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- Enhance both public and private policy maker's understanding of the economics of commodity promotion programs.

- Facilitate the development of new theory and research methodology.

Determinants of Temporal Variations in Generic Advertising Effectiveness

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Abstract

This article develops a varying-parameter advertising model which specifies advertising parameters as a function of variables representing advertising strategies and market environments to explain the varying nature of the advertising responses. Unlike prior models, this model allows researchers to examine the sources of change in advertising effectiveness over time. The model is applied to the New York City fluid milk market for the period from January 1986 through June 1995. Results indicate that advertising strategies and market environments play important roles in determining advertising effectiveness. Particularly, demographic factors were more important than economic factors. The results also suggest that when a market is in an unfavorable or unsaturated condition, advertising generally becomes more important and effective.

Key words: determinants, generic advertising effectiveness, milk, time-varying parameters

DETERMINANTS OF TEMPORAL VARIATIONS IN GENERIC ADVERTISING EFFECTIVENESS

by

Chanjin Chung and Harry M. Kaiser[1]

Introduction

Over the past few decades, generic advertising has been an important marketing strategy for farmers in the United States. Farmers in the United States have invested almost $1 billion annually on generic advertising and other promotional activities in agricultural commodity markets (Forker and Ward). Since most of this money has been generated from various mandatory checkoff programs, evaluating the effectiveness of generic advertising has become an important practice for farmers overseeing the checkoff fund. The importance of evaluating generic advertising has been further heightened because Congress recently mandated the evaluation of all federally sanctioned commodity promotion programs at least once every five years.

There has been considerable literature on evaluation of generic advertising programs, most of which evaluated advertising effectiveness assuming constant parameters throughout the whole sample period. This implies that the economic structure generating the data does not change over the sample period. However, the economic structure may change over time, and consequently the parameters characterizing this economic structure may not be constant. For example, consumers' past responses to advertising may not be the same as their current responses because peoples' taste, demographics, and other economic and social factors have changed. Therefore, econometric models that allow varying advertising parameters may offer more accurate estimates, as well as provide richer information for program managers.

Only a few studies have addressed the issue of varying parameters in the generic advertising literature. In general, previous studies have used two types of varying-parameter models either in which time trends were the explanation for advertising response variations (Singh et al.; Kinnucan and Venkateswaran; Kinnucan, Chang, and Venkateswaran; Reberte et al.) or the advertising coefficient variation's source was purely stochastic (Ward and Myers). Ward and Myers indicated that changes in consumer demand over time, influenced by advertising, might not be accounted for in traditional fixed-parameter models and suggested a random coefficient model in which demand responsiveness to advertising was adaptive subject to permanent and transitory changes. Applying a random coefficient model to the evaluation of advertising effectiveness in the frozen concentrated orange juice market, they found the existence of dynamic effects of advertising on consumer demand. Kinnucan and Venkateswaran developed a time-varying parameter model that allowed for advertising response to change over time by specifying the advertising coefficient as a function of a time trend. They applied the model to the Ontario fluid milk campaign data for the period 1978-87 and found a declining trend of advertising response over the sample period. Kinnucan, Chang, and Venkateswaran used a similar model in examining the effectiveness of the New York City fluid milk campaign during 1971-84. Results of this study found the existence of advertising wearout for each campaign period while displaying an increasing trend of effectiveness over the entire sample period. Reberte et al. estimated the effectiveness of the NYC fluid milk campaign for the period 1986-92 and found decreasing effectiveness of advertising for this sample period.

The aforementioned studies offered more accurate and detailed information on advertising effectiveness than earlier studies with fixed parameter models. Yet, a better understanding of the nature of consumers' changing responses to advertising is needed to develop more effective marketing strategies. The previously reviewed models showed direction (increasing or decreasing) of historical advertising effectiveness, but could not offer insight as to why effectiveness changed. If a model can explicitly analyze the causes of directional changes, it may offer more useful information than previous models.

In our study, we introduce a varying-parameter advertising model which specifies advertising parameters as a function of relevant variables to explain the varying nature of the advertising responses. We

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hypothesize that changes in advertising strategies (e.g., copy theme change) and market environments (e.g., price, competing product advertising, consumers' health concerns, food expenditures away from home, and age and racial mix) influence generic advertising effectiveness over time. "Effectiveness" is defined here as marginal effect (or elasticity) of advertising expenditures on sales. Unlike prior models, the present model allows researchers to examine the sources of change in advertising effectiveness. Furthermore, the relative importance of these variables in explaining different advertising responses can be identified. Specifically, we address the following questions: (1) is advertising effectiveness fixed or dynamic? (2) have previous advertising strategies been effective or not? (3) does advertising effectiveness vary over different market environments? and (4) what are the most important factors which determine advertising effectiveness?

Generic fluid milk advertising in New York City (NYC) is chosen as a case study for applying the general model. This market is of interest because New York state farmers spend almost $11 million a year for fluid milk advertising and more than 60 percent of this money has been invested in the NYC market. In addition, demographics in this market have significantly changed over the last ten years, particularly with respect to racial mix.[2] Monthly data for milk sales, advertising expenditure, and other milk campaign information (e.g., changes in copy themes) are also available for this market during this period.

The next section discusses the econometric model which takes into account the varying nature of advertising parameters, carryover effects of advertising, and the potential cointegration problem of time-series variables. Then, data sources and estimation procedures are presented. The following section reports empirical results to establish determinants of advertising effectiveness and their relative importance. The final section presents conclusions.

2. For the last ten years, proportions of Hispanic and African American populations continuously increased in New York City, while the proportion of people under age 20 steadily decreased. Proportions of Hispanic and African American populations increased from 0.157 and 0.212 in 1986, to 0.187 and 0.241 in 1995, respectively, which indicates approximately a 3 percentage point increase in proportions of both racial groups during this period. The proportion of people under age 20 decreased marginally from 0.269 to 0.263.

The Model

In general, varying-parameter models can be classified into two types: systematic (Singh et al.; Kinnucan and Venkateswaran; Kinnucan, Chang, and Venkateswaran; Reberte et al.) and stochastic variation models (Cooley and Prescott; Hildreth and Houck; Ward and Myers). Systematic variation models assume that model coefficients change over time in a systematic fashion. In other words, coefficients change across observations but the change is a function of observable variables. Stochastic variation models assume that model coefficients follow some type of stochastic (sequential or random variation) process. The varying-parameter model we present in this study is a systematic variation model and builds on previous work in this category.

Modeling Advertising Parameter Function

We assume that the advertising coefficients change over time systematically. Unlike previous studies in which the advertising coefficient is functionally related only to time trend variables, we hypothesize that the advertising coefficient, β_t , is a function of environmental and managerial variables:

$$(1) \qquad \beta_t = f(Z_t, v_t), \qquad t = 1, \ldots\ldots, T$$

where Z_t is a vector of environmental and managerial variables; and v_t is a disturbance term. The rationale for specifying advertising coefficient β_t as a function of relevant variables is the expectation that through estimates of the advertising response to managerial and environmental variables, the model offers more detailed information, allowing researchers and decision-makers a better understanding of the underlying determinants of advertising effectiveness. Managerial variables represent decision-makers' controllable factors through marketing efforts in increasing market sales. These variables may include advertising strategies and other promotional activities. Environmental variables imply market conditions such as market competition and demographic conditions in the product market. Both managerial and environmental variables not only affect sales directly, but are also related to the effectiveness of advertising. For example, the main effect on milk sales of the increased percentage of children in the population is presumably positive. However, the increased population of children may not necessarily increase advertising effectiveness because children already tend to drink more milk than adults and may drink milk anyway without advertising. We also include a random disturbance term, ν_t, to capture various random factors in the specification of equation (1).

Measurement of Advertising Goodwill

Many theoretical and empirical studies support the existence of the dynamic nature of the relationship between sales and advertising expenditures (Nerlove and Waugh; Clarke; Cox; Lenz, Kaiser, and Chung). In this study, we define the advertising goodwill variable as a function of current and lagged advertising expenditures, allowing carryover effects of advertising on sales. To incorporate carryover effects in the model, at least two issues need to be addressed: lag structure and length. Several potential specifications of carryover effects suggested in the previous literature (Cox; Judge et al.) include rational, Pascal, gamma, geometric polynomial, and exponential lag structures. Following Cox, a second-order exponential lag specification is chosen for its flexibility and parameter parsimony. We assume that the advertising carryover effects for both milk and competing products last a maximum of one year. This is supported by previous empirical findings (Clarke; Brester and Schroeder; Lenz, Kaiser, and Chung). Then, the advertising goodwill variable of k-th commodity ($ADST_k$) is measured as:

$$ADST_k = \sum_{j=0}^{12} W_{k,t-j} ADEXP_{k,t-j} \qquad k=1,2 \tag{2}$$

$$W_{k,t-j} = \exp(\lambda_{0k} + \lambda_{1k} j + \lambda_{2k} j^2) \tag{3}$$

where W_k and $ADEXP_k$ represent the weight on each lag and advertising expenditures of k-th commodity, respectively, and λ_{ik} are parameters. Consider end-point restrictions that the weight on the current period is one ($W_{k,t} = 1$) while the weight on the last lag is zero ($W_{k,t-12} = 0$). Then, noting that exp(0) = 1 when $W_{k,t} = 1$ and exp(-20) $\approx$ 0 when $W_{k,t-12} = 0$, equation (3) with end-point restrictions yields:

$$\lambda_{0k} = 0 \tag{4}$$

$$\lambda_{1k} = -\frac{20}{12} - 12\lambda_{2k} \tag{5}$$

Substituting equations (4) and (5) into equation (3) results in:

$$W_{k,t-j} = \exp(-\frac{12}{20} j + \lambda_{2k}(j^2 - 12j)) \tag{6}$$

As pointed out by Cox, equation (6) is parsimonious because just one parameter needs to be estimated rather than three, and it is flexible because it can represent either geometric decay or a lagged peak, depending on the sign of λ_{2k}. Substituting equation (6) into equation (2) yields a complete measurement of the advertising goodwill as:

$$ADST_k = \sum_{j=0}^{12} \exp(-\frac{12}{20} j + \lambda_{2k}(j^2 - 12j)) \cdot ADEXP_{k,t-j} \qquad k=1,2 \tag{7}$$

Cointegration

Another issue dealt with in the process of modeling the NYC fluid milk advertising model is the stationarity assumption on the regression residuals. Standard econometric models assume that regression residuals are stationary. Unstationary residuals could result in spurious regression results (Granger and Newbold). Stationary residuals require all variables in regression to be stationary or for certain linear combinations of nonstationary regression variables to be stationary. If the underlying variables are nonstationary and a certain linear combination of these variables is stationary, these variables are cointegrated (Engel and Granger; Hendry). Estimates of cointegrated models are not spurious but "superconsistent," which implies that t or F statistics are not acceptable.

Two methods are commonly used to test for nonstationarity and cointegration problems: the Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests. Suppose Y_t is the time-series data to be tested for stationarity. Then, two methods are:

(DF test) $$Y_t = a + \rho Y_{t-1} + \epsilon_t$$

$$\text{(ADF test)} \quad Y_t - Y_{t-1} = a + bT + \rho Y_{t-1} + \sum_i \theta_i \Delta Y_{t-i} + \epsilon_t$$

where a, b, ρ, and θ_i are parameters; ΔY_{t-i} represents the first difference operator of Y at t-i; and ϵ_t is an independent and stationary process. The test statistics for the DF and ADF are t-ratios for the null hypotheses that ρ=1 and ρ=0, respectively, which imply Y_t is nonstationary. The null hypothesis can be rejected if the computed t-ratio is larger than a corresponding critical value τ_μ (for the DF test) or τ_τ (for the ADF test), provided by Fuller (p. 373). If any variable in the model turns out to be nonstationary, but regression residual is stationary, then the model is cointegrated. If the null hypothesis cannot be rejected, but the null hypothesis for the first difference series can be, then the level of Y_t is referred to as having the first order of integration I(1).

Empirical Model Specification

For the empirical estimation of the NYC fluid milk demand, per capita fluid milk sales at time t ($SALES_t$) is specified as:

$$(8) \quad SALES_t = \alpha_0 + \alpha_1 \cdot PRICE_t + \alpha_2 \cdot EARN_t + \alpha_3 \cdot CADST_t + \alpha_4 \cdot FAT + \alpha_5 \cdot AGE019_t + \alpha_6 \cdot BLACK_t + \alpha_7 \cdot HISPAN_t + \alpha_8 \cdot EATWHM_t + \beta_t \cdot ADST_t + \sum_{i=1}^{m} \gamma_i \cdot SEASON_i + \mu_t \qquad t = 1, \ldots\ldots, T$$

where α_i, β_t, and γ_i are parameters; PRICE is the retail fluid milk price deflated by the nonalcoholic beverage price index; EARN is the average weekly earnings deflated by the CPI for all items; FAT is a consumer fat concern index; AGE019 is the percentage of the population under age 20; BLACK is the percentage of the African American population; HISPAN is the percentage of the Hispanic population; EATWHM is the percentage of food expenditures from eating away from home; CADST is the per capita advertising goodwill for competing products deflated by media cost index; ADST is the per capita fluid milk advertising goodwill deflated by media cost index; SEASON is seasonality (harmonic) variables represented by the i-th wave of the sine and cosine functions (Doran and Quilkey); and μ_t is the random error term with mean zero and variance σ^2_μ

Equation (8) suggests the coefficient of the milk advertising goodwill variable (ADST), β_t, varies over time. The difficulty in estimating this model is that there are K+T+1 parameters to be estimated with only T observations, (where K is the number of independent variables). To deal with this problem, additional information must be introduced to impose some structure on how the parameter β_t varies over time (Judge et al.). Equation (1) provides this information. The variation in advertising parameter β_t can be explained by differences in managerial efforts and environmental conditions for each time period. Our specific empirical version of equation (1) is specified as:

$$(9) \quad \beta_t = \exp(\delta_0 + \delta_1 \cdot PRICE_t + \delta_2 \cdot CADST_t + \delta_3 \cdot FAT + \delta_4 \cdot AGE019_t + \delta_5 \cdot BLACK_t + \delta_6 \cdot HISPAN_t + \delta_7 \cdot EATWHM_t + \delta_8 \cdot THEME_2 + \delta_9 \cdot THEME_3) + v_t$$

where exp(·) represents the exponential function; $THEME_i$ are binary variables to indicate theme changes in advertising copy (1 if $ADST_t$ corresponds to the i-th campaign theme, 0 otherwise) and δ_i are parameters. The $THEME_i$ variables are defined based on each campaign's primary theme developed by the American Dairy Association and Dairy Council's marketing plans. Three THEME variables are identified over the study period. The first campaign theme ($THEME_1$), focusing on "Benefits of milk's nutrients," covers January 1986 to February 1989. The second campaign theme ($THEME_2$), focusing on "Adults should be drinking more milk," covers March 1989 to February 1993. The last campaign theme ($THEME_3$) focuses on "Do something good for yourself...drink more milk," and covers March 1993 to June 1995. Since $THEME_i$ are binary variables, they may also include changes in other advertising strategies such as copy quality, target audience, media mix, etc. Therefore, $THEME_i$ represent any possible changes in advertising (or campaign) strategies that might have occurred in each campaign period. In equation (9), $THEME_1$ was omitted to avoid a perfect collinearity problem. The exponential functional form avoids negative sales responses to advertising which would violate our *a priori* expectations. Most advertising literature in both marketing and agricultural economics has demonstrated the positive contributions of advertising on sales increase. The parameters (δ_i) are expected to determine the direction and magnitude of the changing effectiveness of advertising. The random variable ν_t is assumed to have mean zero and variance σ^2_ν

In many cases, the level of economic time-series data are nonstationary and therefore their time-paths are well represented by either nonstationary or cointegrated processes. Both DF and ADF tests are applied for all standardized variables and for the estimated OLS residual in equation (8), and t-statistics for parameter ρ are reported in table 1. Test results indicate six out of ten variables are nonstationary under the DF test and four variables are nonstationary under the ADF test while the estimated OLS residual shows stationary path under both tests. Therefore, the model is cointegrated. In addition, note that all nonstationary variables become stationary after being first differenced, which indicates all nonstationary variables have I(1) process. Since the model is cointegrated, the OLS estimates of interests are not spurious but test statistics cannot be used for the inference because they no longer have their usual large sample distributions (Stock and Watson). The next task would obviously be to correct for the cointegrated model.

Several remedies have been suggested in previous literature (Engel and Granger; Phillips and Hansen; Phillips and Loretan; Stock and Watson). Following Phillips and Loretan, and Stock and Watson,[3] but with consideration of specification complexity and collinearity problems, we add the first differenced terms of each nonstationary variable to the model.

Then, by substituting equation (9) into equation (8) and by including first differenced nonstationary variables, we obtain the resulting empirical model as:

$$
\begin{aligned}
(10)\quad SALES_t = {} & \alpha_0 + \alpha_1 \cdot PRICE_t + \alpha_2 \cdot EARN_t \\
& + \alpha_3 \cdot CADST_t + \alpha_4 \cdot FAT \\
& + \alpha_5 \cdot AGE019_t + \alpha_6 \cdot BLACK_t + \alpha_7 \cdot HISPAN_t \\
& + \alpha_8 \cdot EATWHM_t \\
& + \exp(\delta_0 + \delta_1 \cdot PRICE_t + \delta_2 \cdot CADST_t + \delta_3 \cdot FAT \\
& + \delta_4 \cdot AGE019_t + \delta_5 \cdot BLACK_t + \delta_6 \cdot HISPAN_t \\
& + \delta_7 \cdot EATWHM_t \\
& + \delta_8 \cdot THEME_2 + \delta_9 \cdot THEME_3) \cdot ADST_t \\
& + \sum_{i=1}^{m} \gamma_i \cdot SEASON_i + \phi_1 \cdot \Delta PRICE_t \\
& + \phi_1 \cdot \Delta PRICE_t + \phi_2 \cdot \Delta EARN_t + \phi_3 \cdot \Delta AGE019 \\
& + \phi_4 \cdot \Delta BLACK_t + \phi_5 \cdot \Delta HISPAN_t \\
& + \phi_6 \cdot \Delta EATWHM + \xi_t,
\end{aligned}
$$

where Δ represents first difference indicator; and ϕ_i are parameters. Here, $\xi_t = \mu_t + \nu_t \cdot ADST_t$ is heteroscedastic. Therefore, the potential heteroscedasticity problem should be tested. If the hypothesis of homoscedasticity cannot be rejected, indicating ν_t=0, the model can be estimated by a standard ordinary least squares (OLS) estimation procedure. Otherwise, alternative estimation procedures, such as generalized least squares (GLS) or feasible generalized least squares (FGLS), should be considered.

Data Sources and Estimation Procedure

Monthly data from January 1986 to June 1995 for New York City are used in this study. Fluid milk sales are estimates based on data collected by the Division of Dairy Industry Services and Producer Security (DIS), New York State Department of Agriculture and

3. One way to correct the cointegrated regression model, suggested by Phillips and Loretan, and Stock and Watson, is to augment the regression model with leads and lags of nonstationary variables.

Table 1. T-statistics for DF and ADF tests

Variable	DF (H_0: $\rho = 1$)		ADF (H_0: $\rho = 0$)	
	Y_t	ΔY_t	Y_t	ΔY_t
SALES	-6.88	-17.26	-6.30	-10.55
PRICE	-0.57[a]	-6.78	-1.68[a]	-7.08
EARN	-1.88[a]	-12.46	-4.25	-9.62
FAT	-3.37	-10.30	-4.54	-7.10
AGE019	-2.54[a]	-12.52	-0.66[a]	-8.36
BLACK	-1.28[a]	-11.74	-4.89	-8.22
HISPAN	-1.98[a]	-11.86	-2.75[a]	-8.31
EATWHM	-2.18[a]	-13.45	-1.51[a]	-8.12
ADST	-3.91	-7.56	-5.91	-7.92
CADST	-2.68	-3.55	-13.14	-11.51
μ_t	-9.39		-7.14	

[a]Nonstationary at the 10 percent level with sample size 100, based on the critical values -2.58 (for DF test) and -3.15 (for ADF test) (Fuller, p. 373).

Markets. Each year, in May and October, every plant and milk dealer with route sales in New York state must file a report showing the amounts of milk sold in each county in which they do business. In addition, all plants from which processed fluid milk is delivered to New York state dealers, or sold on routes in New York state, must file monthly plant reports. Based on these reports, it is possible to trace all milk sold into any designated market area back to the plants in which it was processed. Based on the May report, and the monthly plant reports for May, plant-specific allocation factors can be developed and applied to the monthly plant reports to estimate monthly in-market sales for January through June. Likewise, the October report provides the basis for estimating monthly in-market sales for July through December. The New York City market includes roughly the northern half of New Jersey--a multi-county area that coincides with the New Jersey portion of the New York-New Jersey Federal Milk Marketing Order (Order #2). Unfortunately, data are not available for New Jersey milk sales. Therefore, in the present analysis, it is assumed that per capita milk sales in northern New Jersey are the same as per capita sales in New York City.

Fluid milk prices for each market come from the DIS publication, *Survey of Retail Milk Prices for Selected Markets in New York State*. This report contains retail prices for each type of milk (whole, 2 percent, 1 percent, and skim) in various container sizes for several cities in New York state. The price series used in this analysis are for whole milk in half-gallon containers.

The Consumer Price Indices (CPIs) for nonalcoholic beverage and for all items in the Northeast are obtained from the *CPI Detail Report* published by the Federal Bureau of Labor Statistics and are used as deflators for price and income, respectively. The income measure used in this study is average weekly earnings of production workers in the manufacturing sector from *Employment Review*, the New York State Department of Labor. The periodical contains timely reports of average weekly earnings of production workers in the manufacturing sector. Although a measure of per capita income would be preferable, reporting lags of several years on this data preclude its use here.

Table 2. Heteroscedasticity tests

Test	Computed Chi-squared statistic	Chi-squared percentile critical value at 95%	Test result
White			
$H_0: \sigma_i^2=\sigma^2$	25.57	43.77	Not rejected
Breusch-Pagan			
$H_0: \sigma_i^2=\sigma^2(\alpha_0+\alpha\cdot ADST_i)$	0.61	3.84	Not rejected
$H_0: \sigma_i^2=\sigma^2(\alpha_0+\alpha\cdot Z^a)$	1.66	44.70	Not rejected

[a]Z is a vector of all independent variables in the model.

The fat concern variable was included because consumer concerns about dietary fat were expected to be an important factor associated with milk consumption and advertising effectiveness. This variable was constructed by Ward, based on a quarterly survey of 14,000 consumers nationwide conducted by the National Panel Dairy Group. Since the survey is random, the 14,000 consumers in one quarter are not necessarily the same as the 14,000 consumers in the next quarter. Because this is a national survey, it was assumed that consumers in the NYC market had identical behavior and attributes as consumers in the rest of the United States. In the survey, consumers were asked whether they completely agree, agree mostly, agree somewhat, neither agree nor disagree, disagree somewhat, disagree mostly, or completely disagree with the statement ... "a person should be cautious about the fat in one's diet." The fat concern variable was constructed based on the percentage of consumers expressing concern regarding this statement. To convert this variable from a quarterly to monthly basis, a linear interpolation procedure was used.

Advertising expenditures for fluid milk include both spendings from the regional milk promotion board and the portion of the national fluid milk advertising expenditures directed to the NYC market. Nominal advertising expenditures, spent by the regional milk promotion board, were provided by the advertising agencies, D'Arcy, Masius, Benton and Bowles, and Leo Burnett. The data include monthly expenditures on radio and television. Adjustments are made to real advertising expenditures using the Media Cost Index (MCI). These adjustments account for not only year-to-year inflation in media costs, but also quarter-to-quarter variations in media costs within any year. Monthly national fluid milk advertising expenditures are supplied by Dairy Management, Inc. These expenditures are also deflated by the MCI and prorated on a population basis to obtain an estimate of the portion of the national fluid milk advertising effort affecting the NYC market.

Nominal advertising expenditures for competing beverages were collected on a quarterly basis from *Leading National Advertisers*. The products included all nonalcoholic and nondairy beverages such as coffee and tea, bottled water, fruit and vegetable juices, and carbonated beverages. To adjust for inflation and seasonal change in media costs, these expenditures were deflated by the MCI. The resulting advertising expenditures, which are on a national basis, were then prorated on a population basis to obtain an estimate of the portion of the national advertising effort affecting the NYC market. Linear interpolation was used to translate this series from a quarterly to a monthly basis.

The source of the historical data on population by age under 20, African Americans, and Hispanics is *1997 State Profile: New Jersey and New York*, Woods and Poole Economics, Inc. Because the county level data is updated only annually, the demographic variables are held constant over the year.

Finally, food expenditures from eating at and away from home are obtained from the USDA publication, *Food Consumption, Prices, and Expenditures*. Because the data is collected annually at the national level, it is assumed that NYC residents exhibit the same consumption patterns, with respect to food away from home purchases, as residents in the rest of the United States over the year.

One of the objectives of this study is to make inferences regarding the relative effects of market environment variables on advertising effectiveness. However, it is not easy to compare the relative importance of the variables that have different scales. For example, advertising expenditures for competing products in dollar terms are not directly comparable to the percentage of African American population. One way to deal with this difficulty is to standardize the variables. The standardized model with an intercept term provides estimates in a predictable way (i.e., standardized coefficients are identical to unstandardized coefficients multiplied by corresponding standard deviations) and scale-invariant statistics such as for R^2, F, and t tests (Vinod and Ullah). Thus, we standardize all independent variables to mean zero and standard deviation one. Another benefit of standardization is computational advantage. As Belseley pointed out, regression algorithms generally have improved performance with "better-conditioned" data. This is particularly helpful to estimate models like equation (10), which are highly nonlinear in both coefficients and variables.

Since equation (10) includes a heteroscedastic random variable, $\xi_t = \mu_t + v_t \cdot ADST_t$, the heteroscedasticity test must be performed to determine an appropriate estimation procedure. Among various types of tests available in econometrics literature, we choose two frequently used tests: White's general test and the Breusch-Pagan Lagrangean multiplier test (Greene). While White's general test does not require any specific assumptions about the nature of heteroscedasticity, the Breusch-Pagan test hypothesizes the disturbance variance as a function of a set of regressors. Table 2 reports test statistics and Chi-squared distribution critical values. For the Breusch-Pagan test, we perform two null hypotheses tests: (I) heteroscedasticity with advertising expenditure only and (II) heteroscedasticity with all independent variables. As one can see, all three tests strongly indicate nonexistence of heteroscedasticity in the model. Since the model satisfies homoscedasticity assumption, we use SAS nonlinear OLS procedure for the estimation of equation (10) (SAS Institute, Inc.).

Results

General regression statistics reported in the lower part of table 3 indicate regression results are satisfactory overall. An R-squared value of 0.9056 indicates that the model explains about 90 percent of the variations in per capita milk sales in the New York City market. The small root mean squared percent error also suggests that the estimated model performs well. The Durbin-Watson statistic 1.8640 is within an inconclusive region at the 1 percent level. Therefore, in order to further investigate possible autocorrelation in the model, we added first-order autocorrelation term to the model and found it to be insignificant while other regression coefficients remained almost unchanged. This result indicates the autocorrelation problem is highly unlikely to exist in this model.

Demand elasticities

Since our model includes main as well as interaction effects, signs and magnitude of economic and environmental effects on sales are determined by the sum of main and interaction coefficients in equation (10), and corresponding t-statistics are based on the combination of their variance and covariances. The best way to see the combined effects is to compute demand elasticities with respect to each economic and environmental variable.

All elasticities, except for price variable, displayed the anticipated signs (table 3). All elasticities with respect to demographic variables were significant at the 10 percent level (or lower), and were larger than those with respect to economic variables. This is not surprising because many studies in generic advertising literature have reported similar results (Kinnucan; Kaiser, Streeter, and Liu; Kinnucan et al.). Price elasticity was expected to be negative, income and own-advertising elasticities positive, and competing product advertising and consumer's fat concern elasticities negative. With respect to demographic variables, percentages of people under age 20 and Hispanic populations should have a positive relationship with milk consumption because these people have been reported to drink more milk than others (Kaiser, Streeter, and Liu; USDA). Percentages of African Americans and eat-away-from-home food expenditures were expected to have negative elasticities because African Americans tend to drink less milk (Blaylock and Smallwood; USDA) and people are less likely to drink milk when they dine away from home.

Determinants of advertising effectiveness

The major objective of this study was to determine

Table 3. Demand elasticities of New York City fluid milk market

With respect to:	Elasticity	T-statistic
Price	0.0096	0.15
Income	0.2813	1.14
Milk advertising	η_t[a]	N.A.
Competing product advertising	-0.0008	-0.13
Consumers' dietary fat concern	-0.0065	0.08
% age under 20	4.1832	1.67[b]
% African Americans	-2.3715	-1.65[b]
% Hispanics	2.6033	1.74[b]
% eat away home expenditure	-1.5262	-4.56[b]
R-squared	0.9056	
Adj. R-squared	0.8644	
Root mean squared percent error	1.6414	
Durbin Watson	1.8640	

[a]Varying advertising elasticities.
[b]siginificant at the 10 percent level or lower.

Table 4. Parameter estimates, marginal effects, and elasticities of variables determining the varying milk advertising parameter

Variable	Estimate[a]		Marginal effect	Elasticity
	δ_i	T-statistic		
Intercept	-6.2389	-4.19		
PRICE	0.8823	2.70	0.0580	0.0097
CADST	-0.1590	-1.86	-0.0105	-0.0001
FAT	-1.5088	-2.67	-0.0992	-1.1047
AGE019	-17.4688	-1.68	-1.1487	-4.6083
BLACK	49.9824	1.85	3.2868	11.3060
HISPAN	-76.5469	-2.29	-5.0337	-13.2962
EATWHM	11.5802	5.95	0.7615	5.2458
THEME2	3.6406	1.66	0.2394	1.5331
THEME3	3.4820	1.77	0.2290	0.8547

[a]All estimates are significant at the 10 percent level or lower.

factors affecting generic advertising effectiveness and compare the relative importance of these factors. An analysis of the estimated parameters (δ_i) in table 4 leads the discussion on this issue. Equation (9) postulated advertising effectiveness could be determined by several relevant variables such as economic and market environmental variables. Large t-statistics of estimated parameters (δ_i) confirm strong influence of these variables in determining varying advertising effectiveness. Signs of the parameters δ_i indicate the direction of the influence of each factor on advertising effectiveness. The advertising coefficient, β_t, revealed positive responses to change in variables, such as price, percentage of African American population, percentage of food expenditure away from home, and change in advertising strategies for campaign periods 2 and 3, while showing negative relationship with competing product advertising, consumers' fat concerns, and percentages of people under age 20 and Hispanic populations. The results, for example, indicated that as the percentage of African American population grew, advertising effectiveness increased, but as the percentage of Hispanic population grew, the advertising effectiveness decreased.

Although no previous theory or empirical evidence exists in determining signs of parameters δ_i, we attempt to draw two possible implications from these results. First, when the market situation is unfavorable, advertising becomes more important and effective. For instance, increase in price, percentage of African Americans, and percentage of food expenditures for eating away from home are all unfavorable factors for milk sales. When these factors increase in the NYC market, advertising might play a more significant role in increasing (or even maintaining) milk demand than when the market situation is favorable. When the market is in a favorable situation due to an increase in factors such as the percentage of Hispanics or the population under age 20, however, milk consumption might go up without increasing advertising efforts. Second, heavy drinkers may have been close to the saturation point or at least may not have had room to drink as much milk as light drinkers. Since people under age 20 and Hispanics are already heavy milk drinkers, they might not be able to increase their milk consumption as much as African Americans can. Two exceptional cases from two foregoing implications were signs on parameters of competing product advertising and consumers' fat concern variables. Negative signs on coefficients on these variables indicated that as competing product advertising expenditures and consumers' concerns on dietary fat grew, milk advertising effectiveness started to erode.

Advertising strategy and market environmental variables were particularly important for changing advertising effectiveness either positively or negatively. The next point of interest is to examine the relative importance of these variables. A few methods have been suggested in previous literature. One way is to standardize regression variables with mean zero and standard deviation one, and compare the coefficients of each variable (Vinod and Ullah). By standardizing data, we imposed uniform scale on each variable so that the effect sizes of regression variables were comparable. Another typical way is to compare elasticities of independent variables on advertising parameters β_t.

Since advertising parameters were specified in a nonlinear functional form, coefficients δ_i did not directly represent a magnitude of relative importance of each variable. Therefore, marginal effects of these variables on advertising parameter and corresponding elasticities were used to compare relative importance. Table 4 presents the computed results. The results showed large marginal effects and elasticities in demographic variables. These results suggested that demographic factors were more important than economic factors and, particularly, the percentage of Hispanics in the population was the most important factor in changing advertising effectiveness.

Hypothesis tests

With the unrestricted model, represented by equation (10), hypothesis testing was also employed to answer questions raised earlier in this paper. Three hypotheses were postulated in relation to these questions. The first hypothesis, that the advertising coefficient was invariant over the sample period, was tested by imposing the restriction, $\delta_1=\delta_2=....=\delta_9=0$ in equation (10). This restriction implied $\beta_t=\delta_0$ and yielded the restricted model (1). The second hypothesis, that advertising strategies were important but environmental conditions were not, was tested by imposing the restriction $\delta_1=\delta_2=\delta_3=\delta_4=\delta_5=\delta_6=\delta_7=0$ in equation (10), yielding the restricted model (2). The last hypothesis, that environmental conditions were important but advertising strategies were not, was tested with restriction, $\delta_8=\delta_9=0$, yielding the restricted model (3).

Each hypothesis was tested using a standard F-test procedure. Test results in table 5 indicated that

Table 5. F-tests for three postulated hypotheses

Model	Computed F-statistics	F-critical value at 5% level	Test result
Full model v.s. restricted model (1)	6.0990	2.00	Rejected
Full model v.s. restricted model (2)	7.6952	2.14	Rejected
Full model v.s. restricted model (3)	6.7323	2.13	Rejected

Note: two types of heteroscedasticity tests, White and Breusch-Pagan tests, were performed for all restricted models 1, 2, and 3 and found none of these models had heteroscedasticity problem.

Table 6. Varying fluid milk advertising elasticities in New York City market, 1986-95

Campaign	Theme	Time period	Long-term advertising elasticity[a]	
			η_I[b]	η_{II}[c]
1	"Benefits of milk nutrients"	1/86 - 2/89	0.0720	0.0759
2	"Milk for adults"	3/89 - 2/93	0.0387	0.0344
3	"Milk does a body good"	3/93 - 6/95	0.0756	0.0656
		Whole study period	0.0578	0.0541

[a]Average long-term elasticity for each time period.
[b]Elasticity evaluated at the level of monthly advertising goodwill stock and milk sales (i.e., $\eta_I = (\beta_t/\text{s.d. (ADST)})\cdot(\text{ADST}_t/\text{SALES}_t)$).
[c]Elasticity evaluated at the mean of monthly advertising goodwill stock and milk sales (i.e., $\eta_{II} = (\beta_t/\text{s.d. (ADST)})\cdot(\text{ADST}/\text{SALES})$).

null hypotheses for all three hypotheses were rejected at the 5 percent level. This implied that the advertising coefficient was time-variant, environmental conditions were important factors in the determination of advertising effectiveness, and recent advertising strategies were more effective than previous ones. Previous studies such as Kinnucan, Chang, and Venkatewaran; Kinnucan and Venkateswaran; and Reberte et al. also supported heterogeneity of advertising effectiveness over time.

Varying advertising elasticities

As specified in equation (9), the advertising goodwill parameter β_t was determined by advertising strategy and market environmental variables in exponential functional form. Then, with estimated parameters δ_i in table 4, it is possible to compute varying advertising elasticities. Table 6 presents fluid milk advertising elasticities in the NYC market for each campaign period as well as for the whole study period. Two types of elasticities were considered: η_I and η_{II}. For η_I, since we had monthly data, elasticities were first calculated for each month, and then averaged for each campaign period and for the whole period. These estimates represented elasticities of each time period because they were evaluated at the level of monthly goodwill stock and milk sales. As one can see in footnote b of table 6, these elasticities were determined by varying advertising parameters β_t, monthly goodwill stock ($ADST_t$), and milk sales ($SALES_t$). This type of elasticity measurement may not be appropriate for the comparison of the relative effectiveness of a constant advertising dollar over time. This is because elasticity η_I was evaluated at different levels of advertising expenditures and sales over time. Dairy farmers may want to know how much the effectiveness of their one dollar investment in fluid milk advertising some years ago has changed over time due to the change in campaign strategies and market environments.

To accommodate this need, another type of elasticity, η_{II}, was reported in the last column of table 6. Unlike η_I, these elasticities were evaluated at the same level of advertising goodwill stock and milk sales. We chose mean points of these variables for the sample period. Both η_I and η_{II} indicated the first campaign was more effective than the second campaign. This was consistent with Reberte et. al. Based on both η_I and η_{II}, the third campaign was more effective than the second, while the first and third campaigns revealed almost equal effectiveness. Clearly, the first and third campaigns were better than the second. No significantly different results were obtained from the two different elasticity measurements. The average advertising elasticities for the whole study period were 0.0578 and 0.0541 for η_I and η_{II}, respectively, which were consistent with previous studies for the NYC market (0.054 from Kinnucan; 0.060 from Lenz, Kaiser, and Chung; 0.0003 - 0.072 from Kinnucan, Chang, and Venkateswaran; and 0.0099 - 0.055 from Reberte et al.).

Conclusions

The objective of this study was to examine the roles of advertising strategy and market environments in explaining changes in advertising effectiveness in the New York City fluid milk market. A fluid milk demand equation was estimated with monthly data for the period from January 1986 through June 1995 with a varying advertising parameter specification. Unlike prior studies, advertising parameters were specified as a function of advertising strategy and market environment variables such as copy theme change, price, competing product advertising, consumers' dietary fat concerns, food expenditures away from home, and age and racial mix. Therefore, the model allows researchers to examine causes of changing advertising effectiveness. Furthermore, by standardizing the scale of each explanatory variable, we were able to identify the relative importance of these variables in determining advertising effectiveness. We also carefully examined all time-series variables in the fluid milk demand equation and found the model was cointegrated. The cointegration problem was corrected in the final version of the empirical model.

Results indicated that advertising strategies and market environments were statistically significant at the 10 percent (or lower) level in changing advertising effectiveness. Particularly, demographic factors such as percentages of African Americans, Hispanics, and under age 20 populations were highly important, compared with economic factors such as price and competing product advertising. Of all relevant factors, the percentage of Hispanics was the most important determinant of generic advertising effectiveness. In regard to the direction of changing advertising effectiveness, generic advertising effectiveness was positively related to price, percentage of African Americans, and percentage of food expenditures for eating away from home, while it was negatively related to competing product advertising, consumers' fat concerns, and percentages of Hispanic and under age 20 populations.

The results imply that when the market is in an unfavorable or unsaturated condition, advertising generally becomes more important and effective. These particular results should be viewed with caution since the estimation was a case study for the New York City market using aggregate time-series data. Further exploration of these results with different data sets will permit a generalization of findings in this study. Despite this caveat, our findings have reasonable interpretations. More importantly, the availability of techniques to understand the dynamic nature of advertising effectiveness opens a potentially important avenue for developing better advertising strategies.

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