tr>
<td>Lowfat Milk</td>
<td>$/.5 gal</td>
<td>.642</td>
<td>.393</td>
<td>.385</td>
<td>1.079</td>
</tr>
<tr>
<td>Juice</td>
<td>$/pound</td>
<td>.356</td>
<td>.419</td>
<td>.207</td>
<td>.742</td>
</tr>
<tr>
<td>Other Beverage</td>
<td>$/gal</td>
<td>.871</td>
<td>.682</td>
<td>.400</td>
<td>1.991</td>
</tr>
<tr>
<td>Other Food Index</td>
<td>-----</td>
<td>1.534</td>
<td>.508</td>
<td>.816</td>
<td>3.098</td>
</tr>
<tr>
<td>Total Food Exp</td>
<td>$</td>
<td>777.5</td>
<td>.582</td>
<td>351.8</td>
<td>1760.5</td>
</tr>
<tr>
<td>Demographic Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCHOOL</td>
<td>years</td>
<td>11.871</td>
<td>.060</td>
<td>10.4</td>
<td>12.6</td>
</tr>
<tr>
<td>POP5</td>
<td>percent</td>
<td>9.074</td>
<td>.185</td>
<td>7.1</td>
<td>11.3</td>
</tr>
<tr>
<td>POP513</td>
<td>percent</td>
<td>15.426</td>
<td>.128</td>
<td>12.6</td>
<td>18.7</td>
</tr>
<tr>
<td>POP65</td>
<td>percent</td>
<td>10.023</td>
<td>.105</td>
<td>8.5</td>
<td>11.9</td>
</tr>
<tr>
<td>NONWHITE</td>
<td>percent</td>
<td>12.858</td>
<td>.122</td>
<td>10.7</td>
<td>15.4</td>
</tr>
</tbody>
</table>

Note: Refer to Table 1 for the definition of the demographic variables.
### Table A2. Pearson Correlation Coefficients for Price and Demographic Variables

<table>
<thead>
<tr>
<th></th>
<th>Prices</th>
<th>Demographic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whole Milk</td>
<td>Lowfat Milk</td>
</tr>
<tr>
<td>Whole Milk</td>
<td>1.000</td>
<td>.9899</td>
</tr>
<tr>
<td>Lowfat Milk</td>
<td>1.000</td>
<td>.8599</td>
</tr>
<tr>
<td>Juice</td>
<td>1.000</td>
<td>.9010</td>
</tr>
<tr>
<td>Other Rev</td>
<td>1.000</td>
<td>.9733</td>
</tr>
<tr>
<td>Other Food</td>
<td>1.000</td>
<td>.7965</td>
</tr>
<tr>
<td>SCHOOL</td>
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<td>.8859</td>
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<tr>
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<td>.7645</td>
</tr>
<tr>
<td>POP513</td>
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</tr>
<tr>
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<td>1.000</td>
<td>.9655</td>
</tr>
<tr>
<td>NONWHITES</td>
<td>1.000</td>
<td>.9195</td>
</tr>
<tr>
<td>EXPEND</td>
<td>1.000</td>
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</tr>
</tbody>
</table>

**Note:** These correlation coefficients are for the natural logarithm of each variable. The variable EXPEND is total food expenditure deflated by Stone's Index. Refer to Table 1 for the definition of the demographic variables.
Footnotes

1. The generic term "lowfat milk" is used here to include buttermilk, lowfat flavored drinks, skim milk, and lowfat milk. For a more detailed discussion of the trends in per capita consumption of fluid milk products refer to Haidacher et al.

2. The term "lowfat milk" in the context of the sales data includes lowfat and skim milk products only. Sales data was used in place of disappearance data because of detailed product differentiation.

3. In the estimated model, the lowfat milk categories include lowfat milk and skim milk. The "other beverages" category is composed of coffee, tea, and non-alcoholic carbonated beverages.

4. Three age categories are used because of the unique nutritional requirements of the very old versus the very young segments of the population. We limited the number of age categories to three because of problems with degrees of freedom and collinearity. In earlier versions of the model, alternative age category groupings were used but resulted in statistically insignificant results.

5. The final estimated equation used (with the coefficient standard error in parenthesis) was:

\[ \text{LOWFATPR} = 1.0754 \times \text{SKIMPR} \]

\[ \text{Std. Error of Est} = 0.027 \]

\[ (0.0033) \]

\[ \text{Mean of LOWFATPR} = 1.061 \]

where \text{LOWFATPR} and \text{SKIMPR} are the monthly half gallon prices of lowfat and skim milk, respectively. Earlier analyses allowed for an intercept term in the above equation but when used to estimate the price of lowfat milk out of the sample period, unrealistically high estimates were obtained and thus omitted from the final regression.
We examined the impact of including a time trend variable in the share equations on the sign and significance of the demographic variables. Inclusion of the time trend did not change the sign nor significance of any of the demographic variables that were significant in the original system nor did it change the significance level of those demographic variables that were not significant. The magnitudes of the variables were not affected appreciably.

As noted by an anonymous reviewer, the following analysis implicitly assumes that the demographic coefficients remain stable over the projection period. An area for further study would be to use a varying coefficients model to allow for these coefficients to change over time. Moschini and Meilke develop a varying coefficients model that may be useful for these purposes.

Given the uncertainty with respect to future prices, this analysis is undertaken with observed prices held constant at 1985 levels. With increased consumption of lowfat milk products, the milkfat that was previously contained in whole milk sales could be used in the production of other dairy products. This reallocation may have substantial effects on the relative prices of both fluid and non-fluid dairy products. In the present analysis we are only concerned with examining the impacts of changes in demographic characteristics on fluid milk demand.

These population projections are based on the Middle Series in order to be consistent with the demographic changes analyzed previously. Refer to Spencer for a discussion of the assumptions associated with the Middle Series.
Bibliography


DAIRYFIELD. 171 (December 1988): 8-10.


