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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. A benefit-cost ratio of the farmer-funded generic advertising program was estimated at \$6.26:1 over the period of 1999-2001, indicating that generic advertising for fluid milk and cheese continues to be a viable and worthwhile program for milk producers.

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Modeling the Effects of Generic Advertising on the Demand for Fluid Milk and Cheese: A Time-Varying Parameter Application

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. The demand relationships are then combined with market-level supply relationships to simulate returns to producers of the generic advertising programs. 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be especially problematic when used for more recent period market simulation purposes for which the mean-response is no longer applicable.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.

We continue now with a conceptual discussion of the time-varying retail demand models. The empirical results for fluid milk and cheese follow, highlighting the change in elasticities over time and the identification of the factors that have contributed to changes in generic advertising response. Finally, we combine the retail demand estimation with estimated multi-market supply relationships to simulate producer returns to the generic advertising programs. We close with some summary conclusions and direction for future research.

The Conceptual Demand 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 include 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) $Y_t = \alpha_0 + \alpha X_t + \phi BGW_t + \psi_t GGW_t + e_t$,

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 ψ_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) $\psi_t = \exp\left(\delta_0 + \delta' Z_t\right) + v_t$,

where $\exp(\cdot)$ represents the exponential function, δ_0 is the intercept term to estimate, Z_t is a vector of exogenous variables assumed to affect consumer response to generic advertising, δ 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 ψ_t over time is relatively flexible and reflects generic

[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.

advertising's *a priori* expected positive effect on demand. Equation (2) partitions the observed parameter variation into its systematic (exp($\delta_0 + \delta Z_t$)) 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]

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:

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

where w_j^g represents the J_g lag weights, $GADV_{t-j}$ is the t-j^{th} generic advertising expenditure, and $\lambda_{i,g}$ (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

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

[4] The brand advertising goodwill variable is similarly constructed to compute the respective brand advertising lag-weights from estimated coefficients $\lambda_{i,b}$ (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.

period is normalized to one.[5] Using the above restrictions and collecting terms implies the following lag-weight formulation:

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

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 $\lambda_{2,g}$. Substituting the (2) and (3) into (1) yields:

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

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

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. $\psi_t \equiv \psi$. 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**. It is reasonable to expect that price, income, race, and other elasticities will vary over time. For example, as average price levels faced by consumers change over time, price response is likely to change as well. While the real price for fluid milk over the sample period has decreased approximately 25%, real cheese prices have increased nearly 30%. Higher real prices in the cheese market should translate into higher price

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

elasticities, ceterus paribus. Another example could be hypothesized with income response. As consumer real incomes continue to increase and expenditures eaten away from home continue to rise, increases in discretionary food purchases may result in elevated income elasticities.

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] Descriptive statistics of model variables are included in Table 1.

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 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:

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[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.

[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.

$$(6)\quad \ln RFD_t = \alpha_0^m + \alpha_1^m \ln RFP_t + \alpha_2^m \ln INC_t + \alpha_3^m \ln T_t + \alpha_4^m \ln AGE5_t + \alpha_5^m BST_t + \alpha_6^m QTR1_t + \alpha_7^m QTR2_t + \alpha_8^m QTR3_t + \phi^m \ln BMGW_t + \psi_t^m \ln GMGW_t + e_t^m$$

and

$$\psi_t^m = \exp\left(\delta_0^m + \delta_1^m RFP_t + \delta_2^m INC_t + \delta_3^m AGE5_t + \delta_4^m BLACK\right) + v_t^m\ ,$$

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:

$$(7)\quad \ln RCD_t = \alpha_0^c + \alpha_1^c \ln RCP_t + \alpha_2^c \ln INC_t + \alpha_3^c \ln FAFH_t + \alpha_4^c \ln OTHER_t + \alpha_5^c QTR1_t + \alpha_6^c QTR2_t + \alpha_7^c QTR3_t + \phi^c \ln BCGW_t + \psi_t^c \ln GCGW_t + e_t^c$$

and

$$\psi_t^c = \exp\left(\delta_0^c + \delta_1^c RCP_t + \delta_2^c INC_t + \delta_3^c FAFH_t + \delta_4^c AGE2044_t + \delta_5^c OTHER\right) + v_t^c\ ,$$

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,

[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.

and *BCGW* and *GCGW* are the brand and generic cheese advertising goodwill variables, respectively.

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 $\sigma_t^2 = \sigma^2 f\left(\kappa_0 + \kappa' W_t\right)$, where W_t is a vector of independent variables and a null hypothesis of homoscedasticity, i.e. $\kappa = 0$ (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 κ 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:

$$(8)\quad \frac{\partial \ln RFD_t}{\partial \ln RFP_t} = \alpha_1^m + \delta_1^m \exp\left(\delta_0 + \delta_1{}' Z_t\right) \ln GMGW_t \cdot RFP_t$$

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 and higher average cheese 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 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 (ϕ^m and ϕ^c). For the time-varying specifications, the long run generic advertising elasticity for the fluid milk model can be derived as:

$$(9) \quad \varepsilon_{LR}^{m} = \frac{\partial \ln RFD_t}{\partial \ln GMGW_t} = \exp\left(\delta_0 + \delta' Z_t\right).$$

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

[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.

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 response.

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). Changes in real price levels over time may be indicative of the different patterns of price response over time.

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. Since the mid-1990s, however, both income elasticities have been trending downward, especially so for fluid milk.

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.[10]

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 fluid milk price can be derived as:

$$(10)\quad \zeta^{m}_{RFP} = \frac{\partial \varepsilon^{m}_{LR,t}}{\partial RFP_t}\frac{RFP_t}{\varepsilon^{m}_{LR,t}} = \left[\delta_1 \exp\left(\delta_0 + \delta' Z_t\right)\right]\cdot\left[RFP_t / \exp\left(\delta_0 + \delta' Z_t\right)\right] = \delta_1 RFP_t \ .$$

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

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[10] It is hypothesized that advertising of pizza and cheeseburgers has a positive effect on the consumption of cheese. Such variables were not included in the model due to a lack of data. Assuming pizza and cheeseburger advertising has a significantly positive effect on cheese consumption, omission of these variables could result in the impact of generic cheese advertising being somewhat overstated.

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 in 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.

Simulation of Producer Returns to Generic Advertising

The Dairy Production and Stabilization Act of 1983 (Dairy Act; 7 U.S.C. 4514) authorizes the Dairy Advertising and Research Program (hereafter referred to as the Dairy Program), while the Fluid Milk Advertising Act of 1990 (Fluid Milk Act; 7 U.S.C. 6407) authorizes the Fluid Milk Advertising Program (hereafter referred to as the Fluid Program). The two programs are complementary in that they both share a common objective to increase fluid milk sales. In the evaluation of the programs, it is assumed that a dollar spent on fluid milk advertising by dairy farmers has the same effect on demand as a dollar spent by processors on fluid milk advertising, since both programs have an identical objective. The Dairy Program additionally has an objective to expand the market for cheese. Accordingly, part of its budget is directed to generic cheese advertising.

Simulation Model Structure

To evaluate the market impacts of the Dairy and Fluid advertising programs, the time-varying retail demand models were simulated with estimated supply relationships at the retail, wholesale, and farm levels. For completeness, we highlight the structure of the econometric model used for simulation, but limit discussion of the specific empirical supply-side estimates. The estimated supply equations are included in an appendix and include relationships for retail, wholesale, and farm markets, with retail and wholesale markets included separately for fluid milk and cheese.

The model is adapted from Kaiser, which is similar to the industry model developed by Liu et al., and represents a partial equilibrium model of the domestic dairy sector (with no trade) that divides the industry into retail, wholesale, and farm markets. While fluid milk and cheese demand are explicitly modeled, other manufactured products are assumed exogenous to the industry model and incorporated within equilibrium closing conditions. The model assumes that farmers, wholesalers, and retailers behave competitively in the market, an assumption supported by recent studies of market power in the dairy industry (Liu, Sun, and Kaiser; Suzuki, et al.).

The general structure is one that begins in the farm market, where Grade A (fluid eligible) milk is produced by farmers and sold to wholesalers. The wholesale market is disaggregated into two sub-markets: fluid (beverage) milk and cheese. Wholesalers, in turn, process the milk into these products and sell them to retailers, who then sell the products to consumers.[11] The model incorporates the federal regulatory programs of milk marketing orders and the Dairy Price Support Program (DPSP). Given the model is national in scope, it is assumed there is one federal milk marketing order regulating all milk, and is incorporated by restricting the prices wholesalers pay for raw milk to be minimum class prices (Kaiser). As such, fluid milk wholesalers pay the higher Class I price, while cheese wholesalers pay the Class III price. Farm prices are then computed based on the distribution of product to alternative uses. The DPSP is incorporated by restricting cheese prices to be greater than or equal to the government purchase price for cheese, with the government purchasing all excess storable manufactured dairy products at the announced purchase prices. The retail market can be expressed as:

$$(11.1) \quad RD_i = f\left(RP_i \middle| S_i^{RD}\right),$$
$$(11.2) \quad RS_i = f\left(RP_i \middle| S_i^{RS}\right),$$
$$(11.3) \quad RD_i = RS_i \equiv R_i^*,\ i = \{fluid\ milk\ (F), cheese\ (C)\},$$

where, RD_i (RS_i) are retail demand (supply) for commodity $i = \{fluid\ milk\ (F),\ cheese\ (C)\}$, RP_i is the own retail price, S_i^{RD} $\left(S_i^{RS}\right)$ is a vector of retail demand (supply) shifters, and R_i^* is the retail equilibrium quantity for the i^{th} commodity. Generic advertising expenditures are included in the vector of demand shifters as described earlier, while wholesale price levels are reflected in the vector of retail supply shifters. Next, the wholesale fluid milk market can be specified as:

[11] All quantities (except fluid milk) are expressed on a milkfat equivalent (ME) basis. Fluid milk is expressed in product form (pounds).

(12.1) $WFD = R_F^*$,

(12.2) $WFS = f(WFP|SF^{WS})$,

(12.3) $WFS = WFD \equiv WF^* \equiv R_F^*$,

where WFD (WFS) is the wholesale fluid milk demand (supply), WFP is the wholesale fluid milk price, and SF^{WS} is a vector of wholesale supply shifters which includes the Class I price.[12]

The specification of the wholesale cheese market is more complicated since the direct impacts of the DPSP occur here and commercial inventory decisions need to be accounted for. The Commodity Credit Corporation (CCC) provides an alternative source of demand by purchasing excess storable products at announced purchase prices. We express the wholesale cheese market as:

(13.1) $WCD = R_C^*$,

(13.2) $WCS = f(WCP|SC^{WS})$,

(13.3a) $WCS = WCD + \Delta INVC + QSPC \equiv QC^W$,

where WCD (WCS) is the wholesale cheese demand (supply), WCP is the wholesale cheese price, SC^{WS} is a vector of wholesale cheese supply shifters including the Class III price, Ä*INVC* is the change in commercial inventories, $QSPC$ is cheese quantity sold by specialty plants to the government, and QC^W is the equilibrium wholesale quantity. $QSPC$ and Ä*INVC* represent a small proportion of total milk production and are assumed exogenous in the model.[13]

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[12] The Class I price is defined as the Class III milk price (or Basic Formula price) plus a fixed fluid milk price differential. As specified, the wholesale demand functions do not need to be estimated since the equilibrium conditions constrain wholesale demand to be equal to the equilibrium retail quantity, this assumption implies a fixed-proportions technology (Kaiser).

[13] Certain cheese plants serve as general balancing plants and sell cheese products to the government only, regardless of the relationship between market and government purchase prices. When market price exceeds the government floor price (i.e. a competitive regime), "regular" purchases should be zero, while purchases from specialty plants may be positive. We disaggregate the quantity purchased by the government into these purchases from specialty plants and "regular" purchases. During competitive periods the *QSPC* variable is set equal to total CCC cheese purchases for that period. However, when the market price is below the announced government purchase price, specialty purchases are defined as the minimum of total CCC purchases for that period and the average quarterly CCC purchase for competitive periods in that year.

The DPSP constrains the wholesale cheese price (*WCP*) to be equal to or greater than the government purchase price (*GCP*); i.e. $WCP \quad GCP$. As such, there are two regimes possible: (1) $WCP > GCP$, and (2) $WCP = GCP$. In the first regime, the competitive case exists and equation (13.3a) applies. In the second case, the equilibrium condition must be augmented with government purchases of cheese (GC), which, therefore, becomes a new endogenous variable when price is fixed; i.e. $WCP = GCP$. The revised equilibrium condition becomes:

(13.3b) $$WCS = WCD + \Delta INVC + QSPC + GC \equiv QC^{W},$$

Farm production is modeled by the following milk supply equation:

(14) $$FMS = f\left(E[AMP] | S^{FM}\right),$$

where *FMS* is national commercial milk marketings, $E[AMP]$ is the expected all-milk price, and S^{FM} is a vector of milk supply shifters. A perfect foresight specification is used for the price expectation (for similar application see LaFrance and de Gorter, Kaiser). The farm-level milk price can be expressed as a weighted average of the Class prices for milk, weighted by the utilization across products; i.e.:

(15) $$AMP = \frac{(P^{III} + DIFF) * WFS + P^{III} * WCS + P^{III} * OMANF}{WFS + WCS + OMANF},$$

where P^{III} is the Class III price, *DIFF* is the Class I fluid milk differential, and *OMANF* is the wholesale supply of other manufactured dairy products treated as exogenous to the model (principally butter and frozen dairy products). Finally, to close the model we add the following equilibrium condition:

(16) $$FMS = WFS + WCS + FUSE + OMANF,$$

where *FUSE* is on-farm use off milk, also treated as exogenous.

All equations are estimated in double-logarithmic form. Farm milk supply was estimated as a function of (*i*) all milk price, (*ii*) feed ration price, (*iii*) slaughter cow price, (*iv*) a time trend as a proxy for technological change in dairy production, (*v*) seasonality via quarterly dummy variables, (*vi*) intercept shifters for the time periods when the Milk Diversion Program (MDP) and Dairy Termination Program (DTP) were in effect, and (*vii*) lagged farm supply to account for rigidities in production adjustments.[14]

Reflecting retail operations and the linkages in the market chain, retail supplies for both products were specified as a function of: (*i*) retail price, (*ii*) wholesale price (a variable cost to retailers), (*iii*) a price index for fuel/energy (another variable cost), (*iv*) a time trend as a proxy for technical change in retailing, (*v*) seasonality via quarterly dummy variables, and (*vi*) lagged retail supply to represent capacity constraints.

Similar conditions apply to wholesalers representing their output linkage to retailers and input linkage to farm production. The wholesale supply equations were modeled as a function of (*i*) wholesale price, (*ii*) the corresponding Class price (a variable cost to wholesalers), (*iii*) a price index for fuel/energy (another variable cost), (*iv*) a time trend as a proxy for technological change in dairy product processing, (*v*) seasonality via quarterly dummy variables, and (*vi*) lagged wholesale supply to represent capacity constraints.

Empirical results from the supply estimation are included in Appendix Table A1. Fluid milk and cheese prices, along with the corresponding left-hand-side supply variables are treated as endogenous. To account for price endogeneity, all equations are estimated using two-stage least squares including lagged supply stocks for fluid milk, cheese, butter, and frozen products as

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[14] Assuming a Cobb-Douglas production relationship and profit maximizing firm behavior, relative prices matter, and the specific form of aggregate supply can be written as:

$$FMS_t = \beta_0 \cdot (AMP_t/PRATION_t)^{\beta_1} \cdot (PCOW_t/PRATION_t)^{\beta_2} \cdot (T)^{\beta_3} \cdot \exp(DTP)^{\beta_4} \cdot \exp(MDP)^{\beta_5} \cdot \exp\left(\sum_{i=1}^{3} \gamma_i QTR_{i,t}\right) \cdot (FMS_{t-1})^{\alpha_1} \cdot$$

Supply equations for the remaining equations can be similarly expressed.

additional instruments. The empirical results are all of the right sign and, for most variables, are statistically significant. For brevity and to move on to the simulation results, attention to the specific empirical results is left to the interested reader.

Simulation Results of Alternative Scenarios

To evaluate recent market impacts of the Dairy and Fluid advertising programs, the economic model was simulated over the time period from 1999 through 2001.[15] To examine the impacts that the two advertising programs had on the markets for fluid milk and cheese over this period, the economic model was initially simulated under two scenarios based on the level of generic advertising expenditures: (1) a baseline scenario, where generic advertising levels were equal to actual generic advertising expenditures under the two programs, and (2) a no-national program scenario, where there was no fluid milk processor sponsored advertising and dairy farmer sponsored advertising was reduced to 42 percent of actual levels to reflect the difference in assessment before and after the national program was enacted. Accordingly, a reduction in the per unit checkoff levy to farmers was also incorporated in the simulation.[16] A comparison of these two scenarios provides a measure of the combined impacts of the two programs.

Table 6 presents the annual averages for selected supply, demand, and price variables over the period 1999-2001 for the two scenarios. Generic advertising by the Dairy and Fluid Programs has had a positive impact on fluid milk consumption over this period. Specifically, fluid milk consumption would have been 4.5 percent lower had the two advertising programs not

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[15] It is important to note that there was generic milk and cheese advertising conducted by some states prior to passage of the 1983 Dairy & Tobacco Stabilization Act, which authorized the Dairy Program. As such, to measure the advertising impacts of the Dairy Program, this study simulated and compared market conditions with the Dairy Program versus market conditions reflecting advertising funding levels prior to when the Dairy Program was enacted. Throughout this report, any scenario referring to the absence of the Dairy Program reflects advertising funding at levels prior to enactment of the Dairy Program.

[16] Specifically, the output price in the farm supply equation is expressed as the milk price variable (AMP) less the per unit checkoff levy. The levy was reduced from the baseline scenario of $0.15/cwt. to $0.063/cwt. for the reduced farmer-sponsored advertising scenarios.

been in effect. Likewise, generic cheese advertising under the Dairy Program had a positive impact on cheese consumption, i.e., consumption would have been 1.0 percent lower without generic advertising. Consumption of milk used in all dairy products would have been 1.9 percent lower had these two programs not been in effect during 1999-2001.

Generic advertising by dairy farmers and milk processors also had an effect on the farm milk price and milk marketings. The simulation results indicate that the all-milk price would have been $0.96 per hundredweight lower without the generic advertising provided under the two programs. The farm milk price impacts resulted in a slight increase in farm milk marketings. That is, had there not been the two advertising programs, farm milk marketings would have been 1.9 percent lower over the 1999-2001 period due to the lower milk price.

A third scenario was subsequently simulated to specifically measure the market impacts of the advertising program supported by the 15-cent dairy farmer checkoff program. This scenario assumes that the advertising program operated by the milk processors is still in effect. As in the earlier scenario advertising expenditures by dairy farmers were reduced to 42 percent of actual levels to reflect the situation prior to the enactment of the Dairy Program. A comparison of this third scenario with the baseline scenario gives a measure of the advertising market impacts of the current mandatory Dairy Program.

The last two columns of Table 6 present the results of this scenario, and the results are similar to the combined fluid milk processor and dairy farmer advertising program results. Had there not been fluid milk and cheese advertising sponsored by dairy farmers, fluid milk demand would have been 1.1 percent lower, cheese demand would have been 1.1 percent lower, and total milk demand would have been 0.8 percent lower than it actually was. Advertising under the Dairy Program also had a significant impact on the farmer milk price. The simulation results indicate that the all-milk price would have been $0.23 per hundredweight lower without generic advertising by the Dairy Program. Finally, farm milk marketings would have been slightly lower (0.8 percent) in the absence of the Dairy Program.

Benefit-Cost Ratio of Generic Advertising by the Dairy Program

One way to measure whether the benefits of a program outweigh the cost is to compute a benefit-cost ratio (BCR). A BCR can be computed as the sum of the change in producer surplus over time due to advertising divided by the cost of advertising.[17] While a BCR for producers can be estimated for the Dairy Program, it cannot be computed at this time for milk processors with the Fluid Program because data on packaged fluid milk wholesale prices, which is necessary in calculating processor net revenue, are proprietary information and not available.

The BCR for the Dairy Program was calculated as the change in dairy farmer producer surplus due to demand enhancement from advertising under the Dairy Program divided by the advertising costs. The demand enhancement reflects increases in quantity and price as a result of the advertising program. As such, costs allocated to the enhancement represent advertising costs. Since advertising expenditures in the model only represent air-time, print space, and other direct media costs, it is necessary to incorporate expenses that reflect general administration, overhead, and advertising production costs in order to reflect the true complete costs of the advertising program supported by the checkoff. Following conversations with staff at DMI, Inc. and a review of Dairy Program budgets, direct media expenditures were prorated upwards by a factor of 1.25. The results show that the average BCR for the Dairy Program was 6.26 from 1999

[17] In general, producer surplus represents the area above the aggregate supply curve and below the equilibrium price. The change in producer surplus can be expressed as: $\Delta PS = -\int_{P_0^*}^{P_1^*} Q(s)\, ds$, where P_0^* and P_1^* represent net equilibrium prices, and $Q(s)$ defines the aggregate supply relationship.

through 2001. This means that each dollar invested in generic fluid milk and cheese advertising by dairy farmers during the period returned $6.26, on average, in net revenue to farmers.

Another way to interpret this figure is as follows. The increase in generic advertising expenditures resulting from the enactment of the Dairy Program cost dairy producers an additional $67 million per year on average since 1999, i.e. the difference between $213 million annually under the baseline scenario and $146 million under the no Dairy Program scenario. The additional fluid milk and cheese advertising resulted in higher milk demand, milk prices, and profits for dairy producers nationwide. Based on the simulations conducted with the economic model, it is estimated that the average annual increase in producer surplus (reflecting changes in both revenues and costs) since 1999 due to the additional advertising under the Dairy Program was $420 million, which represents 1.8 percent of total farm cash receipts from milk marketings. Dividing $420 million by the additional advertising costs of $67 million results in the benefit cost ratio estimate of 6.26.

It should be noted that the BCR estimate here is above those estimated in Kaiser using constant parameter demand models. This is, in part, reflective of the higher fluid milk and cheese generic advertising elasticities estimated over the more recent time period, relative to the mean-response elasticities estimated with constant parameter models over the entire sample period. In addition, previous reports evaluated a five-year time horizon and compared changes in gains in producer net revenue to the value of the entire dairy checkoff. Using a similar procedure, a constant parameter version of the above model was also estimated with results comparable to previous estimates. The goal of this study was to enhance the economic model by allowing elasticities to change over time and with simulation results reflective of current market indicators to evaluate returns to the generic advertising program. The results of this approach indicate that generic advertising for fluid milk and cheese continues to be a viable and worthwhile program for milk producers.

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 prices 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.

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 returns to milk producers than previously used constant-parameter models. The time-varying retail demand estimates were incorporated into a multi-market economic model reflecting supply conditions at the retail, wholesale, and farm levels. The partial equilibrium model of the domestic dairy industry allowed us to trace generic advertising effects at the retail level to producer price response at the farm level. The model was simulated over the period of 1999-2001 to estimate producer net returns to the generic advertising program.

The results indicated a BCR of 6.26; i.e. every dollar invested in generic advertising through the farmer-funded Dairy Program since 1999 returned, on average, $6.26 to producers. While this number is encouraging, it must be put into proper perspective. Additional producer revenues attributed to the success of the generic advertising programs represent a very small proportion of industry revenues; i.e. less than 2%.

The goal of this study was to use the updated demand elasticities to simulate current market activity in response to the generic advertising program. The results of this approach indicate that generic advertising for fluid milk and cheese continues to be a viable and worthwhile program for milk producers.

While the time-varying application provides valuable information on how consumer response to advertising, price, and other factors has changed over time, one could also use such variable estimates to evaluate optimal allocation of fixed advertising budgets over time. Extending optimal advertising theory established in the literature, one could use the time-specific price and advertising elasticities to predict optimal seasonal advertising intensities using different advertising investment rules and also be used as a tool to predict intensity levels in future periods.

Table 1. Description of Variables Used in Econometric Model.[a]			
Variable	**Description**	**Units**	**Mean[b]**
	Consumption/Supply Variables		
RFDPC	Quarterly retail fluid demand per capita	lbs.	53.95 (3.24)
RCDPC	Quarterly retail cheese demand per capita	lbs. MFE	46.72 (10.27)
RBDPC	Quarterly retail butter demand per capita	lbs. MFE	21.76 (2.92)
RFZDPC	Quarterly retail frozen demand per capita	lbs. MFE	12.94 (2.09)
FMS	Quarterly fluid milk production	bil. lbs.	35.74 (3.73)
WFS	Quarterly wholesale fluid supply	bil. lbs.	13.33 (0.65)
WCS	Quarterly wholesale cheese supply	bil. lbs. MFE	11.68 (3.18)
WBS	Quarterly wholesale butter supply	bil. lbs. MFE	6.47 (1.14)
WFZS	Quarterly wholesale frozen product supply	bil. lbs. MFE	3.20 (0.54)
	Prices and Price Indecies		
RFP	Consumer retail price index for fresh milk and cream (1982-84=100)	#	1.14 (0.27)
RPNABEV	Consumer retail price index for nonalcoholic beverages (1982-84=100)	#	1.06 (0.25)
RCP	Consumer retail price index for cheese, (1982-84=100)	#	1.15 (0.32)
RPMEAT	Consumer retail price index for meats (1982-84=100)	#	1.16 (0.29)
WFP	Wholesale fluid price index (1982-84=100)	#	1.11 (0.25)
WCP	Wholesale cheese price	$/lb.	1.28 (0.19)
P^{III}	Basic formula (Class III) price	$/cwt.	11.48 (1.72)
P^{I}	Class I price	$/cwt.	13.96 (1.87)
AMP	All milk price	$/cwt.	12.74 (1.69)
DIFF	Class I differential	$/cwt.	2.48 (1.06)
PFE	Producer energy price index (1982-84=100)	#	0.85 (0.22)
PRATION	Feed ration value	$/cwt.	7.47 (0.81)
PCOW	Cow price	$/head	1016.31 (258.32)

[a] Quarterly dummy variables (Q1-Q3) are also included in all model equations to account for seasonality. Additional instrumental variables for the 2SLS estimation of the demand and supply equations include lagged supply stocks, farm wage rates, cow prices, and feed costs.
[b] Mean and standard deviation computed over the quarterly time period 1975.1 – 2001.4, standard deviation in parentheses.

Table 1. Description of Variables Used in Econometric Model.[a] (continued)			
Variable	**Description**	**Units**	**Mean[b]**
	Demographic Variables		
INCPC	Per capita disposable income, deflated by the consumer retail price index for all items (1982-84=100)	\$000	12.19 (1.42)
BLACK	Proportion of the population African American	#	11.21 (0.54)
ASIAN	Proportion of the population Asian	#	3.30 (1.03)
AGE5	Proportion of the population under age 6	#	7.31 (0.24)
AGE2044	Proportion of the population age 20 to 44	#	38.10 (1.77)
FAFHPC	Per capita food away from home expenditures (1988=100)	\$	215.54 (24.55)
	Miscellaneous Variables		
BST	Intercept dummy variable for bovine somatotropin, equal to 1 for 1994.1 through 2001.4, equal to 0 otherwise	0/1	0.30
DTP	Intercept dummy variable for Dairy Termination Program, equal to 1 for 1986.2 through 1987.3, equal to 0 otherwise	0/1	0.06
MDP	Intercept dummy variable for Milk Diversion Program, equal to 1 for 1984.1 through 1985.2, equal to 0 otherwise	0/1	0.06
	Advertising Expenditures[c]		
GFAD	Quarterly generic fluid milk advertising expenditures, deflated by Media Cost Index (2001=100)	\$mil	21.63 (11.23)
GFAD_DMI	Quarterly generic fluid milk advertising expenditures, Dairy Program, deflated by Media Cost Index (2001=100)	\$mil	17.53 (8.26)
GFAD_MILKPEP	Quarterly generic fluid milk advertising expenditures, Fluid Milk Program, deflated by Media Cost Index (2001=100)	\$mil	4.10 (8.34)
GCAD	Quarterly generic cheese advertising expenditures, Dairy Program, deflated by Media Cost Index (2001=100)	\$mil	10.65 (7.16)
BFAD	Quarterly brand fluid milk advertising expenditures, deflated by Media Cost Index (2001=100)	\$mil	4.04 (2.50)
BCAD	Quarterly brand cheese advertising expenditures, deflated by Media Cost Index (2001=100)	\$mil	32.95 (11.94)

[a] Quarterly dummy variables (Q1-Q3) are also included in all model equations to account for seasonality. Additional instrumental variables for the 2SLS estimation of the demand and supply equations include lagged supply stocks, farm wage rates, cow prices, and feed costs.
[b] Mean and standard deviation computed over the quarterly time period 1975.1 – 2001.4, standard deviation in parentheses.
c. Note that the GFAD_MILKPEP mean appears low since MILKPEP expenditures did not begin until 1995; since 1995 mean quarterly MILKPEP expenditures have been \$19.26 mil. (5.79).

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:				
$\sigma_t^2 = \sigma^2 f(\kappa_0 + \kappa' W_t)$	0.01	0.96	0.13	0.71
Glesjer Tests:				
$Var(w_t) = \sigma^2 [\kappa' W_t]$	0.25	0.62	0.01	0.92
$Var(w_t) = \sigma^2 [\kappa' W_t]^2$	0.25	0.62	0.12	0.73
$Var(w_t) = \sigma^2 \exp[\kappa' W_t]$	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	$\alpha_0^{\mu}, \alpha_0^{\chi}$	-2.568 (1.420)	-7.158 (3.400)
ln *Price*	$\alpha_1^{\mu}, \alpha_1^{\chi}$	0.033 (0.108)	0.083 (0.213)
ln *Income*	$\alpha_2^{\mu}, \alpha_2^{\chi}$	-0.001 (0.180)	0.118 (0.262)
ln *T*	α_3^{μ}	-0.086 (0.024)	na
ln *FAFH*	α_3^{χ}	na	0.596 (0.733)
ln *AGE5*	α_4^{μ}	-0.044 (0.589)	na
ln *OTHER*	α_4^{χ}	na	0.313 (0.223)
BST	α_5^{μ}	-0.069 (0.017)	na
QTR1	$\alpha_6^{\mu}, \alpha_5^{\chi}$	-0.008 (0.005)	-0.088 (0.010)
QTR2	$\alpha_7^{\mu}, \alpha_6^{\chi}$	-0.051 (0.006)	-0.047 (0.009)
QTR3	$\alpha_8^{\mu}, \alpha_7^{\chi}$	-0.050 (0.004)	-0.051 (0.008)
ln $BAGW_t$	ϕ^{μ}, ϕ^{χ}	-0.007 (0.009)	-0.017 (0.026)
Intercept (ψ)	$\delta_0^{\mu}, \delta_0^{\chi}$	-11.332 (5.627)	-9.162 (11.503)
Price (ψ)	$\delta_1^{\mu}, \delta_1^{\chi}$	-1.018 (1.010)	-5.889 (4.233)
Income (ψ)	$\delta_2^{\mu}, \delta_2^{\chi}$	0.031 (0.019)	0.052 (0.040)
FAFH (ψ)	δ_3^{χ}	na	-0.190 (0.041)
AGE5 (ψ)	δ_3^{μ}	0.941 (0.469)	na
AGE2044 (ψ)	δ_4^{χ}	na	0.180 (0.120)
BLACK (ψ)	δ_4^{μ}	-0.136 (0.368)	na
OTHER (ψ)	δ_5^{χ}	na	0.585 (0.753)
AR(1)		0.160 (0.089)	na
Brand Weight Parameter	$\lambda_{2,\beta}$	-2.454 (8.598)	-1.387 (1.789)
Generic Weight Parameter	$\lambda_{2,\gamma}$	-4.757 (1.084)	-1.385 (0.625)
Adjusted R-square		0.94	0.98
Test $\delta_i = 0 \ \forall \ i > 0$	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.

Table 6. Simulated impacts of the Dairy and Fluid Milk Programs on selected market variables, annual average 1999-2001.

		Baseline Scenario[a]	No National Program Scenario[b]		No Dairy Program Scenario[c]	
Market Variable	Unit	Level	Level	% Difference	Level	% Difference
Fluid Milk Demand	bil lbs	55.5	53.0	-4.5	54.9	-1.1
Cheese Demand	bil lbs MFE	68.5	67.9	-1.0	67.8	-1.1
Total Dairy Demand	bil lbs	162.3	159.2	-1.9	161.0	-0.8
Basic Formula Price	$/cwt	11.76	10.92	-7.1	11.54	-1.8
All Milk Price	$/cwt	13.87	12.91	-6.9	13.64	-1.7
Milk Marketings	bil lbs	164.1	161.0	-1.9	162.8	-0.8
Benefit-Cost Ratio[d]	$ per $1				6.26	

[a] Baseline scenario reflects the current operation of the Dairy and Fluid Milk Programs.

[b] No National Program Scenario reflects no Fluid Milk Program and Dairy program advertising at pre-national program spending levels.

[c] No Dairy Program reflects current Fluid Milk Program and Dairy program advertising at pre-national program spending levels.

[d] Benefit-Cost ratio computed for Dairy Program only.

Figure 1. Price Elasticities for Fluid Milk and Cheese.

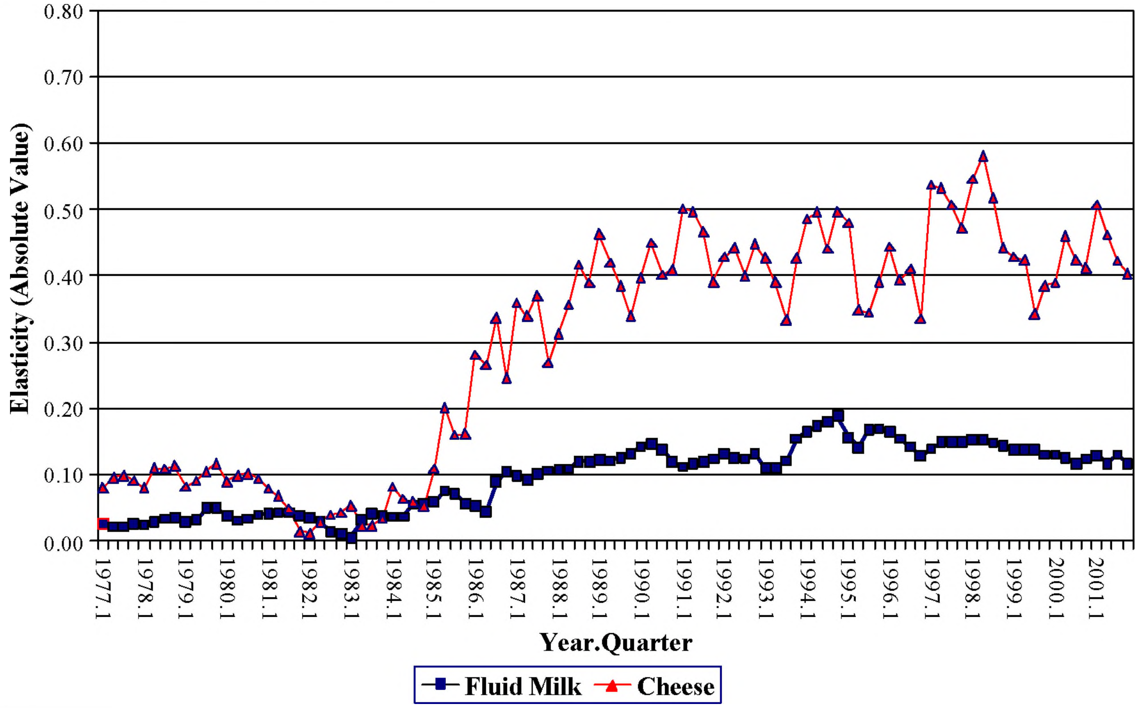


Figure 2. Income Elasticities for Fluid Milk and Cheese.

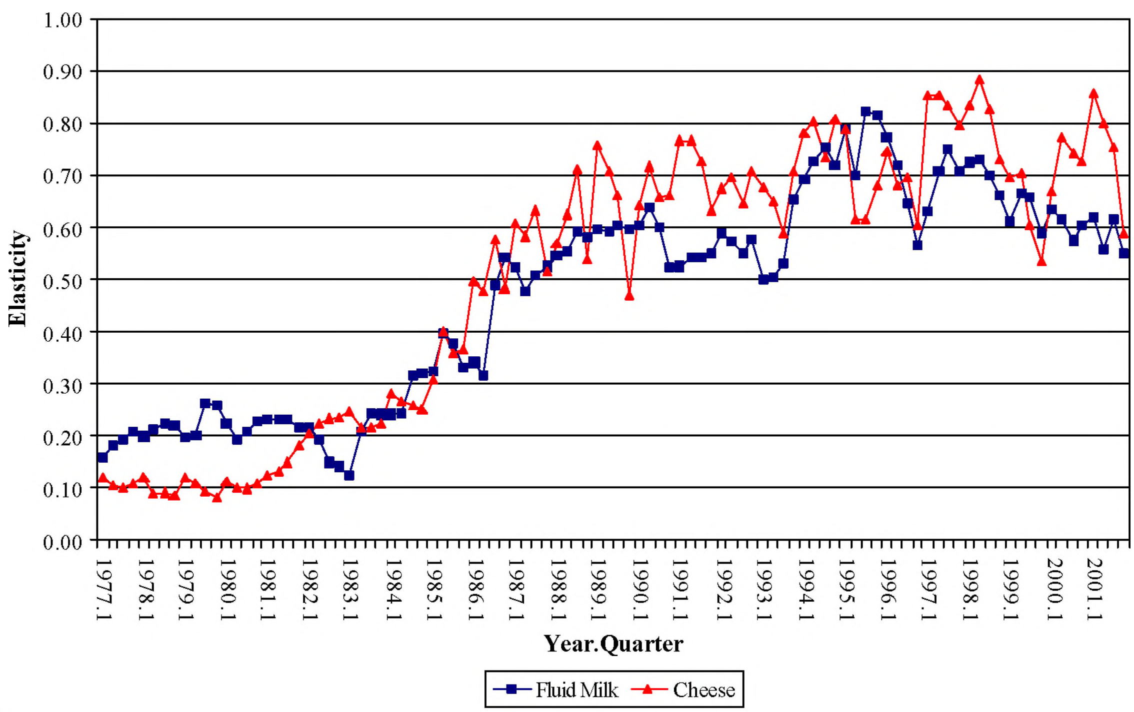


Figure 3. Age Composition Elasticities for Fluid Milk and Cheese.

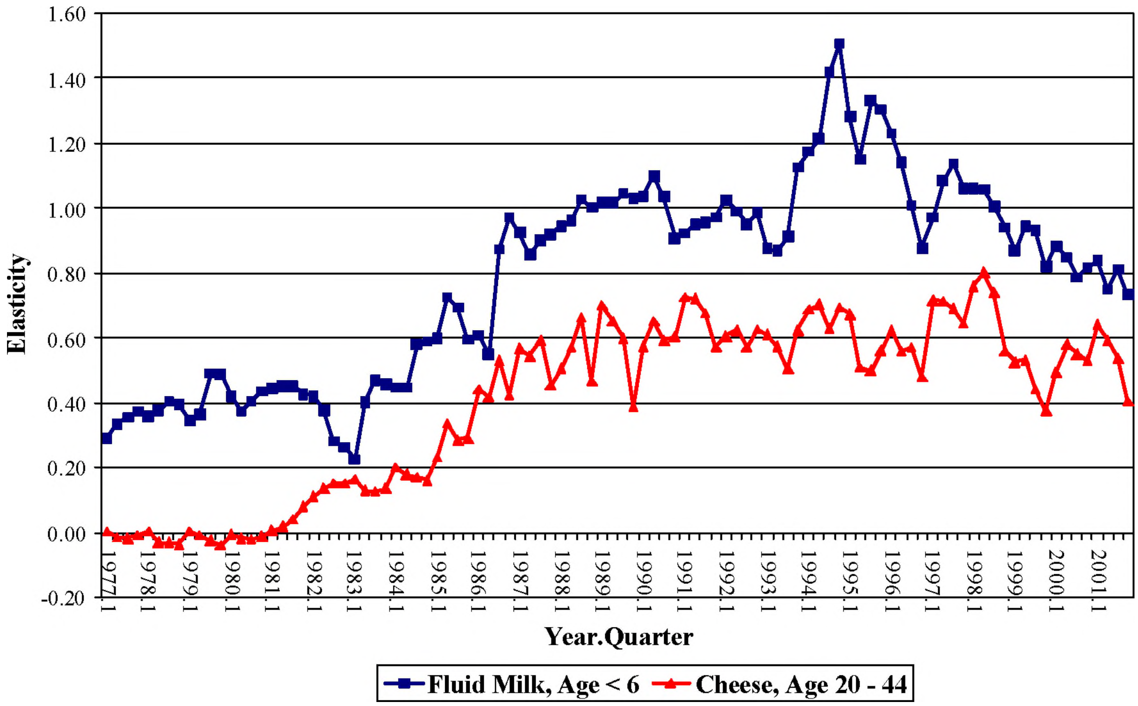


Figure 4. Long Run Generic Advertising Elasticities for Fluid Milk and Cheese.

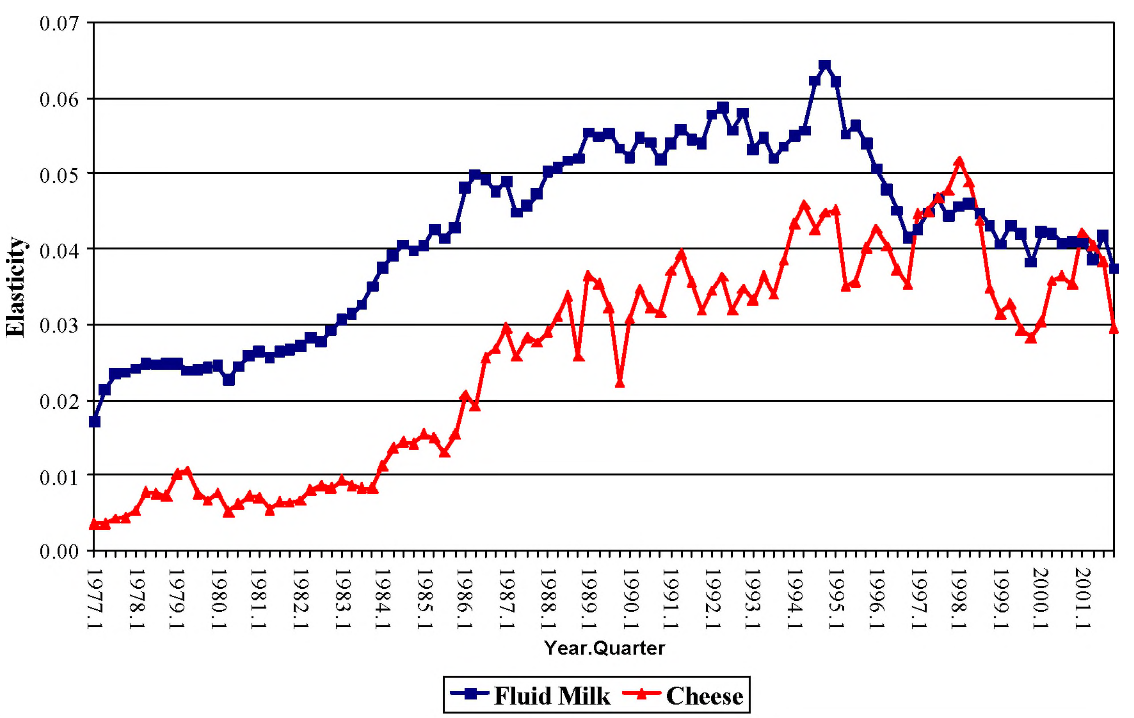
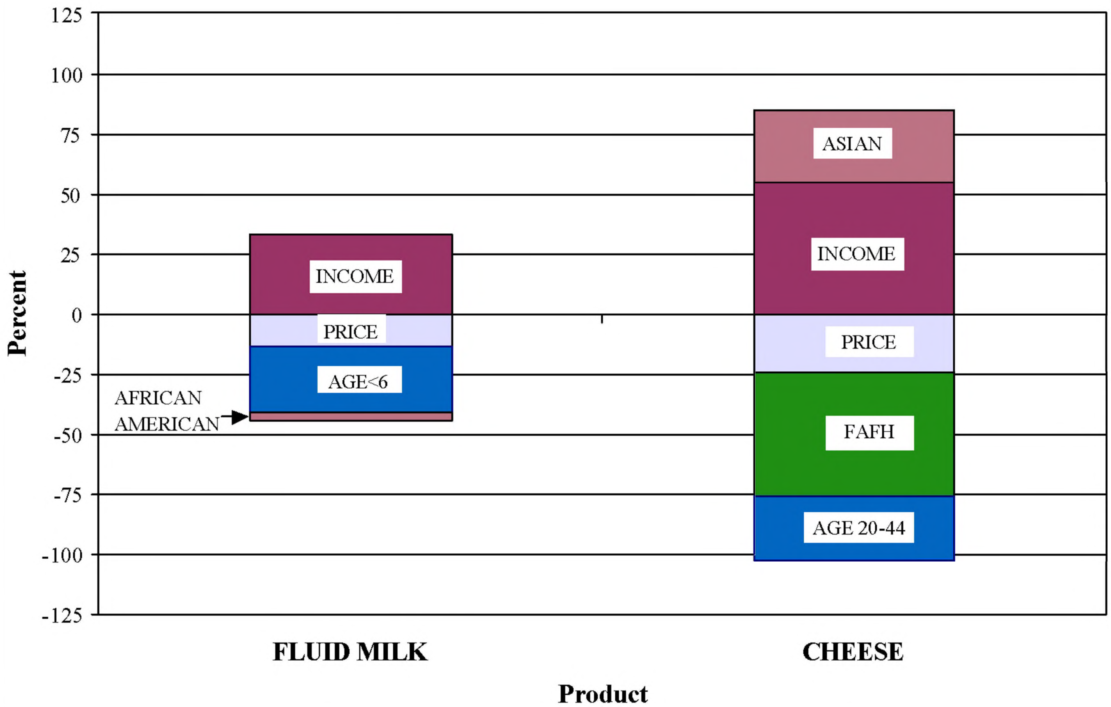


Figure 5. Generic Advertising Response Decomposition, Percent of Total Elasticity Variation 1997-2001.



Appendix Table A1. Econometric Results for Farm, Wholesale, and Retail Supply Equations.[a]

Variable	Parameter Estimate	Standard Error	t-value	p-stat
Farm Milk Supply [Dependent Variable= ln(FMS)]				
INTERCEPT	0.780	0.264	2.96	0.004
ln(AMP/PRATION)	0.078	0.044	1.76	0.081
ln(PCOW/PRATION)	-0.015	0.020	-0.72	0.474
DTP	-0.018	0.010	-1.75	0.083
MDP	-0.011	0.010	-1.12	0.264
ln(T)	0.030	0.011	2.66	0.009
QTR1	0.053	0.006	8.64	< 0.001
QTR2	0.086	0.007	12.66	< 0.001
QTR3	-0.013	0.008	-1.73	0.086
$\ln(FMS)_{-1}$	0.751	0.077	9.82	< 0.001
R-square	0.962			
DW	1.70			
Retail Fluid Milk Supply [Dependent Variable = ln(RFS)]				
INTERCEPT	0.366	0.118	3.11	0.003
ln(RFP/WFP)	0.056	0.070	0.81	0.422
ln(T)	0.006	0.002	2.31	0.023
QTR1	-0.056	0.004	-13.91	< 0.001
QTR2	-0.090	0.004	-24.07	< 0.001
QTR3	-0.044	0.003	-12.96	< 0.001
$\ln(RFS)_{-1}$	0.869	0.048	17.99	< 0.001
R-square	0.942			
DW	2.41			
Retail Cheese Supply [Dependent Variable = ln(RCS)]				
INTERCEPT	-0.267	0.205	-1.31	0.194
ln(RCP/WCP)	0.320	0.102	3.14	0.002
ln(PFE/WCP)	-0.117	0.038	-3.12	0.002
ln(T)	0.081	0.025	3.28	0.001
QTR1	-0.129	0.009	-13.69	< 0.001
QTR2	-0.030	0.011	-2.79	0.006
QTR3	-0.043	0.009	-4.54	< 0.001
$\ln(RCS)_{-1}$	0.619	0.108	5.73	< 0.001
R-square	0.989			
DW	2.35			

[a] In addition to the dependent variables, fluid milk and cheese prices (AMP, RFP, RCP, WFP, WCP, P^{I}, P^{III}) are treated as endogenous. Accordingly, each equation was estimated with 2SLS, including lagged supply stocks of fluid, cheese, butter, and frozen products as additional instruments.

Appendix Table A1. Econometric Results for Farm, Wholesale, and Retail Supply Equations (Continued).[a]

Variable	Parameter Estimate	Standard Error	t-value	p-stat
Wholesale Fluid Milk Supply [Dependent Variable= ln(WFS)]				
INTERCEPT	0.474	0.142	3.35	0.001
$\ln(WFP/P^{I})$	0.067	0.026	2.57	0.012
$\ln(PFE/ P^{I})$	-0.010	0.008	-1.14	0.257
QTR1	-0.052	0.005	-10.77	< 0.001
QTR2	-0.088	0.004	-21.92	< 0.001
QTR3	-0.045	0.003	-13.37	< 0.001
$\ln(WFS)_{-1}$	0.789	0.071	11.18	< 0.001
R-square	0.945			
DW	2.33			
Wholesale Cheese Supply [Dependent Variable = ln(WCS)]				
INTERCEPT	0.927	0.830	1.12	0.267
$\ln(WCP/P^{III})$	0.374	0.377	0.99	0.323
$\ln(PFE/ P^{III}$	0.012	0.027	-0.45	0.655
QTR1	-0.003	0.012	-0.26	0.793
QTR2	0.055	0.012	4.63	< 0.001
QTR3	-0.106	0.013	-8.25	< 0.001
$\ln(WCS)_{-1}$	0.975	0.021	46.28	< 0.001
R-square	0.978			
DW	1.81			

[a] In addition to the dependent variables, fluid milk and cheese prices (AMP, RFP, RCP, WFP, WCP, P^{I}, P^{III}) are treated as endogenous. Accordingly, each equation was estimated with 2SLS, including lagged supply stocks of fluid, cheese, butter, and frozen products as additional instruments.

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