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Modeling the Effects of Generic Advertising on the Demand for Fluid Milk and Cheese:

A Time-Varying Parameter Application

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Abstract

Previous constant-parameter demand models have estimated generic advertising elasticities for cheese to be below that for fluid milk. We relax this assumption, allowing for generic advertising response to vary over time. Cheese advertising elasticities were found below fluid milk up until the mid-1990s; average elasticities since have been similar.

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Introduction

Evaluation of generic commodity promotion programs is a necessary component of managing producer checkoff dollars to determine net benefits to producers. One component of such an evaluation requires the estimation of demand effects of the generic advertising programs. This paper addresses this component by estimating national retail demand relationships for fluid milk and cheese, incorporating generic advertising expenditures. We extend previous research in this area by adopting demand models that allow generic advertising response to vary over time. While time-varying models have been applied to fluid milk studies in New York City (Kinnucan, Chang, and Venkateswaran; Reberte, et al.; Chung and Kaiser) and to the fluid milk market in Ontario (Kinnucan and Venkateswaran), no applications have been made to the national U.S. programs for fluid milk and cheese.

Previous models of national fluid milk and cheese demand incorporating generic advertising (e.g. Kaiser; Sun, Blisard, and Blaylock) have assumed a constant-parameter framework utilizing data spanning relatively long time periods; i.e., 15 to 25 years. It may be unreasonable to expect that a mean-response model is sufficient, given changes in market environments, population profiles, or eating behavior over a long time period. The use of such models may be especially problematic when used for more recent period market simulation purposes for which the mean-response is no longer applicable. The time-varying parameter models estimated here allow for generic advertising response to change over time, modeled as a function of variables reflecting current market and demographic environments.

The time-varying advertising specification includes variables that are also relevant to standard demand specifications. As such, while not only are generic advertising elasticities allowed to vary over time, so are the demand elasticities with respect to the market variables included in the generic advertising parametric specification. Finally, we decompose the contribution of the factors related to the variation of advertising response over time. This gives product marketers information on what factors have caused advertising response to change and, with it, the opportunity to adjust future campaigns to enhance demand response for their products.

The Conceptual Model

One approach to estimating a time-varying parameter model with respect to advertising response is formulated in the context of advertising wearout theory. Wearout theory generally suggests that effectiveness of advertising will vary over time given that once consumers become familiar with the advertisements focused on a particular theme, repeated exposures may be ignored or tuned out, implying a market response that is not constant during a campaign duration (Kinnucan, Chang, and Venkateswaran). This approach is modeled specifying the advertising response parameters as a function of time and associated advertising theme variables. Empirical applications with generic advertising include Kinnucan, Chang and Venkateswaran; Kinnucan and Venkateswaran, and Reberte, et al. While this formulation allows advertising response to change over time, the variation is limited to the argument of wearout to a given campaign and requires data that accurately tracks changes in theme content.

The distinction of specific themes for generic campaigns that are practically different from, say, “Drink More Milk” or “Eat More Cheese” may be somewhat elusive. Many campaign messages have mixed themes, including themes related to education, nutrition, or alternative uses

for the product. In addition, it is likely that variation in advertising response is related to changes in market environments, eating habits, or changes in the consuming population. Chung and Kaiser used such a modeling approach for the fluid milk market in New York City by assuming that the advertising coefficient was a function of both environmental variables (i.e. product price, competing advertising, health concerns, racial and age population proportions, and consumer food expenditures) and managerial variables (i.e. advertising theme variables). We follow a similar approach here, with application to the national generic fluid milk and cheese advertising campaigns.

In addition to capturing the structural heterogeneity in advertising response over time, the dynamic nature of advertising on demand is also modeled. An exponential distributed lag (EDL) structure is applied and is relatively flexible, allowing for either geometric decay or hump-shaped lagged advertising response. The EDL structure is also flexible in that only a maximum lag length needs to be specified, with the appropriate weighting scheme determined empirically from the data. The data used in this application do not included specific advertising theme information and so, in essence, the generic campaign is treated as one common, general theme. The combination of the carryover effects of advertising and the time-varying response from changes in market or economic stimuli is assumed to accurately model the variation in advertising response.

Consider the following general time-varying demand specification:

$$(1) \quad Y_t = \alpha_0 + \alpha' X_t + \phi BGW_t + \gamma_t GGW_t + \varepsilon_t,$$

where Y_t is product disappearance at time period t (t=1,…,T), X_t is a K-dimensional vector of predetermined variables other than advertising, BGW_t and GGW_t are the goodwill stocks of brand and generic advertising expenditures, respectively (to be defined shortly), α_0, α, ϕ, and

y_t are parameters to be estimated, and e_t is a random disturbance term. The subscript *t* on the generic advertising parameter reflects the heterogeneity hypothesized with generic advertising response over time.[1]

Given that the above model requires the estimation of at least 2+*K*+*T* coefficients with only *T* observations, it is necessary to impose some structure on the nature of the time-varying response.[2] To account for the structural heterogeneity of advertising response, we define the goodwill parameter function as:

$$(2) \quad y_t = \exp(d_0 + d'Z_t) + v_t,$$

where $\exp(\cdot)$ represents the exponential function, d_0 is the intercept term to estimate, Z_t is a vector of exogenous variables assumed to affect consumer response to generic advertising, d is a vector of parameters to be estimated, and v_t is a random disturbance term. The exponential function used to model the trajectory of y_t over time is relatively flexible and reflects generic advertising's *a priori* expected positive effect on demand. Equation (2) partitions the observed parameter variation into its systematic ($\exp(d_0 + d'Z_t)$) and random (v_t) components. Systematic variation in advertising response can be modeled as a function of income or price levels, changing age or race profiles, or household purchase patterns. The random sources of parameter variation may stem from infrequent news stories or other publicity about the product, changes in the media mix, or changes in the target audience (Kinnucan and Venkateswaran).[3]

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[1] Since the primary focus of this research is on generic advertising response, only the generic parameters are assumed to vary with time. Estimation of a constant parameter version of (1) showed insignificant brand advertising effects and therefore this effect was left fixed in the time-varying specification.

[2] There are additional parameters to be estimated for the construction of the advertising goodwill variables. These will be discussed shortly.

[3] The following error term distributions are assumed for the advertising parameter specification: $v_t \sim (0, s_v^2)$; $E(e_t, v_t) = 0 \; \forall \; t$; $E(v_t, v_t) = 0 \; \forall \; t \neq t$.

The advertising goodwill variables are computed as a function of current and lagged expenditures, allowing for carryover effects of advertising on sales. To mitigate the impact of multicollinearity among the lagged advertising variables, the lag-weights are approximated using a quadratic EDL structure. Following Cox, the EDL structure for generic advertising can be described as:

$$(3)\quad GGW_t = \sum_{j=0}^{J_g} w_j^g GADV_{t-j}\ ,\ w_j^g = \exp\left(l_{0,g} + l_{1,g}\, j + l_{2,g}\, j^2\right),$$

where w_j^g represents the J_g lag weights, $GADV_{t-j}$ is the t-j^{th} generic advertising expenditure, and $l_{i,g}$ (i=0,1,2) are parameters to be estimated.[4] Previous studies (e.g. Kinnucan, Chang, and Venkateswaran; Reberte et al.; Chung and Kaiser; and Kaiser) have found that a lag length of six quarters is sufficient to model the carryover effect of advertising. The EDL structure is attractive since an upper-bound lag length can be specified, with the data determining the appropriate weighting scheme; i.e. the lag weights can be close to zero before the upper bound lag is reached. The lag weight on the sixth lag is defined to be approximately zero (exp(-30)) and the current period is normalized to one.[5] Using the above restrictions and collecting terms implies the following lag-weight formulation:

$$(4)\quad w_{j,g} = \exp\left(-5j + l_{2,g}\left(j^2 - 6j\right)\right)\quad j = 1,\ldots,6.$$

As Cox points out, this specification is flexible enough to represent either geometric decay or a hump-shaped carryover effect, depending on the level of $l_{2,g}$. Substituting the (2) and (3) into (1) yields:

[4] The brand advertising goodwill variable is similarly constructed to compute the respective brand advertising lag-weights from estimated coefficients $l_{i,b}$ (i=0,1,2). For brevity, we detail the derivation only for the generic advertising variable. The lag weight parameters for both the brand and generic components are estimated simultaneously.

[5] Note that the normalization is simply for mathematical convenience and does not affect the forthcoming advertising elasticities.

$$(5)\quad Y_t = \alpha_0 + \alpha' X_t + \phi \sum_{j=0}^{J_b} w_{j,b} BADV_{t-j} + \exp(\delta_0 + \delta' Z_t) \sum_{j=0}^{J_g} w_{j,g} GADV_{t-j} + w_t$$

$$\text{where} \quad w_t = e_t + \nu_t \sum_{j=0}^{J_g} w_{j,g} GADV_{t-j}.$$

The error term from (2) induces a heteroskedastic error formulation in (5). The appropriateness of the stochastic specification in (2) can be tested by determining whether w_t is actually heteroskedastic. The structural heterogeneity advertising component of (5) can be tested by imposing appropriate zero-restrictions; i.e. $\gamma_t \equiv \gamma$. An advantage of this formulation is that the combined demand equation in (5) reduces to a nonlinear least-squares estimation problem with generic advertising goodwill stocks interacting with the exogenous variables contained in **Z**. In so doing, not only is the demand response to generic advertising allowed to vary over time, but also to those variables contained in **Z**.

Empirical Specification

The empirical specifications of the retail fluid milk and cheese models are similar to those originally specified in Kaiser. Specific advertising theme variables are not included in the time-varying specification due to a lack of data. The data is national, quarterly, and encompasses the time period from 1975 through 2001. Fluid milk and cheese sales represent product disappearance data and were acquired from USDA.[6]

Following Kaiser, we hypothesize that fluid milk and cheese sales are affected by their own price, prices of substitutes, consumer income levels, per capita food expenditures eaten away from home (for cheese), the influence of BST in fluid milk, seasonality, race and age population compositions, and generic and branded advertising expenditures. Furthermore, it was hypothesized that changes in relative price levels, consumer incomes, race and age population

[6] Special thanks to Don Blaney at ERS, USDA for providing much of the data used here, including product disappearance, prices and price indicies, inventory holdings, population, and income data.

compositions, and eating habits would be important factors in modeling the variation in advertising response.[7]

Following the model structure above, the fluid milk empirical model is specified as:

$$(6)\quad \ln RFD_t = a_0^m + a_1^m \ln RFP_t + a_2^m \ln INC_t + a_3^m \ln T_t + a_4^m \ln AGE5_t + a_5^m BST_t + a_6^m QTR1_t + a_7^m QTR2_t + a_8^m QTR3_t + f^m \ln BMGW_t + y_t^m \ln GMGW_t + e_t^m$$

and

$$y_t^m = \exp\left(d_0^m + d_1^m RFP_t + d_2^m INC_t + d_3^m AGE5_t + d_4^m BLACK\right) + v_t^m \ ,$$

where the *m* superscript refers to fluid milk demand parameters, *RFD* is per capita retail fluid milk demand (milkfat equivalent basis), *RFP* is the consumer retail price index (CPI)for fresh milk and cream deflated by the CPI for nonalcoholic beverages, *INC* is per capita disposable personal income deflated by the CPI for all items, *T* is a time trend, *AGE5* is the percentage of the U.S. population under six years of age, *BST* is an intercept dummy variable for bovine somatotropin (1994-current equals 1, 0 otherwise), *QTR1*, *QTR2*, and *QTR3* are quarterly seasonal dummy variables, *BMGW* and *GMGW* are the national brand and generic advertising goodwill variables as defined above, and *BLACK* is the proportion of the population identified as African American.[8]

Similarly, the retail cheese demand model is specified as:

$$(7)\quad \ln RCD_t = a_0^c + a_1^c \ln RCP_t + a_2^c \ln INC_t + a_3^c \ln FAFH_t + a_4^c \ln OTHER_t + a_5^c QTR1_t + a_6^c QTR2_t + a_7^c QTR3_t + f^c \ln BCGW_t + y_t^c \ln GCGW_t + e_t^c$$

and

$$y_t^c = \exp\left(d_0^c + d_1^c RCP_t + d_2^c INC_t + d_3^c FAFH_t + d_4^c AGE2044_t + d_5^c OTHER\right) + v_t^c \ ,$$

[7] The original specification also included branded advertising goodwill stocks in the generic advertising parametric specification; however, estimation and convergence problems precluded its inclusion in the final time-varying model. This was not unexpected given the insignificant branded advertising effects estimated in the constant parameter models for both fluid milk and cheese.

[8] Advertising expenditures were provided by Dairy Management, Inc. (DMI), deflated by a Media Cost Index constructed from information provided by DMI. Population age and race proportions were collected from www.economagic.com. Food-away-from-home expenditures were collected from www.ers.usda.gov/briefing/CPIFoodAndExpenditures/Data.

where the *c* superscript refers to cheese demand parameters, *RCD* is per capita retail cheese demand (milkfat equivalent basis), *RCP* is the CPI for cheese deflated by the CPI for meats, *OTHER* is the proportion of the population identified as Asian/Other (specifically, non-White and non-African American), *FAFH* is per capita expenditures on food eaten away from home, and *BCGW* and *GCGW* are the brand and generic cheese advertising goodwill variables, respectively. Descriptive statistics for the variables included in the retail demand models are included in Table 1.

Estimation and Testing Results

Estimation results are displayed in Table 3. Before discussing those results, we need to evaluate the heteroskedastic nature of the residuals. Imposing homoskedasticity, i.e. removing the error term in (2), reduces the time-varying parameter models to systematic models that can be estimated by nonlinear least squares. The formulation above indicates that the form of heteroskedasticity may be related to advertising. As such, we chose two alternative tests based on the residuals of the fitted models: the Breusch-Pagan and Glesjer tests.

The Breusch-Pagan heteroskedasticity test is a Lagrange multiplier test of the hypothesis that $s_t^2 = s^2 f(k_0 + k'W_t)$, where W_t is a vector of independent variables and a null hypothesis of homoscedasticity, i.e. $k = 0$ (Greene, p.552). The more specific we can be regarding the form of heteroskedasticity, the more powerful is the corresponding test. The Glesjer test is then potentially more powerful given that the form of the heteroskedasticity is specified *a priori*. We consider three formulations of the advertising-related heteroskedasticity as outlined in Table 2. In each case, a preliminary regression is computed to estimate k for use in a feasible generalized least squares (FGLS) estimator of the primary model parameters. A joint test of the hypothesis that the slopes are all zero would be equivalent to a test of homoskedasticity and a Wald statistic

can be used to perform the test (Greene, p. 554). Since the heteroskedasticity can be traced to the generic advertising variable, we include the generic advertising goodwill stock variable as an independent variable for both tests.

The test results fail to reject the null hypothesis of homoskedasticity at any reasonable significance level in all cases. Therefore, we conclude that the fluid milk and cheese models with systematic (non-random) parameter variation are the appropriate specifications (i.e. the random elements do not impact the level of the goodwill parameters) and, thus, can be estimated with nonlinear least squares. This is consistent with the results of Kinnucan and Venkateswaran (1994) for fluid milk in Ontario, and Reberte et al. (1996) for fluid milk in New York City.

Given the time series nature of the data, we also tested for autocorrelation of the residuals. Durbin-Watson statistics were computed for both the constant and time-varying parameter models. While cheese demand did not exhibit any serial correlation in residuals, we do control for first-order autocorrelation in fluid milk demand. Finally, given the nature of the disappearance and price data, price endogeneity is expected. As such, we estimate both models using two-stage nonlinear least squares. The instrument set included the exogenous variables in the demand models; as well as lagged-supply stocks, farm-level wage rates, cow prices, and feed ration costs to capture supply-side influences on retail demand.

Estimation results reveal both models demonstrate reasonable explanatory power with adjusted R-square values at or above 0.94 (Table 3). Wald tests were constructed to test the structural heterogeneity of the advertising parameters. Both models reject the null hypothesis that the associated time-varying advertising parameters are zero at the 10% significance level, however the conclusion is sufficiently stronger in the case for cheese. It is important to remember that individual *t*-tests for parameters are only asymptotically valid for nonlinear

models and caution is advised in drawing inferences from these *t* tests for small samples. The Wald tests confirm that the time-varying specifications are appropriate.

The estimated lag-weight parameters confirm a hump-shaped lagged advertising response commonly applied in previous generic advertising studies for dairy products (e.g. Kaiser, Liu, et al., Suzuki et al.). Converting the lag-weight parameters to the associated distribution parameters (i.e. using equation (4)) and normalized to sum to unity, indicates that the generic fluid milk advertising weights have relatively small weights through the first-quarter lag, peaking at the second-quarter lag (w_2=0.56), and dropping close to zero by the fourth-quarter lag. Cheese advertising exhibited a hump-shaped distribution as well; however, it exhibited a much denser distribution with larger weights to more current periods (w_0= 0.09, w_1=0.63) and diminishing close to zero after the third-quarter lag. The shorter lag-distribution for cheese relative to fluid milk is consistent with the empirical results in Kaiser that applied five-quarter lags to generic fluid milk advertising and three-quarter lags to generic cheese advertising using a polynomial distributed lag structure.

Demand Elasticities

Given the nonlinear specification of the time-varying parameter models, the regression results of Table 3 are most usefully evaluated in terms of calculated elasticities. Table 4 provides selected elasticities for the time-varying models evaluated at the sample means. Given the specification of the time-varying parameter model, all of the elasticities associated with the variables in **Z** change over time. For example, the price elasticity from the fluid milk model can be expressed as:

$$(8)\quad \frac{\partial \ln RFD_t}{\partial \ln RFP_t} = a_1^m + d_1^m \exp\left(d_0 + d_1' Z_t\right) \ln GMGW_t \cdot RFP_t$$

The remaining elasticities are similarly derived. The computation of these elasticities at the sample means provides results roughly indicative of a mean-response model and gives a reasonable expectation of statistical significance. All results are consistent with *a priori* expectations and most are statistically significant.

The price elasticities in Table 4 are of the right sign with magnitudes similar to Kaiser. Income elasticities are positive and inelastic for both products, indicating fluid milk and cheese are normal goods; however, the elasticities are quite similar in magnitude. The negative sign on the time trend for fluid milk is indicative of a decrease in per capita consumption over time, while the large positive sign of FAFH is consistent with the expectation that cheese consumption is higher away from home, where roughly two-thirds of cheese disappearance occurs (USDA).

The positive age composition elasticities are indicative of the higher nutritional demands for young children with respect to milk consumption, higher average consumption by middle-aged consumers. The race variables were significant for cheese, but not for fluid milk. The negative demand effect for African American consumers is well documented; a negative sign was was exhibited here, but was not significantly different from zero. Variation in the *OTHER* variable for cheese, however, did significantly contribute to the variation in cheese demand and demonstrated positive effects from Asian/Other populations.

Long run advertising elasticities can be computed from the associated goodwill stock variables.[9] Given the double-log functional form, branded advertising elasticities are directly interpretable from the estimated parameters (f^m and f^c). For the time-varying specifications, the long run generic advertising elasticity for the fluid milk model can be derived as:

[9] "Goodwill" and "advertising" elasticities are commonly used interchangeably in the literature. Since it is important to include the lagged-distribution effects of advertising, a "long run" effect can be calculated by using the goodwill stock variables derived from the estimated lag-weight parameters. Here, long run advertising expenditure elasticities and advertising goodwill elasticities are used interchangeably.

$$(9) \quad e_{LR}^{m} = \frac{\partial \ln RFD_t}{\partial \ln GMGW_t} = \exp(d_0 + d'Z_t).$$

The long run time-varying generic cheese advertising elasticities are similarly computed, given the respective included variables in **Z**.

Branded advertising expenditures did not significantly contribute to the explained variation in demand in either model estimated. While any advertising objective includes increasing sales, branded advertising efforts heavily concentrate their efforts on gaining market share from their competitors, which may have no, or a potentially negative impact on total sales. This is reflected in the empirical results here. Generic advertising was, however, significant in both models, especially for the case of fluid milk. The long run elasticities calculated at the sample means are similar in magnitude to those in Kaiser.

While, the estimated elasticities at the sample means provide some indication of the relative importance of these variables on per capita demand, it is perhaps more interesting to see how these elasticities have changed over time. We highlight some of these changes next with respect to price, income, age, and generic advertising resposne.

In a time when component- and market order milk pricing options are gaining increased attention, variation in demand price response over time is incredibly important. The time-varying specification offered here, allows for price response to vary over time. As Figure 1 demonstrates, price elasticities were relatively low in the late-1970s and early-1980s for both products. Since the late-1980s, however, cheese price elasticities have been trending upward significantly. Current cheese price elasticities are approximately –0.40 compared to the –0.06 exhibited in the mid-1980s. Fluid milk price elasticities, in contrast, have shown little variation over time, with current estimates slightly above –0.10, consistent with other estimates in the literature (i.e., Kaiser; Sun, Blisard, and Blaylock).

A somewhat surprising result of the model is the suggestion of strong growth in income elasticities for both products over time (Figure 2). While most periods estimate income elasticities for cheese higher than that for fluid milk, the difference is usually small and the relative movement over time is quite similar. While the trend in income elasticities since the mid-1990s is less clear, the relatively high levels exhibited currently should be beneficial to future demand levels as real per capita incomes continue to increase.

While the young age cohort for fluid milk remains an important factor to demand levels, age elasticities have been declining since the mid-1990s as this proportion of the total population continues to decrease (Figure 3). On the other hand, elasticities for the middle-aged cohort for cheese demand have remained relatively constant since the late 1980s when this factor grew in importance. Even so, the positive effects of these cohort classes on per capita demand levels; i.e. very young children for fluid milk and middle-aged consumers for cheese, clearly remains important.

The time-varying long run advertising elasticities show substantial variation over time, with both increasing considerably since the beginning of the sample period (Figure 4). Since 1995, however, both fluid milk and cheese elasticities have demonstrated modest decreases. Both products demonstrated relatively constant response levels early in the sample period and exhibited noticeable increases following inception of the national program in 1984. A similar increase in advertising response was not exhibited in 1995 for fluid milk following the addition of advertising expenditures from the milk processor MILKPEP program. However, these expenditures are combined with farmer-funded expenditures in the data which have been reduced somewhat since MILKPEP began.

Previous constant-parameter studies have consistently shown generic advertising elasticities for cheese demand below that for fluid milk demand (e.g. Kaiser). Looking at the response levels over the entire sample period exhibits this characteristic as well, at least until more recently. In fact, since 1997, generic advertising elasticities for fluid milk have averaged 0.042, compared with an average generic cheese advertising elasticity of 0.039. Recent response levels indicate that both programs have generated quite similar response levels at the margin.

Advertising Response Elasticities

The structural specification of (5) allows not only for advertising response to vary over time, but also provides information on the relative importance of the factor variability that determine changes in advertising response levels. Allowing advertising response to vary over time is important, but knowing what factors contributed to that variation, and by how much, provides valuable information for crafting future strategies, changing the advertising focus, or altering preferred target audiences. By taking the derivative of (9) with respect to the independent variables in **Z**, we can compute what we define as "generic advertising response elasticities." That is, we can derive the percentage change in the long run generic advertising elasticity with respect to a change in the level of the variable. For example, the elasticity of long run advertising response with respect to the retail farm milk price can be derived as:

$$(10) \quad z^{m}_{RFP} = \frac{\partial e^{m}_{LR,t}}{\partial RFP_t}\frac{RFP_t}{e^{m}_{LR,t}} = \left[d_1 \exp\left(d_0 + d'\mathbf{Z}_t\right)\right]\cdot\left[RFP_t / \exp\left(d_0 + d'\mathbf{Z}_t\right)\right] = d_1 RFP_t \; .$$

Advertising response elasticities were calculated at each *t* and averaged over the time period of 1997-2001 to evaluate more recent influences on changes in advertising response (Table 5). The relatively low standard deviations indicate that these response elasticities have been relatively constant over the time period evaluated. The response elasticities do, however, differ considerably between fluid milk and cheese. Price effects were negative in both cases;

however the generic advertising response elasticity for cheese was considerably higher than that for fluid milk. The negative signs indicate that advertising is more effective during periods of lower product prices. As such, coordinating advertising efforts with price promotions would be an effective strategy to increase overall advertising response.

The positive signs on income's generic advertising response elasticities indicate that increasing income levels have increased the effectiveness of both fluid milk and cheese advertising, although the effect was nearly 40% higher for cheese. The large, positive signs indicate that designing advertising messages targeting middle- and high-income should result in higher advertising responses, ceterus paribus.

As consumers spend more on food away from home, generic cheese advertising elasticities are reduced (Table 5). While the predominance of cheese disappearance occurs in the FAFH sector, nearly all generic cheese advertising is focused on at-home consumption. As such, it is reasonable to expect that as consumers spend more of their budget away from home, the current generic cheese advertising message becomes less effective. If per capita FAFH expenditures are expected to increase in the future, then direction of generic cheese advertising towards the away-from-home market may be appropriate.

Both age composition advertising response elasticities for fluid milk and cheese were large and positive (Table 5). A positive demand relationship between per capita cheese consumption and the proportion of the population between 20 and 44 years of age indicates that this cohort group consumes more cheese per capita than those in the younger or older cohorts; the positive generic cheese advertising response elasticity indicates that this cohort is also more responsive to the generic advertising message. A similar relationship exists for the fluid milk category and proportion of the population under age six. It follows then that advertising

strategies targeted towards these cohorts would be an effective approach to increase generic advertising response. That is, targeted messages to middle-aged consumers for cheese and to adults with young children (the implied decision makers for the youngest cohort) would be expected to increase per capita advertising response to these programs.

Finally, both race-related advertising response elasticities for fluid milk and cheese are of the same sign as their respective demand elasticities. That is, as the proportion of African Americans in the population increases, there is both a negative demand effect for fluid milk as well as decreased advertising response. Similarly, the positive demand impact of increases in the Asian/Other population is reinforced with increases in advertising elasticities. From an advertising perspective for cheese, this is a "win-win" situation. The Asian population proportion has increased approximately 11% since 1997, and it appears that this segment of the population is more responsive to the generic advertising message.

The advertising response elasticities highlighted in Table 5 indicate changes in generic advertising elasticities for marginal (i.e., small) changes in the associated variables. However, the resulting effect on changes in the generic advertising elasticity depends on both the level of the response elasticity as well as the actual change in the level of these variables over time. To evaluate the relative contributions of changes in these market and demographic variables on recent changes in generic advertising elasiticities, we multiply the percentage changes in these variables over the time period of 1997-2001 by the associated response elasticity in Table 5. The result of this decomposition is exhibited in Figure 5.

Looking at the generic advertising response elasticities in this framework indicates that decreases in the proportion of the population under age six and increases in per capita income have had the largest impacts on variation in advertising response for fluid milk over the last five

years (Figure 5). Even though the age advertising response elasticity was positive, the negative contribution of the age cohort effect is due to the fact that the proportion of the population in this cohort has decreased since 1997. The effect of price changes over this time period on variation generic advertising elasticities for fluid milk was about one-half of that exhibited by the other two variables, and race effects (via changes in the proportion of the African American population) were minimal. The combined negative contribution of the price, age, and race effects slightly outweigh the positive income contribution and reflects the modest reduction in the generic fluid milk advertising elasticities since 1997.

The largest contributors to the variation in generic cheese advertising response were due to increases in per capita income levels (positive) and per capita FAFH expenditures (negative), with the each factor substantively negating the effect of the other (Figure 5). That is, advertising gains from increases in real per capita income were largely offset by increases in per capita FAFH expenditures. Race, price, and middle-aged cohort effects were also significant but well below those of the income and FAFH effects. While the generic advertising response elasticities were relatively large for the price and age variables, the decomposition effects since 1997 were reduced by relatively small changes in these variables since 1997 (+4% for price, -4% for the proportion of the population age 20-44). Again, the combined negative contributions slightly outweigh the positive contributions, consistent with the modest decrease in generic cheese advertising elasticities since 1997.

Conclusions

The structural heterogeneity of generic advertising response has been rarely tested in the literature and has not been applied to the evaluation of the national generic advertising campaigns for fluid milk and cheese. This study extends previous research by applying such a

model to these generic advertising programs. Previous models of national retail fluid milk and cheese demand incorporating generic advertising have utilized data spanning several decades. It is unreasonable to expect that constant-parameter or mean-response models are appropriate for this lengthy time horizon. The time-varying parameter model used here allows for generic advertising response to the fluid milk and cheese programs to change over time as a function of variables reflecting current market and demographic environments.

Advertising elasticities were shown to be significantly variable over time, with substantial increases in response since the beginning of the sample period. As was the cases with previous constant-parameter models, the generic advertising elasticities for cheese were predominantly below those of fluid milk for much of the sample period. However, since 1997 these elasticities have been relatively similar with average elasticities for fluid milk and cheese equal to 0.042 and 0.039, respectively. The flexible nature of the empirical specification also allowed for variation in other demand elasticities with respect to price, income, population age compositions, food purchase patterns, and race. With the exception of price elasticities for fluid milk, all other elasticities exhibited substantial variation over time.

A decomposition of the advertising variation since 1997 reveals that age composition and income changes were the most important determinants of advertising response variation for fluid milk. Income and FAFH changes were the most important factors contributing to generic cheese advertising response variation, while changes in race, age composition, and price were of secondary importance.

Generic advertising response elasticities indicate that advertising appears more effective during lower price periods. Also, model results indicate that advertising response could be enhanced by targeting middle- to upper-income households, adults with young children (for fluid

milk), and middle-aged consumers for cheese. The negative effect of per capita FAFH expenditure changes on generic advertising response also implies that changing the target of cheese advertising to the away-from-home segment may be appropriate.

Previous constant-parameter fluid milk and cheese demand models have been subsequently used in a simulation context to determine benefit cost ratios of the generic advertising programs. This is the next logical step in the time-varying demand response application for evaluation of these programs. If advertising response has indeed changed over time, simulating the model over time and incorporating supply-side effects should provide more appropriate measures of net return to milk processors and producers. Finally, the variation in price and advertising elasticities could be used to predict optimal seasonal advertising intensities using different advertising investment rules and be used as a tool to predict intensity levels in future periods.

Table 1. Description of Variables.[†]

Variable	Description	Units	Mean[††]
	Endogenous Variables		
RFDPC	Quarterly retail fluid milk demand per capita	lbs. MFE	53.94 (3.24)
RCDPC	Quarterly retail cheese demand per capita	lbs. MFE	46.72 (10.27)
RFP	Consumer retail price index (CPI) for fresh milk & cream (1982-84=100), deflated by the CPI for nonalcoholic beverages	#	1.09 (0.16)
RCP	CPI for cheese (1982-84=100), deflated by the CPI for meat	#	0.99 (0.05)
	Exogenous Variables		
INCPC	Per capita disposable personal income ($000), deflated by the CPI for all items (1982-84=100)	$	12.19 (1.42)
AGE5	Percent of population under age 6	%	7.31 (0.24)
AGE2044	Percent of population age 20 to 44	%	38.10 (1.77)
FAFH	Real per capita food away from home expenditures ($1988)	$	215.54 (24.55)
BST	Intercept dummy variable for bovine somatotropin, equal to 1 for 1994.1 through 2000.4, equal to 0 otherwise	0/1	0.30
BLACK	Percent of population identified as African American	%	11.21 (0.54)
OTHER	Percent of population identified as non-White and non-African American	%	3.30 (1.03)
GFAD	Quarterly generic fluid milk advertising expenditures, deflated by the Media Cost Index ($2001)	$mil.	23.72 (14.00)
BFAD	Quarterly branded fluid milk advertising expenditures, deflated by the Media Cost Index ($2001)	$mil.	4.15 (2.46)
GCAD	Quarterly generic cheese advertising expenditures, deflated by the Media Cost Index ($2001)	$mil.	10.65 (7.16)
BCAD	Quarterly branded cheese advertising expenditures, deflated by the Media Cost Index ($2001)	$mil.	32.66 (11.87)

[†] Quarterly intercept dummy variables (QTR1 – QTR3) are also included in the models to account for seasonality. To allow for supply-side influences in the demand estimation, variables including lagged supply stocks, farm wage rates, cow prices and feed costs are included as instrumental variables

[††] Standard deviation in parentheses for continuous variables.

Table 2. Heteroskedasticity tests for the fluid milk and cheese time-varying parameter models.

	Fluid Milk		Cheese	
Tests	**Test Statistic[a]**	**Probability Level**	**Test Statistic[a]**	**Probability Level**
Breusch-Pagan Test: $s_t^2 = s^2 f(k_0 + k'W_t)$	0.01	0.96	0.13	0.71
Glesjer Tests:				
$Var(w_t) = s^2[k'W_t]$	0.25	0.62	0.01	0.92
$Var(w_t) = s^2[k'W_t]^2$	0.25	0.62	0.12	0.73
$Var(w_t) = s^2 \exp[k'W_t]$	0.01	0.92	0.08	0.77

[a] Test statistics are distributed chi-square with *n* degrees of freedom, where *n* is equal to the number of variables in W_t. Here, $W_t = \ln GAGW_t$

Table 3. Econometric estimates from time-varying advertising parameter models.			
Variable	**Parameter**	**Fluid Milk**	**Cheese**
Intercept	a_0^m, a_0^c	-2.568 (1.420)	-7.158 (3.400)
ln *Price*	a_1^m, a_1^c	0.033 (0.108)	0.083 (0.213)
ln *Income*	a_2^m, a_2^c	-0.001 (0.180)	0.118 (0.262)
ln *T*	a_3^m	-0.086 (0.024)	na
ln *FAFH*	a_3^c	na	0.596 (0.733)
ln *AGE5*	a_4^m	-0.044 (0.589)	na
ln *OTHER*	a_4^c	na	0.313 (0.223)
BST	a_5^m	-0.069 (0.017)	na
QTR1	a_6^m, a_5^c	-0.008 (0.005)	-0.088 (0.010)
QTR2	a_7^m, a_6^c	-0.051 (0.006)	-0.047 (0.009)
QTR3	a_8^m, a_7^c	-0.050 (0.004)	-0.051 (0.008)
ln $BAGW_t$	f^m, f^c	-0.007 (0.009)	-0.017 (0.026)
Intercept (y)	d_0^m, d_0^c	-11.332 (5.627)	-9.162 (11.503)
Price (y)	d_1^m, d_1^c	-1.018 (1.010)	-5.889 (4.233)
Income (y)	d_2^m, d_2^c	0.031 (0.019)	0.052 (0.040)
FAFH (y)	d_3^c	na	-0.190 (0.041)
AGE5 (y)	d_3^m	0.941 (0.469)	na
AGE2044 (y)	d_4^c	na	0.180 (0.120)
BLACK (y)	d_4^m	-0.136 (0.368)	na
OTHER (y)	d_5^c	na	0.585 (0.753)
AR(1)		0.160 (0.089)	na
Brand Weight Parameter	$l_{2,b}$	-2.454 (8.598)	-1.387 (1.789)
Generic Weight Parameter	$l_{2,g}$	-4.757 (1.084)	-1.385 (0.625)
Adjusted R-square		0.94	0.98
Test $d_i = 0 \ \forall \ i > 0$	Wald Stat. Pr>ChiSq	7.78 0.098	17.50 0.004

Note: Standard errors are in parentheses. The Wald test for structural heterogeneity is distributed chi-square, with m=4 and c=5 degrees of freedom, respectively.

Table 4. Demand Elasticities Evaluated at Sample Means.[a]		
Variable	**Fluid Milk**	**Cheese**
Price	-0.087 ***	-0.146
	(0.037)	(0.145)
Income	0.411 ***	0.365 ***
	(0.184)	(0.164)
Time Trend	-0.086 ***	
	(0.025)	
Per Capita Food Away From Home Expenditures		0.435 *
		(0.380)
Age < 6	0.705 ***	
	(0.251)	
Age 20 - 44		0.269 ***
		(0.106)
African American	-0.166	
	(0.453)	
Asian/Other		0.389 ***
		(0.111)
Brand Advertising	-0.007	-0.017
	(0.009)	(0.026)
Generic Advertising	0.037 ***	0.018 *
	(0.009)	(0.010)

[a] Standard errors in parentheses.
* = significant at 15% level, ** = significant at 10% level, *** = significant at 5% level.

Table 5. Average Generic Advertising Response Elasticities, 1997-2001*				
	Fluid Milk		**Cheese**	
Variable	**Elasticity**	**Std. Dev.**	**Elasticity**	**Std. Dev.**
Price	-1.156	0.054	-6.115	0.216
Income	4.416	0.114	7.331	0.189
Food Away From Home Expenditures			-4.718	0.203
Age < 6	6.536	0.103		
Age 20-44			6.628	0.102
African American	-1.628	0.013		
Asian/Other			2.757	0.093

*Interpreted as the percentage change in the long-run generic advertising elasticity for a one-percentage unit change in the associated variable. Computed from equation (12) and averaged over 1997-2001.

Figure 1. Price Elasticities for Fluid Milk and Cheese.

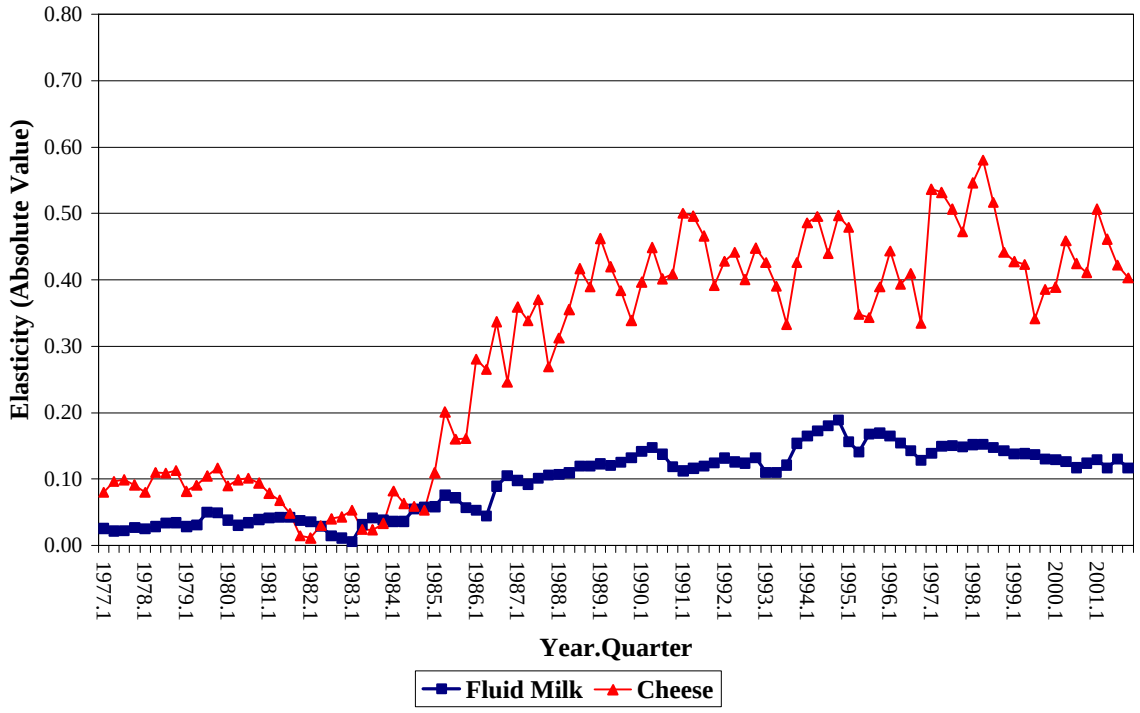


Figure 2. Income Elasticities for Fluid Milk and Cheese.

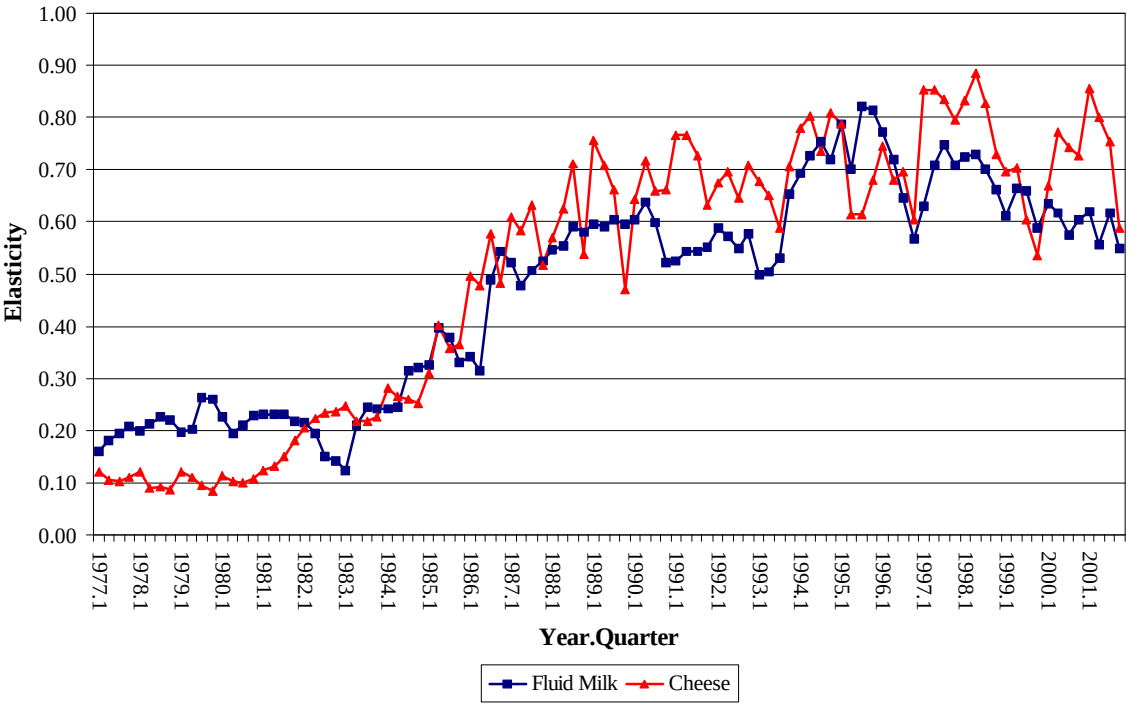


Figure 3. Age Composition Elasticities for Fluid Milk and Cheese.

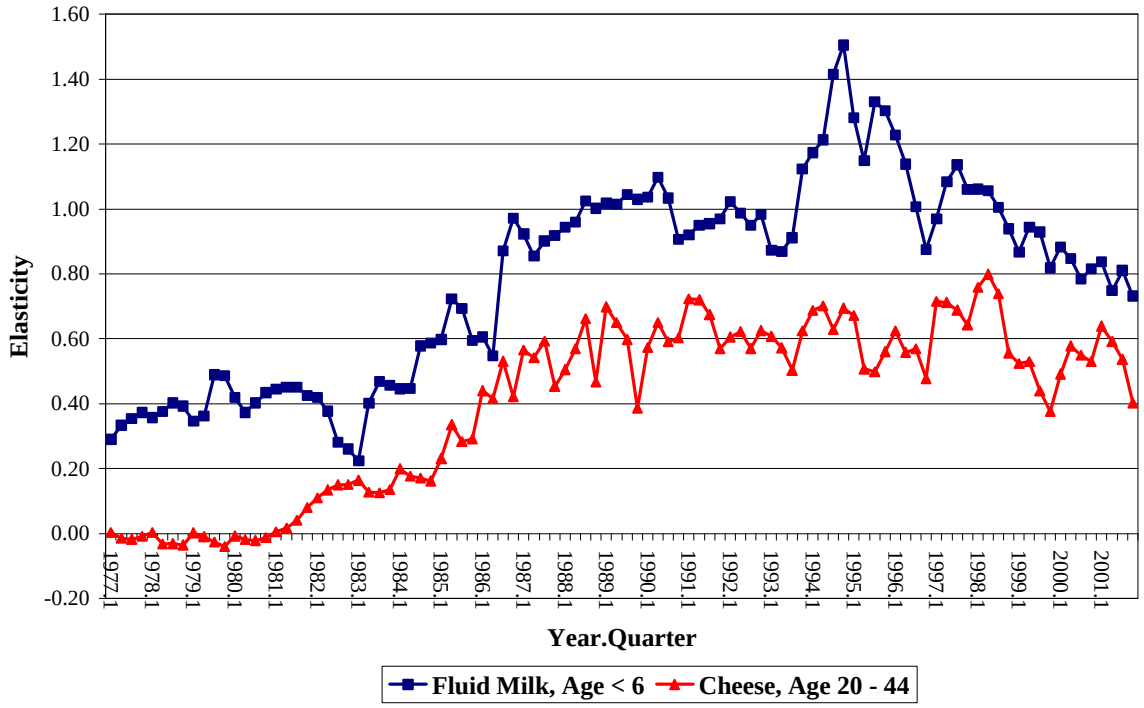


Figure 4. Long Run Generic Advertising Elasticities for Fluid Milk and Cheese.

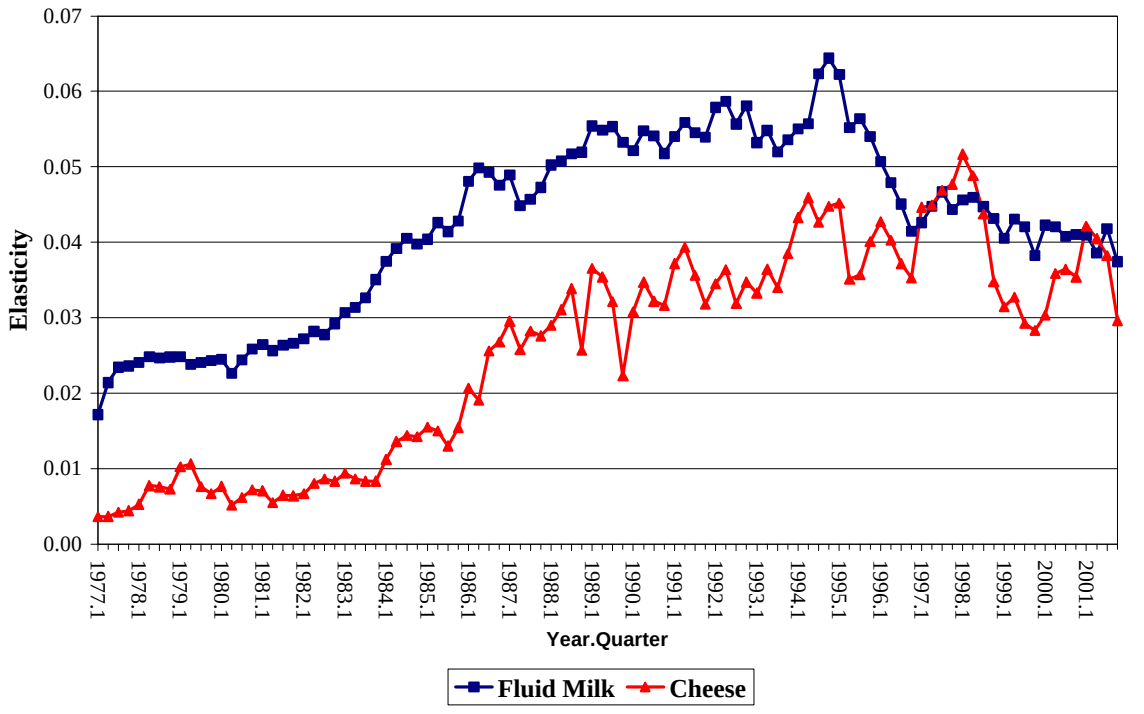
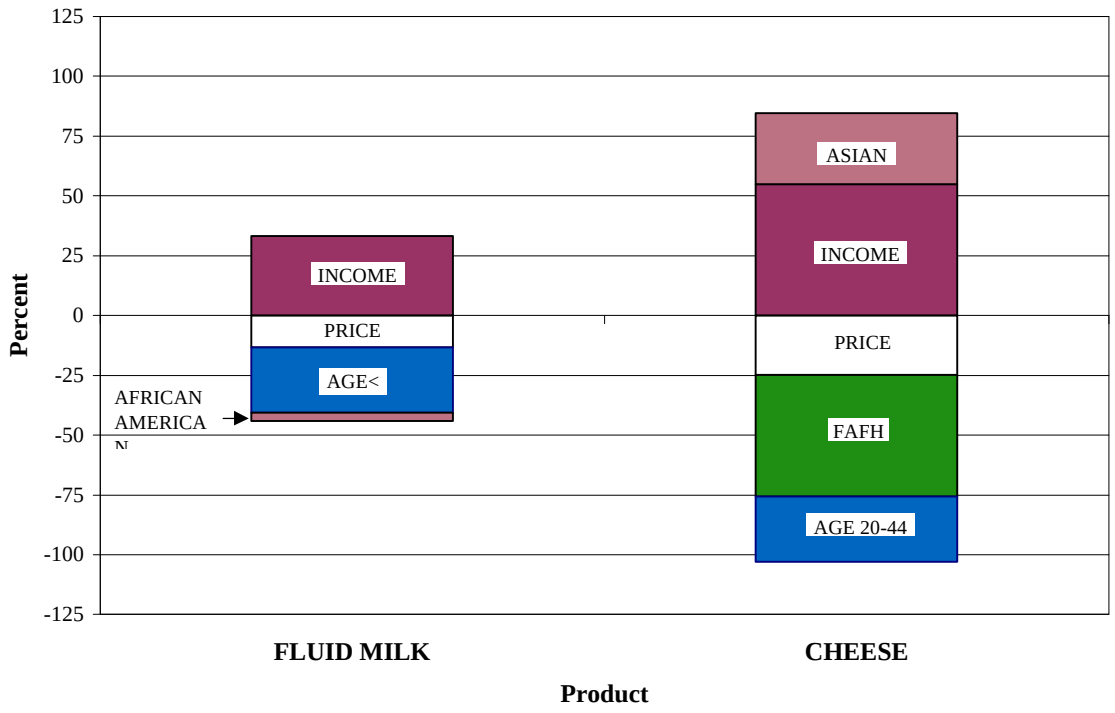


Figure 5. Generic Advertising Response Decomposition, Percent of Total Elasticity Variation 1997-2001.



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