# Allocation of Generic Advertising Funds Among Products: A Sales Maximization Approach

**Henry Kinnucan and Olan D. Forker**

With the passage of the Dairy and Tobacco Adjustment Act of 1983, dairy farmer investment in product research, nutrition education, advertising, and promotion in the United States increased from $60 million to $200 million annually. A key decision faced by boards managing these funds is how best to allocate available advertising funds among the various dairy products. In this paper an economic model is developed that shows the allocation of funds among products that would maximize sales in a given market. The model is applied to the New York City market with results suggesting that over the study period diverting funds from fluid milk to cheese advertising would have enhanced milk-equivalent sales in the market by as much as 1.17% or 8.21 million gallons annually. Alternatively, the model suggests that the same sales level could have been achieved with a different allocation of funds resulting in an estimated 14.6% savings in the amount spent advertising the two products.

*Key words:* advertising and promotion, generic advertising, dairy promotion, dairy policy, sales maximization

Interest in advertising, promotion, and new product research has increased due to declining per capita consumption of basic agricultural commodities such as beef, milk, and eggs; excess production capacity in selected industries; and a perception that consumers are misinformed about product quality or the health consequences of consuming certain foods. In 1983, for example, the Dairy and Tobacco Adjustment Act resulted in a more than tripling of market development funds for dairy products—from $60 to roughly $200 million annually. More recently, the Food Security Act of 1985 authorizes national check-off programs for beef, pork, and watermelons (Manley and Warman).

Managers of farm-funded promotion programs face a recurring problem of determining which products to emphasis in the advertising program, e.g., in the case of dairy should fluid milk, butter, cheese or ice cream receive the greatest concentration of advertising effort? The purpose of this paper is to illustrate a method for determining how best to allocate generic advertising funds among different product categories.

The common approach of assuming (short run) profit maximization and choosing fund allocations that equate net marginal returns from the various product forms may be inappropriate for the dairy industry for two reasons. First, recent dairy legislation explicitly links surpluses with the support price level. Beginning January 1, 1988 and continuing through January 1, 1990, the Food Security Act of 1985 requires that the Secretary of Agriculture reduce the support price by 50¢ per cwt. of milk marketed if Commodity Credit Corporation (CCC) purchases for the ensuing year are expected to exceed five billion pounds of milk-equivalent (Novakovic). Alternatively, the support price must be raised 50¢ if annual CCC purchases are expected to fall below 2.5 billion pounds. Dairy surpluses in 1987 are projected to be close to the 5 billion pound trigger amount, down substantially from the 1983 peak of 16.8 billion pounds (Benjamin). Given the importance of surplus reduction in maintaining or increasing price support levels over the life of

Assistant Professor, Department of Agricultural Economics and Rural Sociology, Auburn University and Professor, Department of Agricultural Economics, Cornell University. Comments by John Adrian, Bill Hardy, Donald Liu, and Lowell Wilson on earlier drafts of the manuscript are appreciated. Special appreciation is expressed to Oscar Cacho for checking the accuracy of the mathematics. Responsibility for the content of the paper rests solely with the author, however.

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the 1985 Act, allocating funds to maximize sales is likely to yield the greatest long-run profits.

Second, under the dairy price support program a profit maximization assumption implies that the entire advertising budget be spent on fluid milk when dairy surpluses exist. All funds are spent for fluid milk advertising because advertising-induced demand shifts for manufactured dairy products (cheese, butter, ice cream, etc.) simply reduce CCC inventories with no effect on farm-level price or marketings (Kinnucan, 1983). Advertising fluid milk, on the other hand, benefits the farmer even in the presence of surpluses because milk is shifted from lower valued manufactured products to the higher valued fluid product, thereby raising the blend price. The likelihood that some manufactured dairy products (especially cheese) are more responsive to advertising than fluid milk, coupled with the importance of surplus reduction, requires a model of sufficient flexibility to permit the advertisement of manufactured dairy products.

The specific research objectives of this study were to: (1) determine whether generic advertising funds spent on fluid milk and cheese in New York City were optimally allocated based on a sales maximization criterion, (2) identify the "optimal" product allocation of alternative size budgets, and (3) assess marginal returns obtainable from optimal product allocation of funds. The New York City market serves as the focus for analysis because substantial funds are invested in this market each year, an ongoing and active dairy farmer board charged with allocating funds is in place, and the needed empirical relationships have been estimated for this market, thus simplifying the analysis. An implicit assumption is that the producer group managing the New York State Dairy Promotion Order follows a two-step decision process in fund allocation. First, they decide what portion of the total budget to allocate to New York City, and then, having made this decision, decide what share of the New York City budget to place in fluid milk vis-à-vis cheese. A further simplifying assumption is that other dairy products such as butter or ice cream are ignored by the board as potential products to advertise.[1]

[1] Restricting the analysis to only two products is done for practical reasons and not because the approach is limited in its capacity to handle more products. In particular, over the study period Federal Order 2 dairy farmers spent essentially all advertising funds on cheese and fluid milk (D'Arcy, et al.), thus it was unnecessary to consider a more complicated model. Extensions of the model beyond the two product case is straightforward as discussed later.

## The Model

The general problem of deciding how best to allocate a given sized advertising budget among different products when sales maximization is the goal can be stated mathematically by the objective function:

$$\text{(1)} \quad \max_{a_i,\, \psi} Z = \sum_{i=1}^{n} q_i(a_i) + \psi \left(a^* - \sum_{i=1}^{n} a_i\right),$$

where:

- $Z$ = total sales,
- $q_i$ = sales-advertising response function of the ith product,
- $a^*$ = predetermined size of the advertising budget,
- $a_i$ = advertising funds allocated to the ith product,
- $\psi$ = Lagrange multiplier, and
- $n$ = number of products.

Equation (1) represents a constrained maximization problem that can be solved for the optimal advertising levels for each of the n products using the familiar rules of calculus. To operationalize equation (1) the number of products in the decision set (n), the budget constraint ($a^*$), and empirical relationships for the sales response functions ($q_i$) all need to be established. In this study, only two products, fluid milk and cheese, are relevant to the decision problem. Empirical sales response functions for these products estimated previously (Kinnucan, 1986; Kinnucan and Fearon) are

$$\text{(2)} \qquad q_m = 7.66\, a_m^{.051}$$

and

$$\text{(3)} \qquad q_c = 4.39\, a_c^{.059},$$

where $q_m$ is daily milk sales in ounces per person, $q_c$ is daily cheese sales in ounces per person on a milk-equivalent basis, and $a_m$ and $a_c$ are annual generic advertising expenditures for fluid milk and cheese, respectively, expressed in cents per capita in 1985 dollars.

Each of the sales response functions were estimated using monthly data pertaining to the New York market covering the time periods 1971–80 and 1977–81. The statistical models (listed in the appendix) include variables to indicate the effects on market sales of prices, income, demographic, and seasonality factors. To permit advertising to have a diminishing marginal effect on sales, logarithmic functional forms were specified. Advertising carryover was modeled using an unrestricted lag structure in the milk equation and a Pascal distribution in the cheese equation.

The exponents in equations (2) and (3) are the estimated long run advertising elasticities for each product. The constants in each equation were adjusted to: (i) reflect a change in units of the advertising variables from monthly expenditures in dollars to annual expenditures in cents, (ii) to permit pegging each advertising variable to a common base year (1985) and (iii) to insure that estimated sales equals actual sales when the functions are evaluated at mean data points ($a_m$ = 23.3¢; $a_c$ = 3.4¢). The constant term of the cheese equation reflects a conversion of cheese sales to a milk-equivalent basis. It was assumed that 1.0 lb. of cheese is equivalent to 9.9 lbs. of raw farm milk.

Substituting equations (2) and (3) into equation (1) and making suitable notational changes yields the following first-order conditions relevant to the stated decision problem:

$$\text{(4a)} \quad \frac{\partial Z}{\partial a_m} = .391 a_m^{-.949} - \psi = 0$$

$$\text{(4b)} \quad \frac{\partial Z}{\partial a_c} = .260 a_c^{-.941} - \psi = 0$$

$$\text{(4c)} \quad \frac{\partial Z}{\partial \psi} = a^* - a_m - a_c = 0.$$

Equation system (4) was solved simultaneously for the three choice variables, $a_m$, $a_c$, and $\psi$ to yield answers to the following questions: (1) Are past NYC allocations consistent with the sales maximizing allocations? (2) What are the marginal returns to alternative budget allocations to the NYC market? (3) What is the optimal (constrained sales maximizing) division of the NYC advertising budget between fluid milk and cheese? and (4) What is the break-even budget allocation to NYC? Answers are presented in the following section.

## Model Results

*Optimal Allocation of Past Expenditures.* Over the sample periods covered by the sales response functions dairy farmers in the Federal Order 2 area spent an average of 26.7¢/person/year in 1985 dollars in NYC advertising fluid milk and cheese. Replacing a* in equation system (4) with 26.7 and solving indicates that the "best" allocation of the 26.7¢ is 16.0¢ to fluid milk and 10.7¢ to cheese. Comparing this result to the actual average allocation of 23.3¢ to fluid milk and 3.4¢ to cheese, suggests that total milk-equivalent sales would have been higher if 7.3¢ had been diverted from fluid milk to cheese advertising, Table 1. Specifically, reducing annual expenditures on fluid milk advertising 7.3¢ results in a decline of .17 oz. However, this decrease is more than offset by the .33 oz. milk-equivalent sales gain realized from increasing cheese advertising expenditures by a corresponding amount, providing a net gain of .16 oz. (1.17%) from the reallocation. Based on a NYC media coverage area population of 18 million, a diversion of funds from fluid milk to cheese could have enhanced annual milk-equivalent sales in the market by as much as 8.21 million gallons.

An alternative question that might have been asked is: "Given the average milk-equivalent sales in the market of 13.72 oz./person/day over the sample periods, what would have been the cost-minimizing allocation of advertising funds consistent with this level of sales?" Viewing equation (1) as the primal objective function and solving the corresponding dual with the total milk-equivalent sales set equal to 13.72 suggests that the 13.72 oz. of milk could have been sold with a total advertising expenditure of 22.8¢ (with 14.0¢ allocated to fluid milk and 8.8¢ allocated to cheese). Com-

**Table 1. Actual Versus Optimal Product Allocation of the Generic Advertising Budget and Sales Effects, New York City, 1979–81**

| | Budget allocation | | | Milk-equivalent sales when budget allocation is: | | Sales difference | |
|---|---|---|---|---|---|---|---|
| Dairy product | Optimal | Actual | Difference | Optimal | Actual | Absolute change | Percent change |
| | ¢/person/yr.–1985 dols. | | | oz/person/day | | | (%) |
| Fluid milk | 16.0 | 23.3 | −7.3 | 8.83 | 9.00 | −.17 | −1.9 |
| Cheese | 10.7 | 3.4 | +7.3 | 5.05 | 4.72 | .33 | 7.0 |
| Both | 26.7 | 26.7 | 0 | 13.88 | 13.72 | .16 | 1.2 |

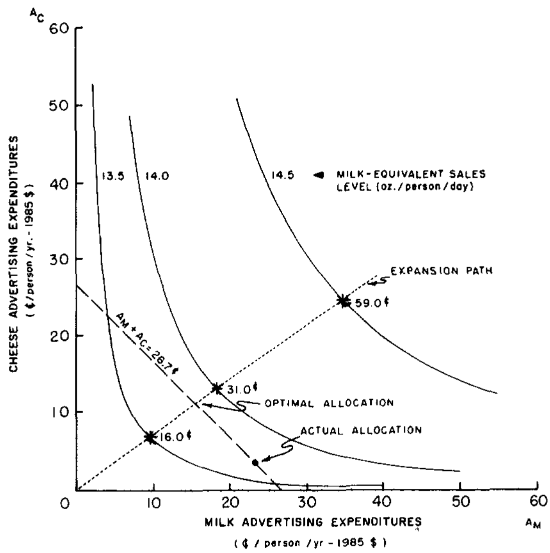


**Figure 1. Allocation of Generic Advertising Expenditures to Fluid Milk and Cheese, New York City**

paring this result with the actual expenditure of 26.7¢, a savings of 3.9¢ per capita or 14.6% is indicated had the cost-minimizing allocation of funds been in place over the study period.

A graphical solution to the foregoing allocation problem emphasizes the substantial cost savings that can be realized by appropriately allocating the budget, Figure 1.[2] The relatively steep curvatures of the sales isoquants, especially at lower sales levels, is suggestive of the costliness of allocative error. Note, too, that the isoquants are convex to the origin, ensuring that the second order sufficiency conditions for a maximum are satisfied.

*Expansion Path.* In addition to indicating the efficiency of historic budget allocations, the sales maximization model can be used to show the best product allocation of any size advertising budget provided that the parameters of the underlying sales response functions remain unchanged. What is needed is an equation for the expansion path that shows the increases in advertising for each product that would minimize cost as sales expand. Such an equation, derived from equation system (4) by appropriate substitutions to eliminate $\psi$ and $a_m$, is:

$$(5) \qquad a^* - a_c - 1.56a_c^{.991} = 0.$$

By specifying the size of the advertising budget a*, equation (5) can be solved using a nonlinear single equation search procedure to obtain the optimal value for cheese advertising, $\bar{a}_c$. The corresponding optimal value for fluid milk advertising can then be obtained from the equation for the budget constraint:

$$(6) \qquad \bar{a}_m = a^* - \bar{a}_c.$$

While equations (5) and (6) provide an exact solution to the allocation problem, the nonlinear nature of the equation for the expansion path makes application cumbersome. Fortunately, equation (5) is only slightly nonlinear (see figure 1), permitting specification of an alternative expression for the expansion path which is much simpler and only slightly less exact (less than 1% error) as follows:

$$(7) \qquad \bar{a}_c \simeq .40a^*.$$

Expression (7) indicates that to maximize milk-equivalent sales from a given NYC generic advertising budget, Federal Order 2 dairy farmers should allocate approximately 40% of the budget to cheese advertising and the remaining 60% to fluid milk advertising. The actual average allocation over the sample period was 13% to cheese and 87% to milk.[3]

*Marginal Returns.* A final result of the model pertains to the Lagrange multiplier. The optimal value of $\psi$ in equation (1) tells how milk-equivalent sales of cheese and fluid milk in the market would be affected by a slight alteration in the size of the advertising budget allocated to New York City. Because the multiplier shows the incremental impact on total market sales of the last dollar spent on advertising, it can be used (in conjunction with price information) to indicate the relative profitability of the indicated allocation.

The value of the Lagrange multiplier consistent with sales maximizing equilibrium can be obtained by solving equation system (4) for $\bar{\psi}$. Solving for $\psi$ when $a^* = 26.7$¢ yields $\bar{\psi} = 0.028$. An interpretation of $\bar{\psi}$ is that if an additional one penny per person per year (in 1985 dollars) was allocated to the New York City market, and *if these funds were*

[2] Caution must be exercised in interpreting figure 1 because in the case of cheese advertising (but not milk advertising) the graphs of the isoquants exceed the observed range of the data (the maximum annualized monthly expenditure for cheese advertising over the study period was 11.3¢; the corresponding expenditure for milk advertising was 76.0¢). It is possible that the cheese response function is no longer valid at expenditure levels exceeding 11.3¢, in which case points on the expansion path beyond the 27¢ combined advertising level must be treated with caution.

[3] The relatively heavy allocation of funds to fluid milk advertising in the market over the study period was based on the assumption discussed previously that cheese advertising is not profitable for the dairy farmer under surplus conditions. That some money nonetheless was spent advertising cheese is an indication of the pressure that exists in the industry to advertise cheese in an effort to boost total milk-equivalent sales.

**Table 2. Marginal Returns from Optimal Product Allocations of Alternative Size Generic Advertising Budgets, New York City**

| Advertising budget[a] | Optimal allocation: Fluid milk | Cheese | Marginal gross farm revenue from advertising | Marginal cost of advertising |
|---|---|---|---|---|
| | ¢/person/year—1985 dollars | | | |
| 20 | 12 | 8 | 14.90 | 1.00 |
| 30 | 18 | 12 | 10.14 | 1.00 |
| 40 | 24 | 16 | 7.72 | 1.00 |
| 50 | 30 | 20 | 6.25 | 1.00 |
| 60 | 36 | 24 | 5.26 | 1.00 |
| 70 | 42 | 28 | 4.54 | 1.00 |
| 80 | 48 | 32 | 4.00 | 1.00 |
| 90 | 54 | 36 | 3.58 | 1.00 |
| 100 | 60 | 40 | 3.24 | 1.00 |
| 350 | 210 | 140 | .98 | 1.00 |

[a]Actual average annual budget over the 1979–81 sample period was 26.7¢ or approximately $4.8 million in 1985 dollars.

*allocated between fluid milk and cheese in a manner consistent with sales maximizing equilibrium*, total milk-equivalent market sales would be enhanced by an estimated 0.028 ounces per person per day.

The relative profitability of the incremental increase in the NYC advertising budget can be determined by placing a value on the additional 0.028 ounces of milk sold and then comparing that value with the incremental expense required to achieve the sales gain. Assuming that (i) dairy farmers in the Federal Order 2 (New York-New Jersey) milk marketing area received an average blend price during the 1979–81 sample period of $12.65 per cwt. (Market Administrator's Bulletin), (ii) each pound of farm milk is equal to 14.8832 ounces of fluid milk (Thompson and Eiler) and (iii) inflation between 1980 and 1985 was 30% (USDC), it can be shown that each additional ounce of milk sold has a gross farm value of 1.106¢.[4] The *annual* increase in market milk-equivalent sales associated with an additional annual per capita advertising expenditure of one penny is 10.22 oz. (0.028 × 365 = 10.22). These numbers suggest that the last penny of advertising expense would yield additional farm revenues of 11.29¢ (10.22 × 1.105 = 11.29) if allocated between fluid milk and cheese such that milk received 60% of the increment and cheese 40%.[5] Marginal returns obtainable from optimal (sales-maximization) allocation of alternative size NYC advertising budgets are indicated in Table 2. Note that the "breakeven" NYC budget exceeds the actual average budget by a substantial margin, indicating that the NYC budget could be expanded significantly without adversely affecting the profitability of the investment.

## Concluding Remarks

Recent national legislation has accelerated the trend toward farmers' use of advertising and promotion as a marketing tool. Accordingly, there is a growing need for economic analyses aimed at improving the effectiveness of these programs. The analysis presented in this paper provides an illustration of how economic models can be used to indicate sales and profit implications of historic and proposed budget allocations. Results from economic models serve as a counterpoint to the recommendations of advertising agencies, thus providing boards with

[4] Noting that $12.65 in 1980 dollars is equivalent to $16.45 in 1985 dollars, when inflation is 30%, the 1.105¢/oz. is computed as follows:

$$\frac{\$16.45}{1\text{ cwt}} \times \frac{1\text{ cwt.}}{100\text{ lbs.}} \times \frac{1\text{ lb.}}{14.88372\text{ oz.}} \times \frac{100¢}{\$1} = \frac{1.105¢}{\text{oz.}}$$

[5] While this estimate appears high, it is consistent with other estimates of marginal returns from commodity promotion. For citrus, Nerlove and Waugh estimated a marginal gross return of $20 per additional dollar spent on generic advertising by orange growers, assuming constant supply. Marginal returns to national generic advertising of fluid milk are estimated to range from $1 to $9 per media dollar spent over the 1976–83 period with an average marginal return of $1.85 in 1983 (Ward and McDonald). Expenditures for development of markets for U.S. soybeans in foreign countries yielded an estimated *average* return of $58 per dollar invested between 1970 and 1980 (Williams). Canadian producers realized marginal gross returns of $6.65 per dollar invested in the development of export markets for Canadian agricultural products (Gunjal). Finally, Rosson et al. estimate marginal returns of $60 and $31, respectively, for investments in foreign market development of U.S. produced apples and tobacco. It might also be noted that the estimated returns are based on a sales (not profit) maximization model. If surplus reduction becomes less important so that a profit maximization approach is considered, profitability measures could differ substantially from those presented in table 2.

an alternative perspective regarding appropriate fund allocation.

Of course, to implement the principles and approach discussed in this paper, reliable empirical measures of the relevant sales-advertising relationships are needed. Moreover, recommendations based on such models must be tempered by the fact that marketing is a dynamic process. Hence, underlying relationships may change during the implementation period or may have changed by the time the recommended allocation is adopted. Thus, monitoring and follow-up are integral components of any attempt to improve marketing decision-making via the use of economic models.

The sales maximization model in this study was applied to a relatively simple problem, the allocation of a generic advertising budget between two products. In situations where a greater number of products must be considered the allocation problem becomes more complex. The major constraint associated with applying the sales maximization model to more complex situations inheres in obtaining the requisite number of empirical sales response functions. If suitable data are available for estimating the necessary functions, extension of the sales maximization model to more than two products is straightforward. Results for the two product case showing a potential budget savings of 14.6% (about $700,000 annually in 1985 dollars) are suggestive of the potential benefits that could be obtained from applying the sales maximization model to more complex problems of fund allocation.

## APPENDIX

The statistical models underlying the sales response functions presented in the text (equations (2) and (3)) are as follows:

*Fluid milk equation*:

$$\begin{aligned}
\ln q_m = \; & \underset{(0.32)}{1.78} + \underset{(0.10)}{0.001}\, S1_t + \underset{(0.06)}{0.001}\, S2_{tl} + \underset{(1.61)}{0.019}\, S3_t - \underset{(-0.36)}{0.004}\, S4_t \\
& - \underset{(-1.07)}{0.012}\, S5_t - \underset{(-1.52)}{0.018}\, S6_t - \underset{(-9.49)}{0.105}\, S7_t - \underset{(-9.89)}{0.103}\, S8_t - \underset{(-2.47)}{0.026}\, S9_t \\
& - \underset{(-1.03)}{0.011}\, S10_t - \underset{(-2.20)}{0.023}\, S11_t + \underset{(1.71)}{0.416}\ln y_t - \underset{(-1.30)}{0.095}\ln mp_t \\
& + \underset{(2.99)}{0.149}\ln cp_t + \underset{(2.93)}{0.044}\ln cfp_t - \underset{(-2.97)}{2.74}\ln r_t + \underset{(0.80)}{1.18}\ln d_t \\
& + \underset{(1.70)}{0.006}\, t + \underset{(3.43)}{0.0081}\ln a_t + \underset{(2.04)}{0.0049}\ln a_{t-1} + \underset{(4.32)}{0.0101}\ln a_{t-2} \\
& + \underset{(2.26)}{0.0053}\ln a_{t-3} + \underset{(4.93)}{0.0118}\ln a_{t-4} + \underset{(1.22)}{0.0030}\ln a_{t-5} \\
& + \underset{(3.33)}{0.0078}\ln a_{t-6} + u_t
\end{aligned}$$

$R^2 = .825 \qquad$ D.W. $= 1.53$

(t-ratios in parentheses)

where:

$t =$ 1, 2, . . . , 108 (July 1971–June 1980),
$q_m =$ per capita daily fluid milk sales in ounces,
$Si_t =$ eleven dummy variables to indicate seasonality in the intercept, $i = 1$ (January) to $i = 11$ (November),

$y_t$ = per capita personal income in 1967 dollars,
$mp_t$ = retail fluid milk price in dollars per quart in 1967 dollars,
$cp_t$ = cola price index deflated by the CPI (1967 = 100) for all items,
$cfp_t$ = coffee price index deflated by the CPI for all items,
$r_t$ = percentage of the population nonwhite in NYC metropolitan area,
$d_t$ = percentage of the population less than age 20 in NYC metropolitan area, and
$a_t$ = per capita monthly generic advertising expenditures for fluid milk in NYC 1975 dollars.

*Cheese Equation.*

$$\ln q_c = \underset{(-1.02)}{-7.28} + \underset{(5.76)}{0.044}\cos1_t - \underset{(-4.04)}{0.030}\sin2_t + \underset{(2.56)}{0.025}\cos4_t$$

$$+ \underset{(1.40)}{0.970}\ln y_t - \underset{(-0.16)}{0.065}\ln cp_t + \underset{(2.74)}{0.0593}\ln G_t + \underset{(1.85)}{0.2021}\ln B_t$$

$R^2 = .862$ D.W = 1.96 $\hat{\rho} = -0.330$

(t-ratios in parentheses)

where:
$t$ = 1, 2, . . . , 36 (January 1979–December 1981),
$q_c$ = per capita daily cheese sales in ounces,
$\left.\begin{array}{l}\cos4_t\\ \sin1_t\\ \sin2_t\end{array}\right\}$ harmonic variables (Doran and Quilkey) used to denote seasonality in the intercept term,

$y_t$ = per capita personal income in 1967 dollars,
$cp_t$ = retail cheese price index (1977–100) deflated by the CPI for all items (1967 = 100)
$G_t$ = per capita generic cheese advertising expenditures in 1967 dollars expressed as a weighted average of current and past expenditures,
$B_t$ = per capita brand cheese advertising expenditures in 1967 dollars expressed as a weighted average of current and past expenditures.

To capture the dynamic effects of advertising in the cheese model, a modified form of the Pascal distribution was used to select the weighting scheme and a 24-month weighting period beginning January 1977 was used for both the brand and generic advertising variables. Summing the individual coefficients of the current and lagged advertising variables of the fluid milk model yields a long run generic advertising elasticity for fluid milk of 0.051.

For further details on estimating procedure used for the fluid milk model, see Kinnucan (1986). Additional details about the estimation procedure for the cheese model are available in Kinnucan and Fearon.

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