Optimal Media Allocation of Generic Fluid Milk Advertising Expenditures: The Case of New York State

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A fixed-effects panel data demand model for five New York State markets is estimated to determine the differential impacts of generic fluid milk advertising by media type. Empirical results indicate that among the four media outlets, television advertising has the largest impact on per capita demand, followed by radio, outdoor, and print. Based on the estimated media-specific elasticities, media reallocation of advertising expenditures suggests that milk sales could increase significantly. The results indicate that cooperative media plan strategies developed between the New York regional advertising program and the national advertising programs would achieve the greatest benefits.

Key Words: generic advertising, milk, optimal media allocation, panel data

Since the Dairy Adjustment Act of 1983, milk producers have contributed billions of dollars through mandatory check-offs to support generic dairy advertising and promotion, nutrition research, consumer education, and new product development. Since 1995, milk processors have also operated their own advertising program (MilkPEP), which is funded by a mandatory check-off on fluid milk sales. In combination, the two check-offs raise well over $300 million every year. How to most effectively use the money is always an issue for program managers and stakeholders. Therefore, research on strategic marketing issues such as target consumer groups, temporal spending patterns, and optimal media outlet spending is important.

Investigating optimal spending strategies in allocating given marketing budgets should be conducted so as to maximize retail demand impacts of marketing efforts and improve returns to the check-off investments. This work focuses on one important allocation decision—the allocation of generic advertising budget dollars between various media opportunities. Fluid milk generic advertising expenditures account for a significant, although diminishing, component of check-off dollars. Given the reallocation of check-off dollars to alternative sources of promotion, it is timely to examine allocation decisions among media advertising outlets to maximize the effectiveness of these scarce funds.

Accordingly, the objective of this study is to obtain optimal media generic advertising expenditure shares for New York State fluid milk programs, given the expenditures in the national generic fluid milk programs. Generic fluid milk advertising in New York markets comes from two general sources—national and local programs. Funds for the national programs come from both mandatory check-offs on farm milk sales and on sales from fluid milk processors nationwide. New York dairy farmers, as with farmers in other states, contribute at least one-third of their check-off (5 cents of the 15 cents per hundred-weight) to the national farmer program, with the remainder of the check-off funds allocated to local programs. The farmer-contributed portion of national activities is operated by Dairy Management Inc. (DMI), while the processor-contributed portion of national activities is operated by the Milk Processor Education Program (MilkPEP). New York re-

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gional programs, funded solely by New York dairy farmers, are operated by the American Dairy Association and Dairy Council (ADADC) for the New York City, Albany, and Syracuse market areas. Through a contractual relationship with the Rochester Health Foundation, ADADC also places advertising in the Rochester market. Milk for Health on the Niagara Frontier also utilizes a share of the New York share of check-off funds and operates an independent advertising program in the Buffalo market. With the mingled effects of national and local generic advertising activities in the New York market, the optimal media allocation of New York advertising expenditures given the actual national expenditures becomes a unique problem that has not been previously addressed in the literature.

Pritchett, Liu, and Kaiser (1998) evaluated optimal media allocation decisions for the U.S. national generic fluid milk program using a dynamic maximization approach. With the estimation of retail fluid milk demand, price transmission, and farm milk supply equations, their objective was to maximize the discounted net revenue stream from farm milk sales, where the control variables were advertising expenditures for each media outlet.

Kinnucan and Thomas (1997) used a static maximization approach to study the media allocation problem for the U.S. catfish generic advertising program. The allocation rule derived depended solely on the media-specific advertising elasticities. Both studies found that a reallocation of the budget to different media outlets relative to the historic expenditures could give producers a significantly higher return.

In this study, we adopt the static framework approach used by Kinnucan and Thomas (1997) due to its relatively simple implementation for empirical analysis, and then extend its application to the local advertising optimality problem. Unlike Pritchett, Liu, and Kaiser (1998), our approach requires estimating only a retail demand equation that incorporates media-specific effects. The media allocation decision then depends on only the relative magnitudes of the media-specific advertising elasticities. In addition, we extend previous studies by employing a fixed-effects panel data model to estimate regional New York milk demands that effectively captures differences in milk sales across markets.

The next section gives a brief description of New York milk production and market characteristics, followed by a presentation of the fixed-effects panel data demand model. The static optimization approach used for advertising media allocation is then illustrated, followed by a discussion of the data, results, and conclusions.

New York Milk Supply and Advertising Investment

To simplify the problem, we categorize the raw milk produced by New York farmers into two class uses: fluid milk and manufactured dairy products. Total farm milk production (Q) is distributed to fluid milk as Class I products (Q_1) and to manufactured milk products (predominantly cheese) as Class II products (Q_2).[1] The Class II price (P_2) of Q_2 is the basic formula price determined by market conditions. The Class I price (P_1) of Q_1 is equal to P_2 plus a fixed Class I differential (ΔP_1). This price differential is exogenous to farmers and is regulated by federal and state milk marketing orders. For the fluid milk market, we assume that Q_1 goes directly to the retail market via fluid milk processors. The retail supply and demand for Q_1 can then be defined as

$$(1) \qquad Q_1^s = S(P, P_1, Z)$$

$$(2) \qquad Q_1^d = D(P, A, X)$$

$$(3) \qquad Q_1^s = Q_1^d = Q_1 ,$$

where Q_1^s and Q_1^d are the retail supply and demand quantities, respectively, P is the retail price of Q_1, A is the generic fluid milk advertising dollars invested by farmers, Z is a vector of supply shifters, and X is a vector of demand shifters. Under these assumptions, the farmer's profit equation for producing milk can be expressed as

$$(4) \qquad \pi = P_1Q_1 + P_2Q_2 - C(Q_1 + Q_2) - (\theta + r)A ,$$

[1] In reality, there are more than two classes of milk used, including classes of soft products, of hard products (cheese), and of butter and nonfat dry milk.

where C is the farmer's cost function, θ is the "incidence" parameter that represents the portion of the advertising tax levy borne by farmers (Chang and Kinnucan 1991), and r is the opportunity cost of the advertising investment, or the interest rate that could be earned on the next best use of the advertising fund. If we assume that fluid milk advertising impacts only Q_1, i.e., fluid milk demand, then the farmer's marginal return of the fluid milk advertising investment, A, can be derived as

$$\text{(5)} \qquad \frac{\partial \pi}{\partial A} = (P_1 - C')\frac{\partial Q_1}{\partial A} - (\theta + r),$$

where C' is the farmer's marginal cost of producing milk, and $\partial Q_1/\partial A$ is the marginal effect of advertising on fluid milk demand.

New York Retail Fluid Milk Demand

In order to estimate consumer demand for New York fluid milk, we specify (2) in double-log form[2] as

$$\text{(6)} \qquad \begin{aligned} \ln Q_{it} &= \alpha_i + \lambda \ln Q_{it-1} + \gamma_1 \ln P_{it} + \boldsymbol{\gamma_2 X_{it}} \\ &+ \sum_{m=1}^{M} \beta_m A^*_{mit} + u_{it}, \quad i = 1, \cdots, n; \; t = 1, \cdots, T, \end{aligned}$$

where i represents market regions and t represents time, Q_{it} and Q_{it-1} are the per capita milk demands at time t and t-1 by region i, respectively, P_{it} is the retail milk price at time t in region i,[3] $\mathbf{X}$ is a vector of exogenous variables that shift fluid milk demand such as the price index of other non-alcoholic beverages and per capita income, and A^*_{mit} is the generic advertising goodwill for media type m at time t and region i. Advertising goodwill (A^*_{mit}), is defined as

$$\text{(7)} \qquad A^*_{mit} = \sum_{j=0}^{J_m} w_{mj} \ln A_{mit-j},$$

where j indicates the lag of logarithm of advertising expenditures, w_{mj} is the jth lag weight for advertising expenditures in media type m, and J_m is the total advertising lag length for media type m.

One can specify the weight w_{mj} in several ways. In this study, we follow Cox (1992) and define it as a quadratic exponential lag function:

$$\text{(8)} \qquad w_{mj} = \exp(\delta_{m0} + \delta_{m1} j + \delta_{m2} j^2),$$

where the δ's are the lag weight parameters to be estimated. We assume that the weight on the last lag ($j = J_m$) is restricted to be zero and the weight on current time ($j = 0$) advertising expenditures is restricted to be 1 for normalization purposes. Under these endpoint restrictions, (8) can be re-expressed as

$$\text{(9)} \qquad w_{mj} = \exp[\frac{-20}{J_m} j + (j^2 - jJ_m)\delta_{m2}].$$

In (9) we have only one parameter left to estimate, δ_{m2}, and we assume exp(-20) $\approx$ 0. This specification, though arbitrary, does allow for either geometric decay or a lagged peak in the response surface of interest. Determination of the length of the advertising lag effects is also a bit arbitrary. According to Clarke (1976) and Leone (1995), for a mature, frequently purchased, low-priced consumer good, the lag length is between 6 and 12 months. In this study, we set the generic milk advertising lag length for all the media types to be 12 months.[4]

Note that the intercept α_i in equation (6) varies across regions (i) and captures the fixed-effects of each region. Differences in milk sales across regions are captured through differences in these fixed effects. The long-run price and m media type advertising elasticities from (6) are

$$\text{(10)} \qquad \eta = \frac{\gamma_1}{1 - \lambda}$$

and

[2] Though the double-log functional form gives constant elasticities, it is commonly used due to its simplicity and preferred estimation results.

[3] Price is assumed to be exogenous here. The Hausman and Granger exogeneity test could not reject price exogeneity at the conventional 10 percent significance level in our model.

[4] Alternative lag lengths were considered, including 6, 8, and 10 months. The 12-month lag structure was chosen as it provided the best statistical fit to the data and empirical results.

$$E_m = \frac{\beta_m \sum_{j=0}^{J_m} w_{mj}}{1-\lambda}, \tag{11}$$

respectively. The lagged dependent variable in (6) captures consumer purchasing habit persistence as in conventional time-series models. It indicates that demand in the current period will be proportional (as determined by λ) to what it was in the previous period, along with the demand impacts associated with advertising and the other variables. The error term u_{it} in (6) is defined to be autocorrelated as below:

$$u_{it} = \rho u_{it-1} + e_{it}, \tag{12}$$

where e_{it} is white noise with mean zero and the variance of σ^2. It is necessary to separate autocorrelation from advertising carryover in order for the model to give an accurate indication of advertising's effect on demand (Clarke 1976).

Optimal Allocation

The long-run marginal effect of advertising expenditures on media type m at time t for region i on the demand for Q_1 can be derived from (6) as

$$\frac{\partial Q_{it}}{\partial A_{mit}} = \frac{Q_{it}}{A_{mit}} E_m, \tag{13}$$

where E_m is constant over time and regions and is given by (11). Substituting (13) into (5) and noting that

$$A_{it} = \sum_{m=1}^{M} A_{mit} \forall \; i, \; t$$

yields

$$\frac{\partial \pi_{it}}{\partial A_{mit}} = (P_1 - C') \frac{Q_{it}}{A_{mit}} E_m - (\theta + r). \tag{14}$$

For notational convenience, we suppress the subscripts for P_1, C', θ, and r, which are all unique to time (t) and region (i). The optimal A_{mit} with an unlimited budget can be derived by setting (14) equal to zero. As pointed out by Kinnucan and Thomas (1997), for a given limited advertising budget A, the optimal allocation of the fund to different media can be determined by

$$\frac{A_{mit}}{A_{lit}} = \frac{E_m}{E_l}, \tag{15}$$

and implies that the marginal returns of the investments to any two media, m and l, are the same at any given time and region. Equation (15) indicates that the advertising expenditure allocation between any two media depends solely on the ratio of their respective elasticities.

In (6), total generic advertising expenditure (A_{mit}) is composed of two parts—New York regional advertising expenditures (A_{mit}^R) and U.S. national advertising expenditures (A_{mt}^N), where the national advertising expenditures vary over time but not across the five New York markets. Equation (15) provides the allocation rule for the total advertising fund. Since New York advertising fund agents have no direct control over spending decisions for the national fund, the optimal allocation for New York funds given a fixed national budget based on (15) becomes

$$\frac{A_{mit}^R + A_{mt}^N}{A_{lit}^R + A_{lt}^N} = \frac{E_m}{E_l}. \tag{16}$$

However, since national spending varies across media and time, we cannot solve for A_{mit}^R or A_{lit}^R directly. Instead, the optimal allocation of New York funds (A_{it}^R) given the national spending (A_t^N) can be accomplished by applying the following iterative procedure: (i) calculate the marginal effect of each national media spending on New York milk demand at time t for market i using the modified function of (13),

$$\frac{\partial Q_{it}}{\partial A_{mt}^N} = \frac{Q_{it}}{A_{mt}^N} E_m;$$

(ii) allocate New York funds in each market to the largest value of the marginal effect computed in (i); and (iii) allocate any remaining New York funds in each market with the second largest value of the marginal effect, then the third, and so on, until the marginal effects for all the media are equal, or until all funds are allocated.

Data and Variables

Monthly data from January 1986 to June 2003 for five New York regional market areas—Albany, Buffalo, New York City, Rochester, and Syracuse—were used to estimate equation (6). The dependent variable is per capita retail fluid milk sales for each of the five markets. Combined, these markets represent total fluid milk sales in New York State. The independent variables include the retail fluid milk price, Consumer Price Index for nonalcoholic beverages, consumer income, race (African American), ethnicity (Hispanic), age compositions (percentage of people under age 6 years, and 10 to 19), advertising goodwill for four media outlets (television, radio, outdoor, and print), a time trend, and monthly dummy variables.

Fluid milk sales were estimated based on data collected by the Division of Dairy Industry Services and Producer Security (DIS), New York State Department of Agriculture and Markets. For each May and October, plants and milk dealers with route sales in the state file reports documenting the amounts of milk sold in each county in which they do business. In addition, fluid milk processing plants that provide fluid milk to New York State dealers, or sell milk on routes in the state, file monthly plant reports. Utilizing both sets of reports, it is possible to trace all fluid milk sold into designated market areas back to the plants in which it was originally processed. Plant-specific allocation factors are developed from the May and October dealer reports that are then applied to the monthly plant reports to estimate monthly in-market sales for the entire year. The May report is used to estimate monthly in-market sales for the first six months of the year, and the October report is used to estimate monthly in-market sales for the second half of the year. Regional market sales data were converted to a per capita basis by dividing sales by the regional market populations (Figure 1). Population data were obtained from the U.S. Census Bureau.

Consumer Price Indices (CPIs) for nonalcoholic beverages and for all items in the Northeast region of the United States are collected from the U.S. Bureau of Labor Statistics. The CPI for all items (converted to a base year of 2003 = 1.0) was used to deflate prices and income to 2003 dollars. The CPI for nonalcoholic beverages is used as a proxy for the price of competing beverages.

Retail fluid milk prices come from the DIS publication entitled *Survey of Retail Milk Prices for Selected Markets in New York State*. The survey includes retail fluid milk prices for different types of milk (whole, 2 percent, 1 percent, and skim) in various container sizes for several cities in the state of New York. Given the high correlation in prices across fat contents evident from the data, we utilize only the retail price for fluid whole milk in half-gallon containers.

The income measure used is real per capita personal disposable income. The nominal regional total income data and the regional population data were separately collected for each county in New York from the U.S. Department of Commerce, Bureau of Economic Analysis, and then allocated to each of the five defined market regions. Nominal per capita personal disposable income was calculated by dividing the sum of the regional total personal incomes by the total regional population. Nominal per capita income levels for each region were then deflated by the CPI for all items.

Historical county-level data on age, race, and ethnicity populations were collected from *Population Estimates*, U.S. Census Bureau, on an annual basis and then extrapolated to monthly time intervals.[5] Similar extrapolation procedures were used for the income and population variables, as these were available only on an annual basis at the county level.[6]

The sum of real regional and national generic advertising expenditures by media type is used to represent the total level of generic advertising efforts. Nominal regional generic advertising expenditures were collected from the American Dairy Association and Dairy Council (ADADC).

[5] Online data source is available at http://eire.census.gov/popest/es[-]timates_dataset.php

[6] Extrapolation procedures are conducted using the PROC EXPAND procedure in SAS (Version 9.1). The spline functions that are fitted by the EXPAND procedure approximate continuous curves based on the input data. The extrapolated variables represent demographic, population, and income series that change modestly within one particular year and are generally trending monotonically. Relative to more variably trending data, the expansion procedure should more reasonably capture these within-year trends.

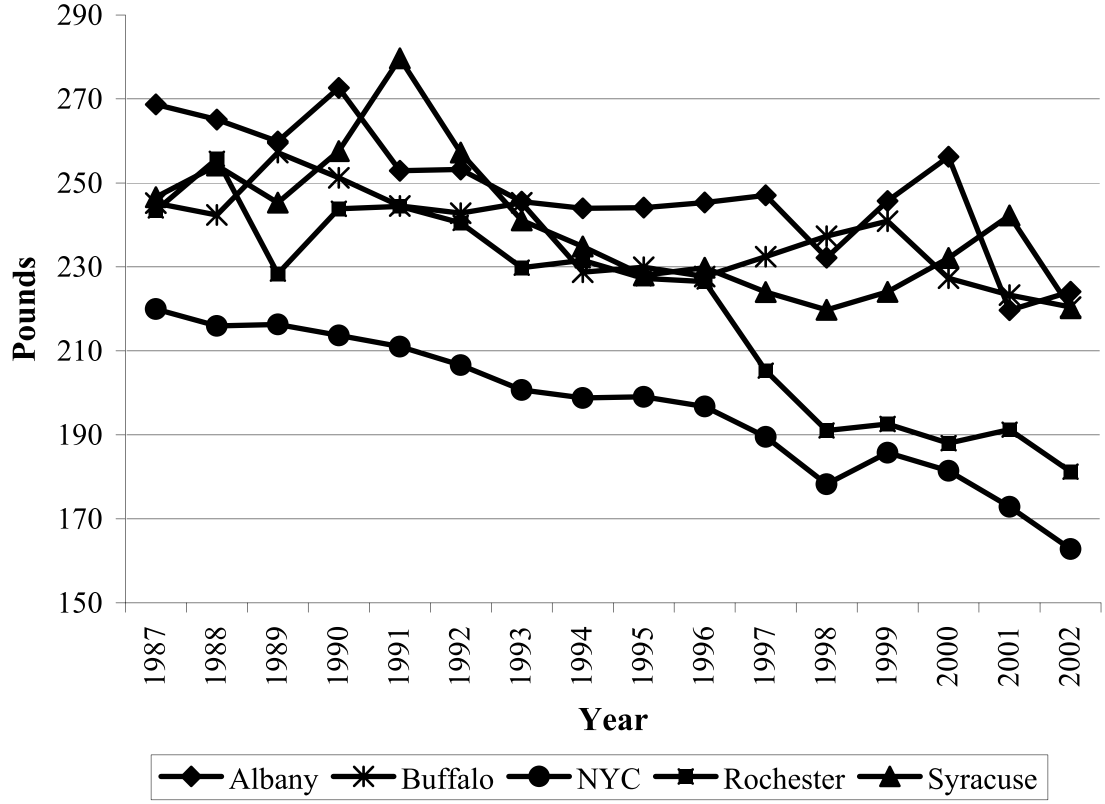

Figure 1. Annual per Capita Milk Sales in New York State

Nominal national generic advertising expenditures were collected from Dairy Management Inc. (DMI) through Lowe Worldwide, Inc., its contracted advertising agency. The national data were generated by AD*VIEWS, an advertising tracking program (© 2004, Nielsen Media Research).

Furthermore, since both the Fluid Milk Processor Promotion Program and the Producer Promotion Program at the national level have the same primary objective—to increase fluid milk consumption—and the impact of each program on milk demand cannot be satisfactorily segregated, we combine both programs' efforts to represent total national generic fluid milk advertising efforts. Similar to the Consumer Price Index, a Media Cost Index (MCI) is used as a deflator to deflate generic fluid milk advertising expenditures. The MCI is generated by annual media cost per thousand changes with seasonal adjustment factors supplied by DMI's advertising agency, Lowe Worldwide, Inc.

Demand Estimation

Maximum likelihood estimation procedures were used to estimate equation (6). The standard errors of the estimated parameters were obtained from the inverse of the negative Hessian matrix. Table 1 provides the estimated parameters of the model, other than those associated with the generic advertising media variables. We found that the fixed regional effect of New York City was significantly lower from other regions at the 5 percent significance level, and is consistent with annual regional per capita sales over time (Figure 1). The own-price effect was negative, but not significant, while the cross-price (non-alcoholic beverage) effect was positive and significant, indicating a substitute relationship between the two commodities. The insignificance of the own-price elasticity for fluid milk is not uncommon in the literature (e.g., Chung and Kaiser 2000, Lenz, Kaiser, and Chung

Table 1. New York Milk Demand Estimates

Variables	Estimates	t-ratio
Fixed Effects		
α_1 (Albany)	-4.780	-2.226
α_2 (Buffalo)	-4.451	-2.185
α_3 (New York City)	-5.881	-2.561
α_4 (Rochester)	-4.849	-2.250
α_5 (Syracuse)	-4.637	-2.224
Monthly Dummies		
January	-0.013	-2.544
February	-0.103	-15.707
March	-0.027	-3.448
April	-0.067	-8.480
May	-0.056	-6.863
June	-0.126	-15.529
July	-0.134	-14.798
August	-0.102	-11.864
September	-0.057	-7.450
October	-0.006	-1.024
November	-0.026	-5.142
Coefficients		
Time trend	-0.003	-1.683
Lagged sales	0.223	4.837
Milk price	-0.033	-0.979
Beverage price	0.315	2.928
Income	0.049	1.237
African American	-0.420	-1.985
Hispanic	0.337	1.800
Age < 6	0.410	1.659
Age 10–19	-0.535	-1.866
Model Parameters		
σ	0.038	18.822
ρ	0.615	24.001

1998, Kaiser and Reberte 1996), suggesting that milk is a staple good.

Similar to previous results, we find that African Americans drink less milk than Caucasians, while Hispanics drink more (Vande Kamp and Kaiser 1999, Chung and Kaiser 2000, Lenz, Kaiser, and Chung 1998). We found that, consistent with previous results, young children under 6 years old drink more milk than other age groups. Also, people of the age between 10 and 19 years of age drink less milk than other age groups, partly due to shifts in consumption from milk to other beverages, such as carbonated soft drinks and sports drinks. The estimated parameter on lagged sales (λ) was 0.223 and significantly different from zero. The time trend was found to be negative, indicating that per capita milk sales declined over time. The correlation coefficient of the error term (ρ) was 0.615, indicating that the first-order autocorrelation correction procedure was appropriate.

The β and δ_2 estimated parameters in Table 2 represent the demand impacts associated with the media advertising goodwill and lag weights, respectively. The normalized generic advertising lag weights for the four media are also presented, indicating that the initial advertising effects of television are relatively high, reach a maximum at the 2-month lag, and then consistently diminish from thereon. Radio and print advertising have similar lag distributions, with hump-shaped patterns peaking at the 6-month lag. In contrast, outdoor advertising appears to have an immediate maximum impact and then declines exponentially over time.

While no economic theory can describe differences in distributional patterns by media type, the patterns can be intuitively interpreted, as discussed by Pritchett, Liu, and Kaiser (1998). For example, the more common hump-shaped distributions imply that once consumers observe the advertising message the first time, it takes time for them to fully absorb the information and respond. In contrast, the distinct difference in presentation of outdoor messages suggests an initial and fuller reaction, followed by declining responses over time. In any event, the distinct differences in lag distributions across advertising media types highlight distinct consumer responses over time which are hidden in more aggregated advertising demand analyses.

From these weights and using (11), we calculate the four media-specific advertising elasticities (Table 2). The standard errors of the elasticities are obtained using the Delta method (Rao 1973). Television has the largest estimated elasticity (0.057), followed distantly by radio (0.005), outdoor (0.003), and print (0.003). Interestingly, the magnitude of the television elasticity is more than ten times larger than that of all other media, with the radio elasticity only slightly above the elasticities estimated for outdoor and print. In addition, these elasticities were relatively consistent with

Table 2. Estimates of Parameters Related to Advertising Variables

Parameters	TV	Radio	Outdoor	Print
β (coefficients of advertising goodwill)	0.0086	0.0007	0.0011	0.0004
γ_2 (lag weight parameters)	0.0099	-0.1535	0.0059	-0.1565
Lag weights (normalized)[a]				
Lag 0	0.9390	0.0275	1.0000	0.0245
Lag 1	0.9883	0.1868	0.7263	0.1829
Lag 2	1.0000	0.4196	0.5129	0.4144
Lag 3	0.9734	0.6597	0.3503	0.6569
Lag 4	0.9100	0.8570	0.2296	0.8558
Lag 5	0.8137	0.9768	0.1431	0.9762
Lag 6	0.6905	1.0000	0.0836	1.0000
Lag 7	0.5485	0.9229	0.0448	0.9233
Lag 8	0.3981	0.7577	0.0212	0.7583
Lag 9	0.2521	0.5318	0.0084	0.5324
Lag 10	0.1252	0.2885	0.0024	0.2888
Lag 11	0.0348	0.0865	0.0003	0.0866
Lag 12	0	0	0	0
Elasticities				
Estimates[b]	0.0572	0.0046	0.0031	0.0030
t-ratio[c]	2.2211	1.6732	2.9398	1.7314

[a] Weights are normalized by being divided by their maximum for each medium.
[b] The estimated elasticities are for the long run. Given the size of the coefficient on the lagged sales (0.223) provided in Table 1, the long-run elasticities are 22.3 percent larger than the short-run estimates.
[c] Standard errors of these elasticities are derived from the Delta method (Rao 1973).

the previous studies (e.g., Kaiser and Reberte 1996, Pritchett, Liu, and Kaiser 1998, and Kinnucan and Thomas 1997). Historically, television has represented the dominant media advertising outlet, representing around 70 percent of total media advertising expenditures. Based on these elasticities and utilizing (13) and (15), we can determine the optimal media allocation over time.

Optimal Media Advertising Allocations

We have three types of advertising funds to be allocated, as described in the introduction—national farmer (DMI), national processor (MilkPEP), and New York regional funds. In this study, we allocate the advertising funds by media to maximize New York farmers' profits under three scenarios: (i) allocating all funds, including DMI, MilkPEP, and New York regional; (ii) allocating New York regional funds given fixed national funds (DMI plus MilkPEP); and (iii) allocating farmer funds (DMI plus New York regional) given a fixed MilkPEP budget.

Scenario 1: Optimal Allocation of All Advertising Funds

The allocation for this situation is relatively easy. From (15), we compute the optimal percentage allocation of total advertising expenditures on television, radio, outdoor, and print as 84.3 percent, 6.8 percent, 4.5 percent, and 4.4 percent, respectively. The allocation is fixed over time and regions given the constant estimated media-specific advertising elasticities. Figure 2 shows the total annual actual and optimal spending from 1987 through 2002.[7] On average, the actual allocations for this period were 73.8 percent for television,

[7] For ease of exposition, we aggregate New York advertising expenditures from the five market areas to the state level and the monthly data to an annual basis in Figure 2, and later, for scenario 2, in Figure 3.

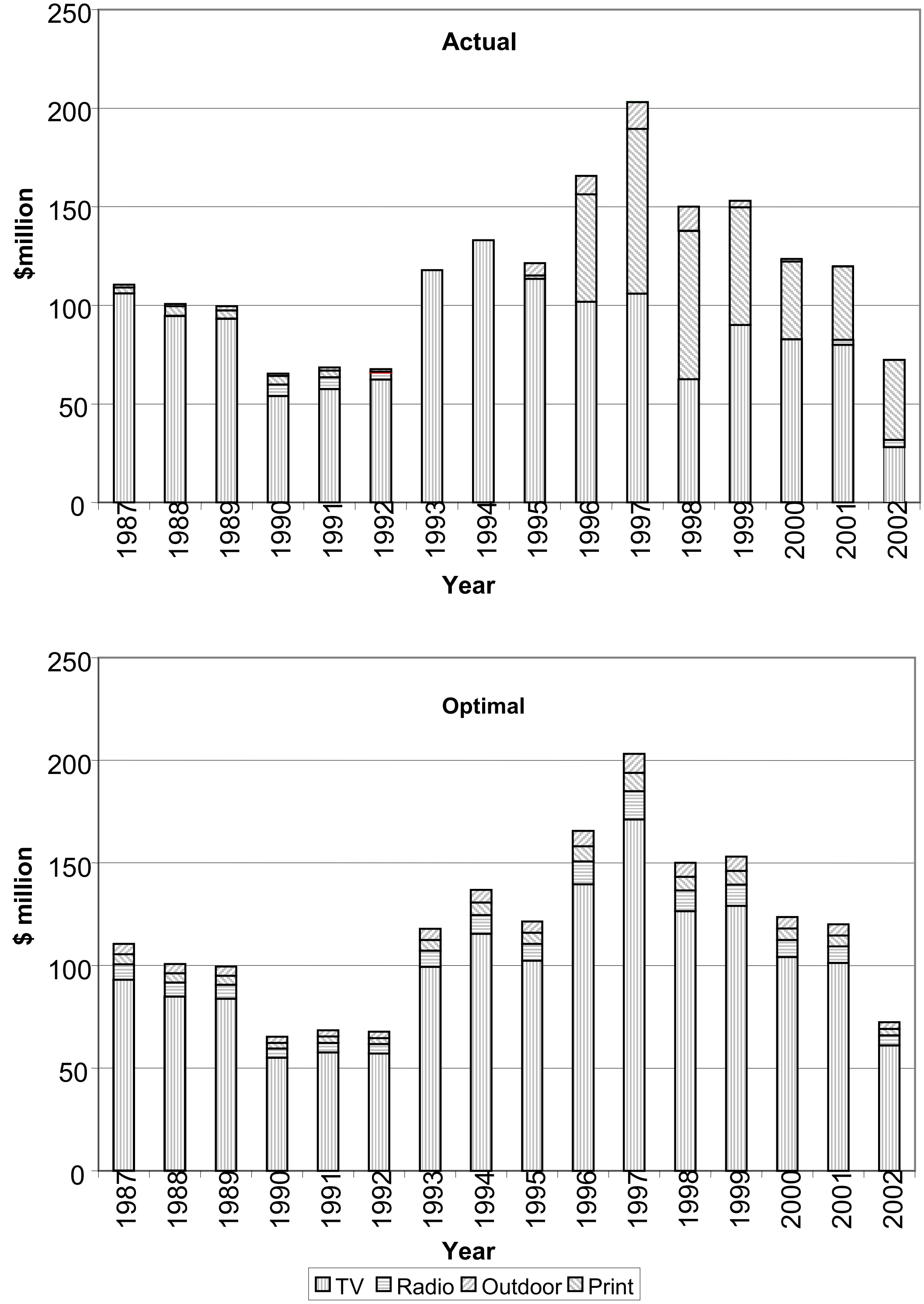

Figure 2. Total Actual and Optimal Fluid Milk Generic Advertising, by Media Type (2003$), Scenario 1

1.4 percent for radio, 2.8 percent for outdoor, and 22.0 percent for print. The relatively large spending on print is predominantly due to heavy print media efforts associated with the MilkPEP program and operated independently from DMI efforts. These numbers indicate that actual historical spending was far from the optimal spending levels. From (6), we can calculate the change in expected New York milk sales by reallocating the advertising expenditures for the study period. From this computation, monthly per capita New York state milk sales are estimated to increase by 5.1 percent from this reallocation.

Scenario 2: Allocation of New York Regional Funds with a Fixed National Budget

As discussed above, we cannot allocate advertising funds for this scenario using (15) directly. As such, we calculate the marginal effects on New York per capita sales for each media at the actual (fixed) national advertising expenditures using the modified function of (13),

$$\left(\frac{\partial Q_{it}}{\partial A_{mt}^{N}} = \frac{Q_{it}}{A_{mt}^{N}} E_m\right).$$

Then, we allocate the advertising funds in each New York market area according to the relative magnitudes of the marginal effects. Figure 3 shows the actual and optimal expenditures of the New York advertising fund over the data period.[8] The average actual New York generic advertising media spending distribution over the studied time period was 71.0 percent, 25.0 percent, 4.0 percent, and 0.0 percent, for television, radio, outdoor, and print, respectively. In contrast, the average optimal media spending distribution is 11.8 percent, 54.7 percent, 22.8 percent, and 10.7 percent, for television, radio, outdoor, and print, respectively.

Note that the optimal spending distribution depends not only on the relative magnitude of the media-specific advertising elasticities, but also on the given (fixed) level of national media spending and marginal sales gains from those fixed spending levels. Given the relatively high level of national television expenditures, less advertising in this media is required optimally for supplemental New York efforts. The associated increase in monthly per capita milk sales from this reallocation is approximately 2.8 percent.

Scenario 3: Allocation of Total Farmer Funds with a Fixed MilkPEP Budget

Since the focus of this study is to evaluate farmers' investments, the separation of fluid milk processors' investments from farmers' investments is meaningful. This case appears relatively similar to scenario 2; i.e., given part of the funds as fixed, how to optimally allocate the rest? In reality, however, the allocation process is different. Specifically, under this case, the allocation process proceeds in two steps, given that New York local efforts are not directly coordinated with national farmer-funded efforts. As such, the first step is to allocate DMI national farmer funds given MilkPEP spending as fixed according to the mean marginal effects from (13) over the five New York market areas. The allocation at the national level is identical for the five New York markets.

For the entire data period (i.e., since 1986) we have only media-specific data for the combined national farmer and national processor efforts. However, since January 2002, we also have separate media-specific advertising expenditures for MilkPEP. As such, this scenario can be evaluated only for the more recent time period. The average actual DMI national farmer generic advertising media spending distribution over this time period was 78.7 percent, 20.8 percent, 0.5 percent, and 0.0 percent for television, radio, outdoor, and print, respectively. In contrast, the average optimal distribution for this period was 72.7 percent, 17.9 percent, 9.4 percent, and 0.0 percent, for television, radio, outdoor, and print, respectively.

The second step is to allocate the New York funds for each of the five market areas given the actual MilkPEP spending and the optimal DMI farmer fund spending determined in step one. Figure 4 shows the actual and optimal allocation of the New York funds aggregated across the five market areas over this time period. The average actual New York generic advertising media spending distribution over this recent time period was 16.5 percent, 83.5 percent, 0.0 percent, and 0.0

[8] Note that actual allocations are monthly for the five New York markets but, for ease of exposition, these figures show only the aggregate annual results.

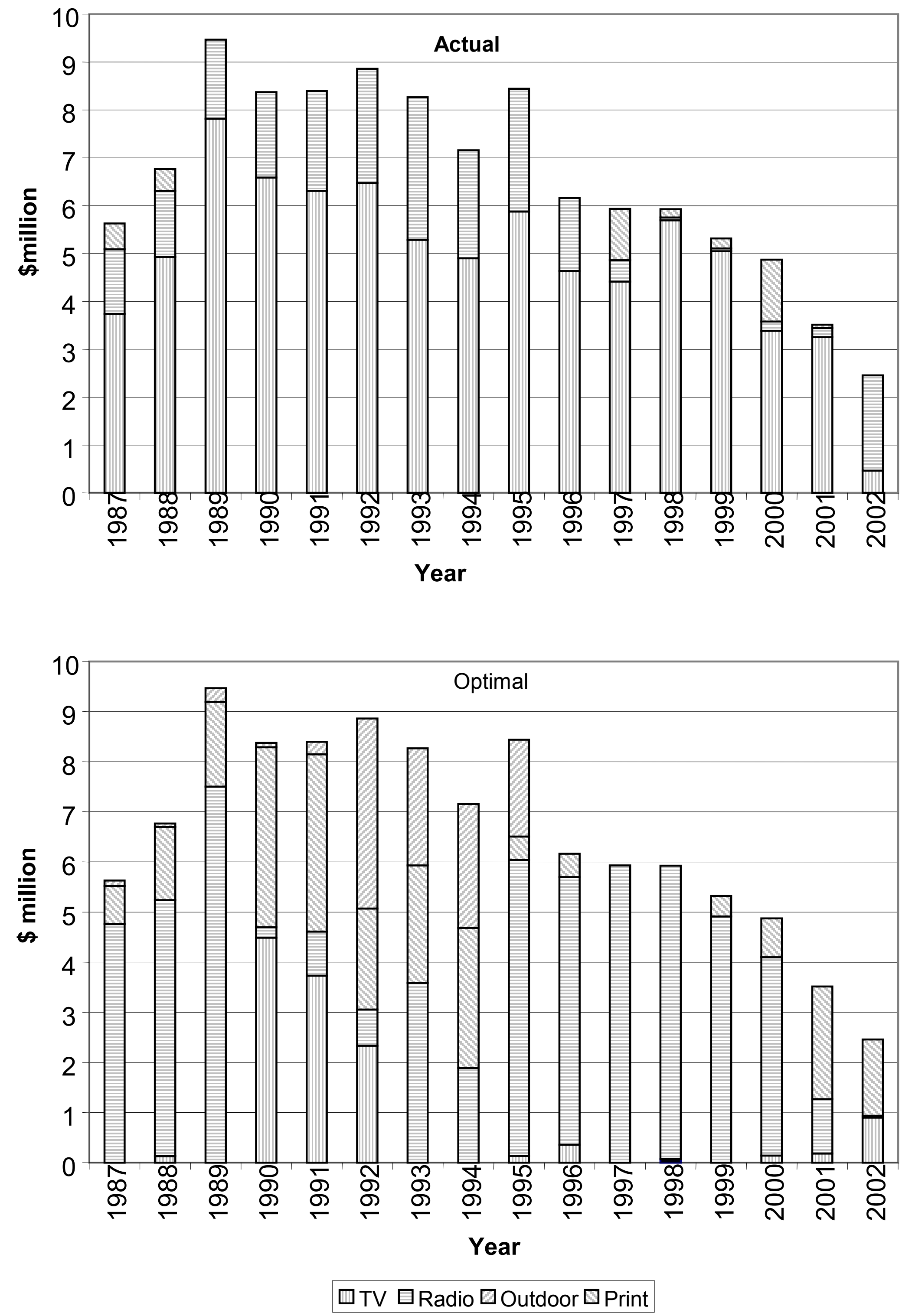

Figure 3. New York Milk Actual and Optimal Advertising, by Media Type, Given Fixed National Budget (2003$), Scenario 2

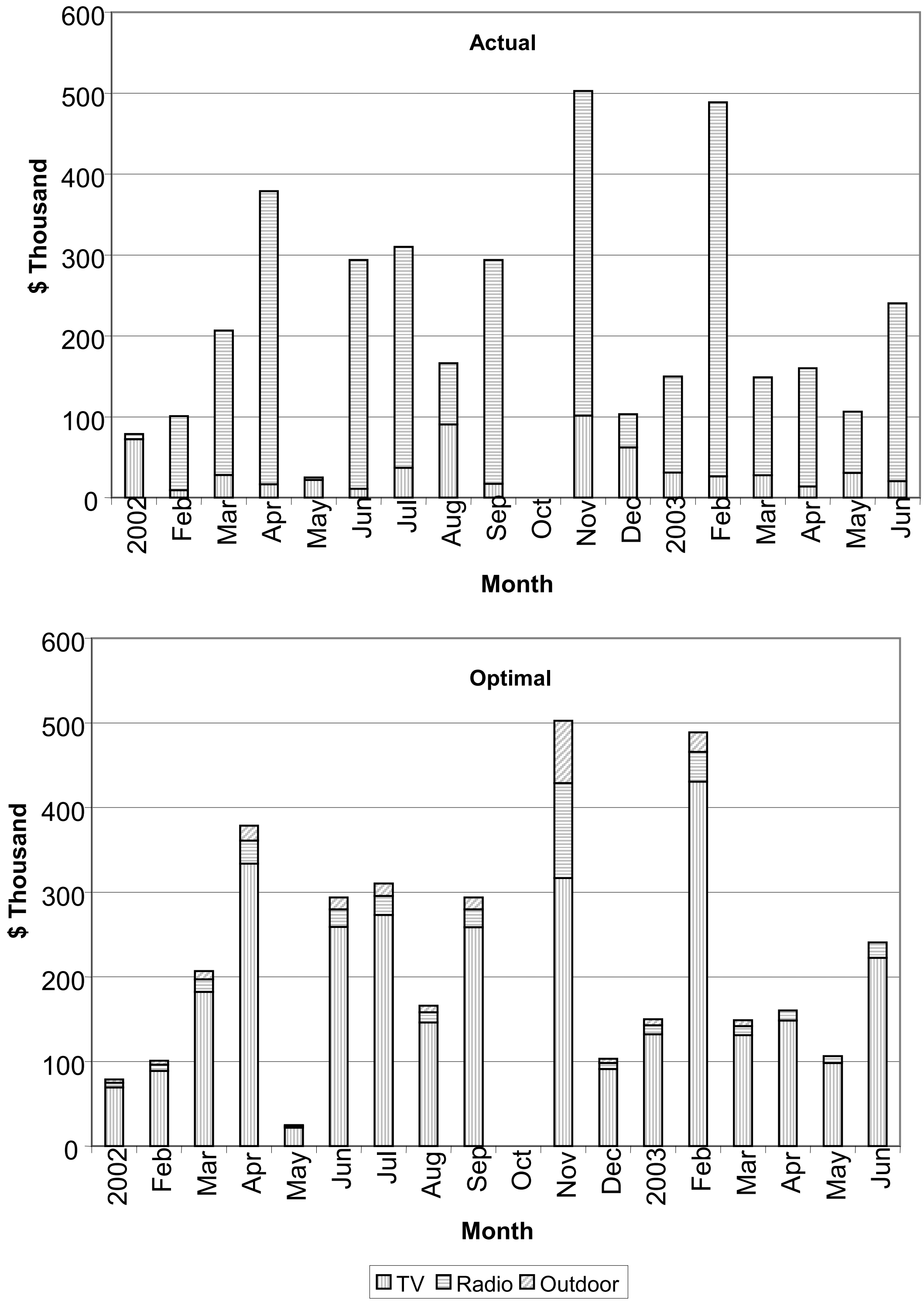

Figure 4. New York Milk Actual and Optimal Advertising, by Media Type, Given Fixed MilkPEP for the Period of January 2002 to June 2003 (2003$), Scenario

Table 3. Monthly Changes in New York Milk Sales and Farmers' Benefits under Various Advertising Reallocations for the Period January 2002 to June 2003

Scenarios	Sale Changes	Farmers' Benefits
Reallocation of total funds	+1.71%	$0.15 million
Reallocation of New York funds only	+7.37%	$0.64 million
Reallocation of total farm funds	+2.49%	$0.22 million

percent for television, radio, outdoor, and print, respectively. In contrast, the average optimal media spending distribution is 85.3 percent, 9.3 percent, 5.4 percent, and 0.0 percent, for television, radio, outdoor, and print, respectively. Now, with decreased optimal national farmer television spending over this time frame, higher allocations of television in regional advertising are required. Under this situation, the reallocation of the actual farmer generic advertising expenditures to different media would increase New York per capita milk sales by 2.5 percent.

For purposes of comparison, we calculated the changes in per capita milk sales for the reallocation scenarios of (i) and (ii) above for the same data period as used in this scenario and report them in Table 3. Table 3 also provides the associated farmer benefits calculated from the changes in sales and the average farmer's class I price differential. For this time period, the reallocation of total funds would increase New York milk per capita monthly sales by 7.4 percent ($0.64 million in farmer benefit) on average, and the reallocation of New York advertising funds would increase the monthly per capita sales by 1.7 percent ($0.15 million in farmer benefit). Comparing these results with those for the entire time period reveals that actual New York regional expenditures by media given national expenditures are closer to optimal levels for more recent time periods (Scenario 2), indicating improved New York media advertising planning in local markets in response to national efforts. However, when evaluated for total fund reallocation (Scenario 1), more recent time period allocations were further from the estimated optimal levels. The result is plausible given that national program efforts are directed to markets including and in addition to New York State.

Conclusions

For the purpose of analyzing New York farmer investments in fluid milk generic advertising, we estimated a retail demand function for New York fluid milk markets utilizing a fixed-effects panel data model. Media-specific advertising expenditure elasticities were estimated and used to determine the optimal allocation of advertising expenditures across media types.

Empirical results showed that television has the largest marginal demand effect, followed by radio, outdoor, and print. The time-invariant computed elasticities were 0.057, 0.005, 0.003, and 0.003 for television, radio, outdoor, and print, respectively. Based on these elasticities and relative media-specific advertising spending levels, we reallocated advertising funds in several scenarios depending on the source of funds (e.g., state or national, and farmer or processor) to be adjusted. We found that for all scenarios the reallocation of advertising expenditures by media could increase per capita milk sales substantially, with ranges from 1.7 percent to 7.4 percent depending on the time frame and funding sources considered. Since the reallocations of given annual advertising budgets are virtually no-cost amendments, understanding the components of optimal media allocation should be important to product marketers in designing future effective advertising strategies.

The results also imply that the degree to which distinct marketing organizations promoting similar products can coordinate their marketing efforts has significant implications for improving consumer sales. Evaluated over the entire data period, increases in New York per capita sales from optimal media reallocations when total fluid milk advertising funds (national and local, farmer and processor) were adjusted were two times that when only state-level farmer advertising was adjusted. Cooperative and interdependent development of media strategies between regional and national programs would achieve the greatest benefits to all funders of the programs.

While this paper addresses media allocation of advertising expenditures, the methods introduced here could also be applied to other fund allocation decisions—for instance, the allocation of advertising expenditures among various products such as fluid milk and cheese. Incorporating time-varying advertising effects would also be a useful extension to this research so as to more effectively capture changes in dynamic advertising response over time.

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