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MEDIA ADVERTISING EFFECTS ON MILK DEMAND: THE CASE OF THE BUFFALO, NEW YORK MARKET

with an Empirical Comparison of Alternative Functional Forms of the Sales Response Equation

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MEDIA ADVERTISING EFFECTS ON MILK DEMAND: THE CASE OF THE BUFFALO, NEW YORK MARKET

by Henry W. Kinnucan*

Changing demographics and a declining population spell a shrinking market for fluid milk in New York. During the decade of the seventies alone the retail volume of fluid milk sales in the State declined 14 percent (NYDAM). To meet this challenge, in May 1972 dairy farmers voted to enact the New York State Dairy Promotion Order. Since that time, Federal Order 2 dairy farmers have invested over $42 million in activities designed to improve the market for milk and milk products (Stavins and Forker; Newcomb).

Research relating to the media advertising component of these Promotion Order expenditures indicate that this effort has been successful but that there are substantial intermarket differences in the economic effectiveness of the investment (Thompson 1978b, 1979; Kinnucan 1982b). The reasons for these intermarket differences are not well understood, but may be related to variations in the level or intensity of milk advertising across the markets. This paper explores this theme further. The fluid milk nonbrand media advertising campaign in the Buffalo, New York market is chosen for analysis because the advertising expenditure level there is three times higher than that experienced in the other New York markets previously studied (25¢ per capita per year in Buffalo compared to 8¢ in New York City, 9¢ in Albany, and 7¢ in Syracuse over the period 1978-80).1/ Moreover, Buffalo, with over 1.6 million people in its immediate seven-county area, is an important market for milk in the State, and hence information bearing on the important determinants of milk demand specific to this market may be of general interest. Finally, because the demographic characteristics of the Buffalo market population are similar to the Rochester market, the results of the Buffalo study can readily be compared to the results pertaining to this market.2/

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1/ Care must be exercised when using per capita expenditure levels to compare media exposure levels across markets. Mainly because of population size differences, markets differ in their cost-efficiency of advertising. Data presented in the 1980 Media Plan of the American Dairy Association/Dairy Council of New York (prepared by D'Arcy-MacManus & Masus, Inc. advertising agency) indicate that advertising costs in the major Upstate markets are 30%-50% higher (on a Gross Rating Point basis) than in New York City. Thus comparing the Buffalo expenditure with the New York City expenditure overstates the actual difference in the amount of advertising occurring in the two markets. Mitigating this, however, is the approximately 10% spillover of Canadian milk advertising into the Buffalo market (discussed later in the text). Taking these two factors into account and discounting the Buffalo investment (conservatively) by 30% still leads to the result that the Buffalo exposure to nonbrand milk advertising substantially exceeds the average New York City level of exposure (by a factor of 2.2-17.5¢/person ÷ 8.0¢/person).

2/ According to the 1980 census, the proportion of the population less than age 18 is 27.9% and 26.8%, respectively, in Rochester and Buffalo. The proportion of Blacks in Rochester and Buffalo is 8.0% and 9.2%, respectively (U.S. Dept. of Commerce, p.1).

In addition to providing evidence relating to the economic effectiveness of the producer-funded nonbrand milk advertising campaign conducted in the Buffalo area, this study also provides quantitative information on the other important determinants of milk demand specific to this market. Furthermore, the study makes a methodological contribution by examining the sensitivity of the results to alternative specifications of the functional form of the milk demand equation.

The paper proceeds by first discussing the econometric model and estimating procedures. Data are then discussed and regression results are presented. Demand elasticities based on alternative functional forms of the milk demand equation are presented. Estimates of the profitability of the advertising investment and the short-run profit maximizing levels of advertising expenditure are presented. Finally, the limitations of the study are discussed and some conclusions drawn.

The Model

In addition to advertising other variables influence the demand for milk. Previous research indicates that the demographic characteristics of the population are perhaps the most important determinants of the level of milk sales in a given market (see Kinnucan 1982b and the references cited therein): Americans tend to drink less milk as they grow older and Blacks drink less milk than whites. If the age structure or racial composition of the market population is changing over the sample period then these variables should be included in the specification of the sales response function. Economic circumstances also influence milk sales. The price of milk relative to other beverages such as soft drinks and coffee and the overall price of all consumer products influences milk sales as does the overall level of consumer incomes. Seasonal changes in the consumer preference for milk as a beverage is an important factor when monthly data are used.

In order to obtain an accurate picture of the effect of advertising on sales the influences of these other factors must be removed (or held statistically constant). This is accomplished by specifying the following regression equation,

$$q_t = f(Z,\ I_t,\ PM_t,\ PC_t,\ PCF_t,\ T_t,\ A_t,\ \varepsilon_t) \qquad (1)$$

where[3/]

t = 1,2,...42 (January 1978 to June 1981)

q = per capita daily fluid milk sales adjusted for the calendar composition of the month.

Z = a vector of harmonic variables to denote seasonality in the intercept term.

3/ The data, along with a more precise definition of variables, are provided in Appendix tables 1 and 2.

I = per capita before-tax personal income in 1967 dollars.

PM = retail price of whole milk in paper half-gallon containers in 1967 dollars.

PC = cola price index deflated by the Buffalo area CPI (1967=100) for all items.

PCF = coffee price index deflated by the Buffalo area CPI (1967=100) for all items.

T = trend variable (incremented by one for each successive month in the data series) to represent demographic changes.

A = stock of advertising goodwill measured as a weighted average of current and past advertising expenditures.

ε = a stochastic error term assumed to satisfy the Gauss - Markov assumptions for best linear unbiased estimates for all forms of f.

f = an as yet unspecified functional form.

The exact functional form of equation (1) is left unspecified at this point because theoretical restrictions are not strong enough to select, a priori, one functional form over another. Moreover, because previous research (Thompson 1975) indicates that quite different inferences can arise depending upon the choice of functional form, the issue of functional form selection is discussed in detail in a subsequent section of this paper.

Monthly dummy variables are commonly used to represent seasonality in a regression equation. However, this approach consumes a relatively large number of degrees of freedom where monthly data are used (eleven) and may be unnecessarily precise when the dependant variable exhibits a fairly regular seasonal pattern from year-to-year as does milk sales. An alternative approach, which has the advantage of capturing the seasonality effect with fewer variables, is to use harmonic variables (see Doran and Quilkey). Hence equation (1) is specified using harmonic, rather than dummy variables, to denote seasonality in the intercept.

A trend variable is specified to capture the influence of demographic change on the demand for milk. Because the average age of the U.S. population is increasing, as is the Black proportion of the population, one would expect the sign of the regression coefficient of this variable to be negative if the same trends are occurring in the Buffalo area - and if in fact the trend variable is picking up the influence of these variables.

A final variable in equation (1) that may require some explanation is the "goodwill" variable A_t. This specification of the advertising effect arises from the suggestion of Nerlove and Arrow who state (p. 130): "One possibility of representing the temporal differences in the effects of advertising on demand would be to include a number of dated, past advertising outlays in the demand function. However such an approach is not especially useful. A more promising analytical approach, and one which has considerable intuitive appeal, is to define a stock, which we shall call "goodwill"...which we suppose summarizes the effects of current and past advertising outlays on demand." In addition to its intuitive appeal (i.e., at any point in time a certain amount of consumer goodwill toward a product exists as a result of current and past advertising efforts), the goodwill specification seems to enjoy a certain amount of success in empirical applications (see e.g., Nerlove and Waugh, Ball and Agrawala, Bultez and Naert). The main problem in its implementation is in choosing an appropriate procedure for computing its numerical value. At the most general level the goodwill variable is defined as,

$$A_t = \sum_{i=0}^{\infty} w_i A_{t-i} \tag{2a}$$

$$0 < w_i < 1 \tag{2b}$$

$$\sum_{i=0}^{\infty} w_i = 1 \tag{2c}$$

where the w_i are fractional values used to weight the relative importance of current (a_t) and past advertising outlays (a_{t-i}) in determining the current level of goodwill. The practical application of equation (2) poses two immediate problems: dealing with infinite sum (because only a limited number of observations on advertising are available) and determining the appropriate values for w_i. The infinite sum problem is usually dealt with either by arbitrarily limiting the number of past advertising values used in the computation of A_t (see e.g., Bultez and Naert) or by assuming that the w_i decline geometrically and applying a Koyck transformation to the demand equation (see e.g., Clarke). The problem of appropriate weights is usually resolved by either choosing a set of weights which seem "reasonable" to the researcher in the context of the problem at hand (see e.g., Nerlove and Waugh) or by assuming that the weights follow some probability distribution and using maximum likelihood procedures to determine the appropriate value(s) for the parameter(s) (see e.g., Bultez and Naert).

The approach taken here is a hybrid of the above approaches. First, the reduced form of the sales response equation is estimated by unrestricted Ordinary Least Squares, i.e., in the system (ignoring for the moment all variables except advertising)

$$q_t = \alpha + \beta A_t + U_t \tag{3a}$$

$$q_t = \alpha + \beta(w_0 A_t + w_1 A_{t-i} + \ldots + w_n A_{t-n}) + U_t \tag{3b}$$

$$q_t = \alpha + \beta \sum_{i=0}^{n} \gamma_i A_{t-i} + U_t \tag{3c}$$

where $$\gamma_i = \beta w_i \tag{3d}$$

OLS is applied to equation (3c) for different values for n. Because the regression coefficients of the reduced form equation each contain the constant β, they should provide some hints on the pattern of the decay weights w_i (particularly if the lagged regressors are not highly correlated). A geometrically declining set of weights are then imposed at the point in the lag structure where the γi attains its greatest value. A justification for this procedure is that it makes maximum use of the information content of the data with respect to the actual shape of the goodwill decay structure. For example, current advertising expenditures may contribute less to the current level of goodwill than later expenditures because of the need for consumers to be exposed to an advertisement a certain minimum number of times before a response is forthcoming. The approach just described permits the first few terms in equation (3c) to be estimated free of restrictions, if need be, to capture this effect.

A Digression on Functional Form Selection

Econometric results are often conditioned in a nontrivial way by the assumed mathematical form of the relationship between variables. Estimated demand elasticities are known to vary by 50 percent or more at the means because of differences in functional form (Prais and Houthakker, Salathe). Projections made at data extremes (or beyond the range of the sample) can differ significantly depending on the functional form of the forecasting equation (Tomek). This problem of functional form selection appears to be especially acute when econometric models are used for computing optimal advertising levels. One study found the optimal level of nonbrand milk advertising in New York City to be 30 times higher when estimated from a linear sales response function compared to a semilogarithmic equation (Thompson 1975, pp. 100-101).

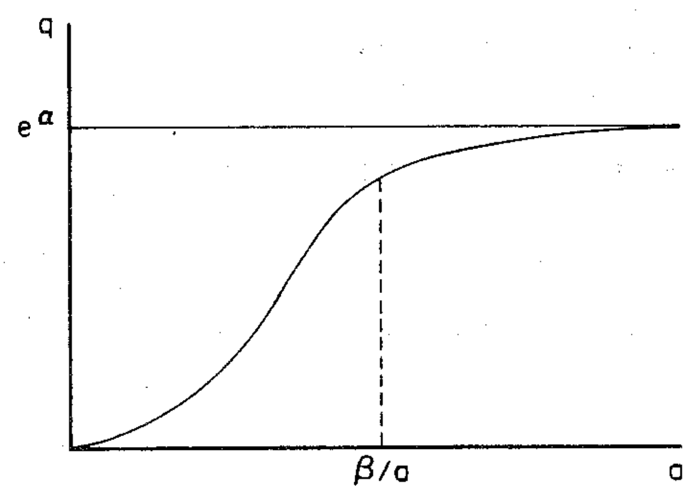
Applied researchers usually use three criteria in selecting an appropriate functional form (Goreux): statistical accuracy in fitting the data, the simplicity of the computation, and the economic interpretation of the function in terms of the underlying theory. The characteristics of five functional forms widely used in food demand analysis because they satisfy the computational simplicity criterion, are listed in table 1. These same functional forms serve as the basis for analysis in this study.

Table 1. CHARACTERISTICS OF DIFFERENT FUNCTIONAL FORMS FOR THE SALES-ADVERTISING RELATIONSHIP

Functional Form	Equation	Marginal Product of Advertising	Advertising Elasticity
Linear	$q = \alpha + \beta a + E$	β	$\beta a/q$
Logarithmic	$\ln q = \alpha + \beta \ln a + E$	$\beta q/a$	β
Semilogarithmic	$q = \alpha + \beta \ln a + E$	β/a	β/q
Log-inverse	$\ln q = \alpha - \beta/a + E$	$\beta q/a^2$	β/a
Inverse	$q = \alpha - \beta/a + E$	β/a^2	β/aq

Because economic theory and empirical evidence (see Simon and Arndt) point to diminishing marginal returns to advertising, all equations but the linear form in table 1 appear to be acceptable on this score. (The mathematical expressions for the marginal product of advertising (table 1) all contain, with the exception of the linear equation, the advertising variable in the denominator.) The logarithmic equation may be a less desirable representation of the sales-advertising relation than the other nonlinear forms because the advertising elasticity is assumed invariant with respect to the level of advertising. This contradicts the notion of a saturation level of advertising (Naples) which, in turn, implies a declining elasticity at higher advertising expenditure levels.4/ Additionally, the concept of a satiation level for milk consumption requires a functional form which permits the advertising elasticity to decline with higher levels of milk consumption. The semilogarithmic and inverse functional forms each accommodate these considerations. Finally, for a situation where the advertising data cover a wide range, the log-inverse functional form is appealing. In addition to satisfying the requirements of diminishing returns and a declining elasticity, its graph has a sigmoid shape (figure 1). This shape implies increasing returns at a very low level of advertising but diminishing returns at higher levels. The inflection point occurs at one-half the value of the advertising coefficient ($\beta/2$) and identifies the minimum level of advertising necessary to achieve diminishing returns (and hence the minimum profitable level of investment.) The graph also asymptotically approaches an upper limit of sales (e^{α}) as advertising increases indefinitely, which is consistent with the notion of a saturation level of advertising.

FIGURE 1. GRAPH OF THE LOG-INVERSE FUNCTION $\text{LN } q = \alpha - \beta/a + \epsilon$



4/ Despite its limitations, the logarithmic form is widely used in advertising studies because the regression coefficients are directly interpretable as elasticities.

The Data

Monthly data for the period January 1978 to June 1981 are used to estimate equation (1). The milk sales data pertain to the Buffalo Standard Metropolitan Statistical Area counties of Allegany, Cattaraugus, Chautauqua, Erie, Niagara, Orleans, and Wyoming.5/ The advertising expenditures are actual (not budgeted) monthly cost for milk commercials appearing on television, radio, billboards, newspapers and buses in the Buffalo area over the sample period. Television was the principal advertising medium used - accounting for about 75 percent of the annual investment each year. The total advertising investment over the three and one-half year period was $1.52 million.

Consumer income pertaining to the Buffalo area was obtained from New York State Department of Commerce Bureau of Business Research Publications (for exact references and other detail see Appendix table 1, footnote 3). The milk price data used are those collected monthly by the New York State Department of Agriculture and Markets and pertain to the Buffalo area prevailing price of whole milk in paper half-gallon containers. Price data for soft drinks and coffee specific to the Buffalo area were not available, hence U.S. city average price indices for these beverages (published by the U.S. Commerce Department) are used as proxies for the respective Buffalo area prices. These prices and income data were deflated by the Buffalo area Consumer Price Index for all items.

A look at an annual summary of these data reveal some important trends (table 2). First, despite the fact that the price of milk (adjusted for inflation) was nearly constant during the sample period and despite a growth in real incomes, per capita milk sales declined about one-half gallon each year. Part of the reason for this decline may be attributable to substitution effects i.e., consumers switching to coffee in response to the 33 percent decline in the real price of coffee that occurred over the period. Another factor may be the declining intensity of milk advertising - from 10.1¢ per capita in 1978 to 8.0¢ in 1980.6/ Finally underlying changes in the demographic composition of the market population may be partially responsible. The regression analysis presented later should sharpen our insights into the actual affects of these various factors in explaining this downward trend in milk sales.

5/ The efforts of Lyle Newcomb and Ed Johnston of the New York State Department of Agriculture and Markets in collecting the milk sales and advertising data are gratefully acknowledged.

6/ The 25¢ annual per capita expenditure discussed earlier was in current dollars. The 10.1¢ and 8.0¢ figures referred to here are expressed in terms of 1967 dollars (see table 2, footnote b). Between January 1978 and June 1981 average media advertising costs on the U.S. increased 40% (see appendix table 2, footnote 4).

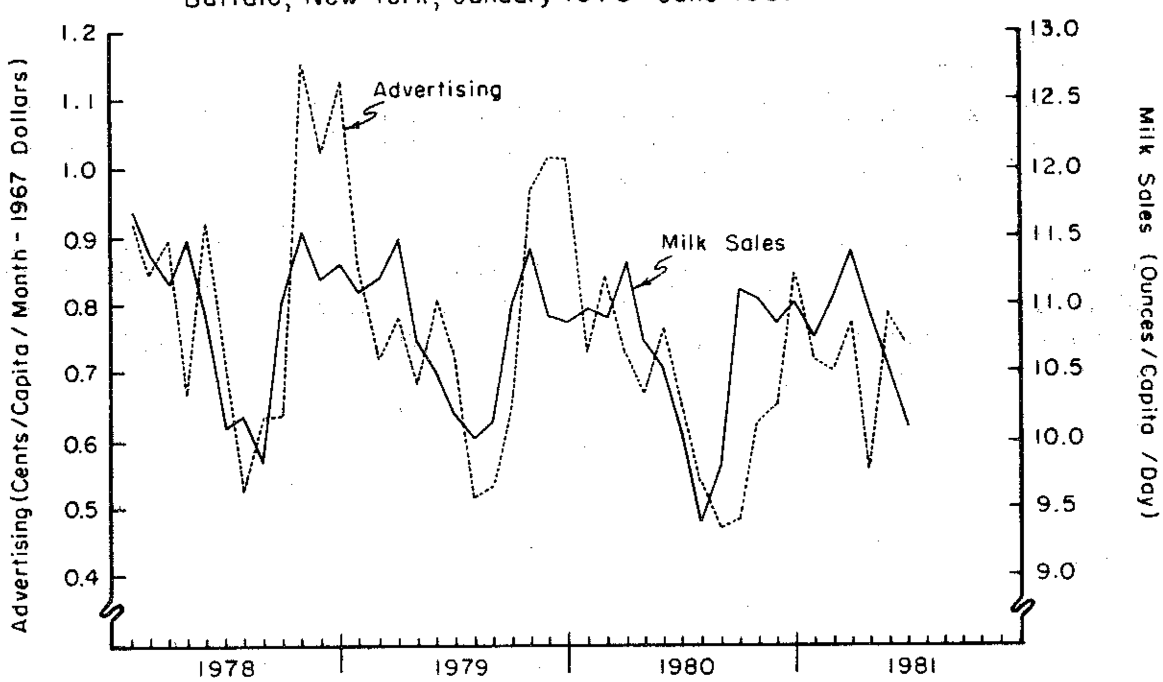
Table 2. MILK SALES, NONBRAND MILK ADVERTISING EXPENDITURES, INCOME, AND BEVERAGE PRICE DATA,[a/] Buffalo, New York, 1978-1981

Year	Milk Sales	Advertising Expenditures[b/]	Personal Income[c/]	Milk Price[c/]	Cola Price Index[c/]	Coffee Price Index[c/]
	(gals./capita)	(¢/capita)	($/capita)	($/½ gal.)	---(1967=100)----	
1978	31.4	10.1	3869	0.47	113	212
1979	30.9	9.3	3900	0.47	113	182
1980	30.4	8.0	3898	0.47	114	180
1981[d/]	15.2	4.3	3962	0.47	116	142

a/ Sources are listed in Appendix Tables 1 and 2.
b/ Deflated by the McCann-Erikson Combined Media Cost Index (1967=100).
c/ Deflated by the Buffalo Area Consumer Price Index for all items (1967=100).
d/ First six months only.

The milk sales data follow a regular seasonal pattern and the advertising expenditures vary significantly from month-to-month over the sample period (figure 2). Thus, the regression results discussed in the next section should be of fairly high quality with respect to estimates of the advertising effect (because regression coefficients pertaining to variables exhibiting a large amount of variation are more precise than those for variables exhibiting less variations).

FIGURE 2. FLUID MILK SALES AND NONBRAND ADVERTISING EXPENDITURES, Buffalo, New York, January 1978 - June 1981



Regression Results

OLS estimates of the five functional forms of the milk demand equation yield similar results from a statistical standpoint (table 3).7/ Each equation "explains" over 90 percent of the variation in milk sales over the sample period. The Durbin-Watson statistic in each equation is close to two-suggesting the absence of first order serial correlation in all equations. The t-ratios of the independent variables in all equations are consistent in sign and magnitude. However, the COND(X) statistic indicates that the logarithmic and semilogarithmic forms exhibit a greater degree of multicollinearity than do the other forms.

Originally each equation was estimated with all eleven harmonic variables. On the basis of t-tests and an evaluation of the net contribution of each individual harmonic in explaining the seasonal movements in milk sales only five of the original eleven harmonics were retained. Further, the same five harmonics are used in all the equations.8/

The statistical performance of the five equations was evaluated using two criteria: (within sample) prediction accuracy and goodness of fit. Predictive accuracy was measured by how well the predicted sales from each equation correlated with the actual sales. Goodness of fit comparisons were made by applying a nonparametric test to the standardized residual sum of squares of each equation (see Rao & Miller, p. 109).

The equations are virtually indistinguishable from a predictive accuracy standpoint: the correlation coefficients between actual and predicted sales for each equation is 0.96 (table 4). According to the goodness of fit criterion the inverse and semilogarithmic functional forms are slightly superior to the others in terms of lower residual sums of squares. However, differences are not great enough to reject the null hypothesis (at generally acceptable confidence levels), that the various functional forms are empirically equivalent.

7/ All equations are estimated using the econometric software package TROLL.

8/ The harmonic variables in table 1 are defined as cos_k = cosine ($6 \pi kt$) where t = 1,2...42 (i.e., t is incremented by one for each successive observation on the dependent variable) The $sine_2$ term has a similar definition. See Doran and Quilkey for further information on the use of harmonic variables as a substitute for seasonal dummy variables in regression equations.

Table 3. REGRESSION ESTIMATES OF THE MILK DEMAND EQUATION UNDER ALTERNATIVE FUNCTIONAL FORMS, Buffalo, New York, January 1978–June 1981 Data

	Functional Form									
	Linear		Logarithmic		Semilogarithmic		Log-inverse		Inverse	
Variable	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Intercept	8.992	2.02	-2.844	-0.687	-43.554	-1.01	2.376	5.81	10.405	2.45
cos_1	0.457	5.96	0.048	6.47	0.503	6.48	0.053	7.00	0.554	7.03
$sine_2$	-0.351	-4.90	-0.036	-5.06	-0.373	-4.98	-0.039	-5.25	-0.402	-5.21
cos_2	-0.314	-4.97	-0.028	-4.62	-0.304	-4.83	-0.027	-4.47	-0.290	-4.67
cos_3	-0.159	-3.17	-0.016	-3.30	-0.171	-3.34	-0.018	-3.50	-0.188	-5.54
cos_4	0.146	3.00	-0.014	3.00	0.148	3.06	0.014	3.12	0.152	3.19
Income	0.000646	0.46	0.351	0.67	3.708	0.68	0.00010	0.78	0.001	0.80
Milk Price	-15.621	-1.33	-0.730	-1.41	-7.251	-1.35	-1.520	-1.43	-15.096	-1.37
Cola Price	0.051	1.65	0.512	1.60	5.313	1.60	0.004	1.62	0.045	1.61
Trend	-0.0005	-1.08	-0.0005	-1.30	-0.0006	-1.32	-0.0006	-1.49	-0.0007	-1.52
a_t	17.878	0.49	-0.0014	-0.05	0.0238	0.08	-0.000092	-0.46	-0.0007	-0.37
at-1	45.190	1.29	0.0291	1.18	0.3000	1.17	0.000176	1.04	0.0018	1.03
$\bar{a}$b/	119.829	3.33	0.0938	3.36	0.9639	3.33	0.000744	3.47	0.0077	3.45
Sum	182.897	---	0.1214	---	1.2876	---	0.000829	---	0.00880	---
R^2	0.914		0.914		0.917		0.918		0.920	
$\bar{R}^2$	0.869		0.870		0.874		0.875		0.879	
DW	1.98		1.90		2.00		1.89		2.00	
RSSa/	0.00752		0.00781		0.00722		0.00751		0.00694	
COND(X)	564		5411		5030		553		553	

a/ To make the residual sum of squares comparable across all equations, the residual sum of squares obtained from the linear semilogarithmic and inverse functional forms are divided by the square of the geometric mean of the dependent variable (see Rao and Miller, pp.107-111). The geometric mean of milk sales is 10.802.

b/ The $\bar{a}$ variable is a weighted average of past advertising expenditures beginning with a_{t-2} and extending through a_{t-6}.

Table 4. CORRELATION COEFFICIENTS AND TEST STATISTICS USED TO EVALUATE ALTERNATIVE FUNCTIONAL FORMS OF THE MILK DEMAND EQUATION

Functional Form	Correlation Coefficient a/	Test Statistic b/
Linear	0.956	0.681
Logarithmic	0.957	---
Semilogarithmic	0.958	1.414
Log-inverse	0.958	0.705
Inverse	0.959	2.125

a/ Refers to the square of the simple correlation coefficient between the actual and predicted values of milk sales. Log values were converted to natural numbers before computation of the correlation coefficients.

b/ Computed under the null hypothesis that the functional form in question is empirically indistinguishable from the logarithmic functional form. The test statistic follows a chi-squared distribution with one degree of freedom (for computational procedures see Rao and Miller, pp. 105-111). The critical value at the 90 percent level of confidence is 2.706.

The signs and magnitudes of the coefficients of the economic variables are generally consistent with a priori expectations. Looking at the results for the logarithmic specification, the income elasticity is estimated at 0.35. While imprecise due to its large standard error, this estimate is consistent with other studies which show milk demand to be income inelastic. For example, Boehm (p.41) estimates the income elasticity for fluid milk in the Buffalo area at 0.068-0.130.

The milk price elasticity estimated by the logarithmic equation is -0.73 and statistically significant at the 10 percent level according to a one tail t-test. This elasticity is somewhat large compared to estimates in other studies (e.g., the Boehm study puts the own-price elasticity for milk on Buffalo at -0.132 to -0.317) and may be partially explained by the relatively high prices for milk in Buffalo relative to other markets.9/

The cola price elasticity estimated from the logarithmic equation (0.512) is statistically significant at the 10 percent level based on a one tail t-test. Its positive sign indicates that consumers in Buffalo regard cola as a substitute for milk, i.e., a one percent rise in cola prices is associated with a 0.5 percent rise in per capita milk consumption, ceteris paribus. This elasticity,

9/ An examination of retail milk prices in 24 upstate New York markets revealed that Buffalo was the highest priced market in 1970 and the second highest priced market in 1980 (Kinnucan 1982a). The average 1980 Buffalo price for whole milk in paper half-gallon containers was 7.6 percent above the upstate average and 17.8 percent above the lowest priced market (Binghamton).

too, is somewhat larger than the 0.20 estimate obtained in other studies (see e.g., Thompson 1979, Kinnucan 1982b) and may be due to the relatively rapid rise in real cola prices that occurred during 1980 (a 7.3 percent increase).10/

The estimated coefficient of the trend variable, which represents the combined influence of omitted variables such as the age and race structure of the population is consistently negative across all equations. This means that even if consumer incomes, milk and cola prices, and milk advertising remain unchanged, per capita milk consumption will decline over time because forces not explicitly identified in the model have unfavorable trends with respect to milk consumption. More specifically, on the basis of the trend coefficient estimated from the log-inverse equation, per capita milk sales would decline by 0.72 percent annually (-0.0006 x 12 x 100), ceteris paribus, because of the unfavorable effects of temporal changes occurring in variables not explicitly accounted for in the model. However, this trend estimate should be treated with caution because its t-ratio (-1.49) indicates that its numerical value is not very precisely determined.

The regression estimates of the advertising effect is consistent across all equations and indicates the following: the effect of advertising milk in Buffalo did not become apparent until the month following the initial expenditure, it reached its maximum effectiveness in the second month following the original expenditure and thereafter the effect diminished rapidly until it was virtually dissipated by the sixth month (figure 3). The total effect (current period plus carry-over effects) of milk advertising is positive and statistically significant in all equations.11/

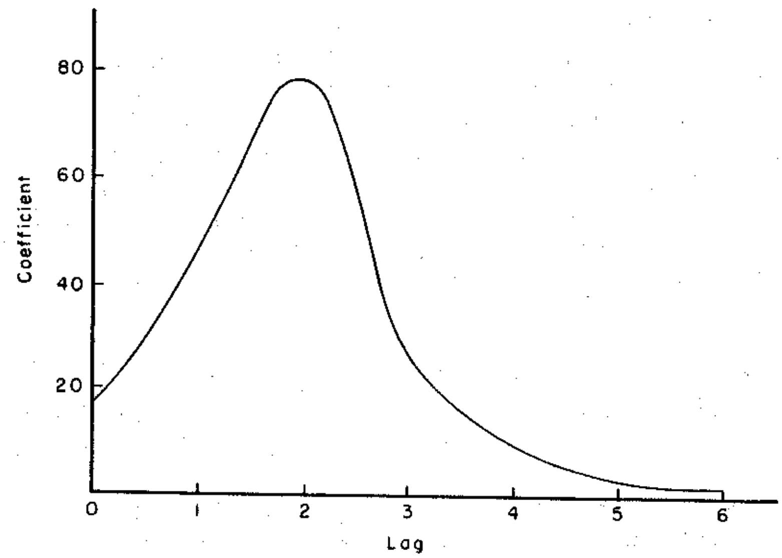
According to the logarithmic equation, the long-run advertising elasticity is 0.121. This estimate is large compared to those obtained for other New York markets, i.e., 0.051--New York City, 0.015--Rochester, 0.005--Syracuse, and 0.004--Albany (Thompson 1978a, b; Kinnucan 1982b), suggesting that the Buffalo market is highly responsive to nonbrand fluid milk media advertising. It is impossible to say for certain why Buffalo is more responsive, but some possible explanations offer themselves. First, Buffalo area consumers may have been exposed to significantly greater amounts of milk advertising than were the consumers in the other markets (per capita advertising expenditures were three times higher and Canadian advertisements affect the market).12/ Thus, one interpretation is that a higher expenditure level for advertising results in a more effective advertising campaign.

10/ Initial analysis was conducted with an equation that included the coffee price variable specified in equation (1). Because of very low t-ratios obtained for this variable and the collinearity it caused, it was deleted from further analysis.

11/ An F-test comparing models with and without advertising variables rejects the latter model at the 1% level of statistical significance (e.g., F = 4.37 compared to the critical F_c (4,22;0.01) = 4.31 for the linear model in table 1).

12/ Buffalo has an overlapping media coverage area with Ontario. Therefore, Buffalo area residents are exposed to advertising originating in Canada as well as the U.S. The advertising data used in this study pertain only to

FIGURE 3. DECAY STRUCTURE[a] FOR GENERIC ADVERTISEMENT OF FLUID MILK, BUFFALO, NEW YORK



a/ Based upon a linear specification of the milk demand equation. Lag structures for other functional forms are similar

Another possible explanation may be an upward bias in the estimated sales response caused by an inadequate treatment of price effects. In particular, foodstores in the Buffalo area reportedly engaged in considerable price cutting of lowfat milk during the sample period.13/ The milk price variable used in the

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expenditures made by U.S. dairy farmers for milk advertisements placed on U.S. television and radio stations. To the extent that Buffalo area consumers viewed Canadian television and listened to Canadian radio, these expenditure data would understate the actual amount of milk advertising occurring in the Buffalo area because the Ontario Milk Marketing Board also conducted generic milk advertising over the study period. (According to estimates provided by Michael Pearce of the Ontario Milk Marketing Board, spillover effects of Canadian milk advertising into the Buffalo market accounted for almost 10 percent of the annual U.S. expenditure over the sample period. See Appendix table 3.) While using a data series which understates the actual quantity of milk advertising occurring in the market results in an upward bias in the estimated marginal effect of the advertising effort, it does not affect the estimated value of the elasticity. In fact, additional analysis revealed that including Canadian milk advertising in the analysis has an inconsequential effect on the regression results (compare regression nos. 3 and 4 of Appendix table 4).

13/ Personal correspondence with Herbert Kling and Charles Huff of the New York State Department of Agriculture and Markets. In addition, according to numbers supplied by Ed Johnston of NYSDAM, lowfat milk is a signicant component of total milk sales in the Niagara Frontier area. For example, in 1980 44.4% of total fluid sales in the market was lowfat, compared to the State average of 17.5%.

model pertains only to whole milk. To the extent that this variable inadequately "holds constant" the actual influence of price on milk sales, the estimated "advertising effect" may in part be reflecting the positive effects that price competition in lowfat milk has had on sales in this market.14/

A further explanation may be the regularity of the Buffalo advertising expenditure vis-a-vis the other markets. Over the sample period, milk advertising in Buffalo followed a fairly regular seasonal pattern which coincided fairly closely with the seasonal sales patterns (see figure 2). By contrast, monthly advertising expenditures in the other markets typically followed an erratic pattern--falling to zero in many instances. To the extent that "pulsing" is less effective than a continuous steady rate of advertising (see Kinnucan and Forker and references cited therein) this would explain in part the higher advertising elasticity obtained for Buffalo relative to other New York markets.

Finally, differences in advertising copy may be a factor. The milk advertisements used in the Buffalo market over the study period were produced by a different advertising agency than the ones used in the other markets. The advertising themes were also different: in Buffalo "thank you milk" vs. "milk's the one" or "the fresher refresher" in the other markets. The larger advertising elasticity for Buffalo may be due in part to the greater relative effectiveness of the advertising creative used in this market. (However, it must be emphasized that these explanations are merely speculation. The evidence presented in this study simply suggests that the Buffalo fluid milk advertising program is more effective than are the advertising programs conducted in other New York markets; it does not provide any information, per se, as to why these differences may exist.)

Demand Elasticities for Fluid Milk in Buffalo Obtained from the Various Functional Forms

As indicated earlier, previous research indicates that estimated demand elasticities can vary by 50 percent or more because of differences in functional form. This phenomenon is not observed for the data analyzed in this study. The income, own-price, cross-price and long-run advertising elasticities (computed at mean data points) for the various functional forms are similar (table 5). Each elasticity lies well within one standard deviation of the corresponding elasticity computed from the logarithmic equation. Thus for these data estimated demand elasticities, when evaluated at the mean data points, are not much affected by the functional form of the milk demand equation.

14/ Additional analysis discounted this explanation, however. Adding a lowfat milk price variable to regression equations or replacing the whole milk price variable with a weighted average of whole and lowfat milk prices did not result in a significant change in the advertising elasticity (see Appendix table 4).

Table 5: DEMAND ELASTICITIES OBTAINED FROM DIFFERENT FUNCTIONAL FORMS OF THE MILK DEMAND EQUATION, Buffalo, New York

Functional Form	Elasticity[a/]			
	Income	Own-Price	Cola-Price	Advertising
Linear	0.233	-0.681	0.537	0.127
Logarithmic	0.351	-0.730	0.512	0.121
Semilogarithmic	0.343	-0.670	0.491	0.119
Log-inverse	0.391	-0.716	0.455	0.110
Inverse	0.361	-0.658	0.474	0.108

a/ Evaluated at means.

The above finding does not mean that different functional forms have similar economic implications. Although the elasticities are similar in the mean range of the data, they can change drastically at data extremes depending on the functional form. For example, the inverse functional form produces a long-run advertising elasticity twice as large as the one obtained from the logarithmic equation when both are evaluated at two standard deviations below the average level of milk advertising (table 6). Similarly, the magnitude of the long-run advertising elasticity implied by the inverse functional form is much smaller at a higher expenditure level than the one obtained from the logarithmic functional form. Thus estimates of how sales will change in response to large changes in advertising will vary significantly depending upon the functional form of the equation. Given the large changes over time that can occur in milk advertising this is not an insignificant finding (e.g., nonbrand milk advertising in New York City increased 67 percent between 1972 and 1975 and then declined 51 percent by 1979 (Kinnucan 1982b)).

Table 6. LONG-RUN ADVERTISING ELASTICITIES OBTAINED FROM DIFFERENT FUNCTIONAL FORMS OF THE MILK DEMAND EQUATION EVALUATED AT DIFFERENT POINTS ALONG THE DEMAND CURVE, Buffalo, New York Market

Functional Form	Long-run Advertising Elasticity Evaluated at:[a/]				
	$\mu - 2\sigma$	$\mu - 1\sigma$	μ	$\mu + 1\sigma$	$\mu + 2\sigma$
Linear	0.079	0.104	0.127	0.148	0.166
Logarithmic	0.121	0.121	0.121	0.121	0.121
Semilogarithmic	0.133	0.125	0.119	0.113	0.108
Log-inverse	0.199	0.142	0.110	0.090	0.076
Inverse	0.248	0.168	0.123	0.096	0.077

a/ The μ refers to the sample means of advertising and milk sales ($0.00753/month [1967 dollars] and 10.82 oz/person/day, respectively). The standard deviation (σ) of advertising is $0.00168 and of milk sales is 0.553/oz/person/day.

The Profitability of the Advertising Investment

The econometric analysis discussed above indicates that nonbrand milk advertising in Buffalo over the period January 1978 to June 1981 had a positive statistically significant effect on milk sales. To determine if the advertising program was profitable to investing producers, one needs to know whether the advertising-induced shift in demand is sufficiently large to compensate for costs. To determine this, Hadar (p.127) introduces the concept of "discount-equivalence." The discount-equivalence is the reduction in price necessary to maintain sales at its current level when advertising is reduced to zero. An analytical expression for this concept is:

$$h(\bar{q},\bar{a}) - h(\bar{q},o) > p^{a}a/\bar{q} \tag{7}$$

where $h(\bar{q},\bar{a})$ is an inverse demand function indicating the price the firm must charge in order to sell $\bar{q}$ units of q, given an advertising level of $\bar{a}$. The $h(\bar{q},o)$ is the (lower) price the firm must charge in order to continue selling $\bar{q}$ units in the absence of advertising, and $p^{a}\bar{a}/\bar{q}$ is advertising expenditures on a per unit basis. The inequality sign in expression (7) means that for advertising to be profitable the price-discount $(h(\bar{q},\bar{a}) - h(\bar{q},o))$ necessary to maintain demand in the face of an advertising cut (to zero) must exceed the per unit level of advertising expenditure $(p^{a}\bar{a}/\bar{q})$ which existed before the elimination of the advertising.

Applying the discount-equivalence criterion to the farm-funded milk advertising program is straightforward: the price reduction necessary to maintain demand when advertising falls to zero is simply the Class I-Class II price differential. This is so because under the price support program advertising has the effect of shifting milk from Class II (manufacturing) to Class I (fluid) use. The resulting benefit to the producer is the price premium obtained from the increased Class I utilization vis-a-vis Class II utilization. In terms of the inequality (7) the price support program insures that q will be the same regardless of the level of a; the only difference is that with a positive level of advertising producers can increase the value of the milk they sell by selling a greater proportion of milk as Class I.

Applying the discount-equivalence concept to the Buffalo advertising program we have,

$$h(\bar{q},\bar{a}) - h(\bar{q},o) = 0.07262¢/\text{oz. and}$$

$$p^{a}\bar{a}/\bar{q} = 0.00232¢/\text{oz.}$$

where 0.07262¢ is the average 1980 Class I-Class II price differential in the Niagara Frontier Milk Marketing expressed on a per fluid ounce basis in terms of 1967 dollars (254¢/100 lbs. x 100 lbs./1488.372 oz. x 1/2.35 = 0.07262¢) and 0.00232¢ is the average per ounce expenditure on advertising (0.7529¢/month/person ÷ 324 oz./month/person) also in 1967 dollars. Because 0.07262¢/oz. exceeds 0.00232¢/oz. decisively, one can conclude on the basis of the discount-equivalence criterion that the Buffalo milk advertising program has been profitable for affected dairy producers. In fact, this calculation suggests that milk advertising in the Buffalo area could have been increased by a factor of 31.3 (0.07262/.00232) and still have been a profitable investment for dairy producers.

An estimate of the actual profitability of the milk advertising investment can be obtained alternatively by using the econometric models (table 3) to estimate milk sales first with and then without advertising and comparing the farm value of the resulting sales difference to the associated advertising costs. An application of this procedure (summarized in table 7) provides results which indicate that the nonbrand milk advertising investment in Buffalo was indeed profitable. The advertising program increased annual per capita milk sales an estimated 1.18 to 1.58 gallons (four to 5.5 percent) over the amount that would have been sold had advertising remained at its lowest observed level throughout the test period.15/ The farm value of this sales gain for the SMSA market ranges from $1.8 - 2.4 million. The average return on the advertising investment is at least between $4.35 and 5.81 (see footnote c of table 7) and may be as high as $16.85 - $22.52 per media dollar invested.

The results presented in table 7, in addition to showing the profitability of the advertising investment, reveals the sensitivity of the estimated level of profitability to the choice of functional form. In this study the estimated sales gain attributable to advertising (and hence the profitability of the advertising investment) varies by as much as 33 percent because of differences in functional form. The smallest profitability estimates are obtained from the functional forms which assume either that the marginal product of advertising is constant (the linear form) or declines at a relative slow rate (the logarithmic and semilogarithmic forms). To the extent that nonbrand milk advertising is subject to fairly rapidly diminishing returns the linear, logarithmic and semilogarithmic equations may provide an unduly conservative estimate of the true profitability of the advertising investment.16/

15/ In principal sales could have been estimated with advertising held at a near zero level rather than its lowest observed level. However, estimates so computed would be based on data beyond the range of the original sample and hence would be subject to error of possibly large proportions.

16/ Empirical evidence in support of the contention that nonbrand milk advertising is subject to rapidly diminishing marginal returns is provided in a controlled market experiment conducted by Clement et al. In this study they found milk sales rising 4.5 percent over base-line sales when advertising was increased by 15 cents per capita. When advertising was increased to 30 cents per capita, the sales increase, compared to baseline sales, was only 5.9 percent.

Table 7. PRODUCER RETURNS FROM INCREASED NONBRAND ADVERTISING AS MEASURED BY DIFFERENT FUNCTIONAL FORMS OF THE MILK DEMAND RELATION, Buffalo, New York Market, 1980

Functional Form	Estimated Milk Sales with Advertising at its: Actual Level	Lowest Level[a/]	Sales Gain Attributable to Increased Advertising	Farm Value of the Sales Gain	Average Return Per: Total Media Dollar Invested[c/]	Additional Media Dollar Invested[d/]
Linear	30.56	29.38	1.18	$1,805,121	$4.35	$16.85
Logarithmic	30.55	29.20	1.35	2,053,309	4.94	19.17
Similogarithmic	30.55	29.18	1.37	2,092,135	5.04	19.52
Log-Inverse	30.54	29.00	1.54	2,361,554	5.69	22.04
Inverse	30.54	28.96	1.58	2,412,901	5.81	22.52

a/ The lowest observed monthly level of advertising was $22,202.89 in undeflated dollars (about 1.43¢ per capita).

b/ Calculated by multiplying the monthly sales gain by the monthly Class I-Class II milk price differential for the Niagara Frontier area. Sales figures increases refer to the SMSA population rather than the Media Coverage Area population.

c/ These numbers represent the average return to the advertising program assuming that a) advertising expenditures below the lowest observed level has no significant effect on sales and, b) that consumers outside the SMSA (but within the MCA) did not respond to the milk advertisements. They are computed by dividing the total 1980 media cost of the advertising program ($415,207.45) into the numbers of the preceding column. Computing average returns in this way provides a lower limit on the profitability of the investment.

d/ This column of numbers are estimates of the additional return, per dollar invested, that producers receive when advertising is increased from its lowest observed level (about 1.43¢/person/month) to its actual level. It is calculated by dividing the farm value figures in column four by the amount actually spent on advertising (prorated for the SMSA population) to achieve this sales gain.

The Optimal Level of Nonbrand Milk Advertising

Aside from knowing that a given level of advertising is effective in terms of increasing sales and providing a favorable return on the investment, the advertiser or promotion group needs to have some idea of the appropriate level of expenditure in a given market. One approach is to simulate optimal advertising levels using an economic model which takes into account advertising's effect on the supply and demand conditions for the product (see e.g., Thompson, Eiler, Forker). An alternative approach is to compute the optimal expenditure level directly from the estimated sales response equation using the short-run profit maximization rule that the last dollar in advertising expenditure yield one additional dollar in sales revenue. This latter approach has the advantage of providing an easily determined upper bound on the optimal expenditure level and therefore is employed here.

Previous research has indicated that the computed optimal level for advertising can change drastically depending on the functional form chosen to represent the sales response function. For example, the optimal level of generic milk advertising in New York City computed from a linear sales response equation was 30 times higher than the corresponding optimum based on a semilogarithmic equation (Thompson 1975, pp. 100-101). The same study found similar differences when other functional forms of the sales response equation were used. Therefore, in arriving at an estimate of the short-run profit maximizing level of milk advertising for Buffalo, results based on several different functional forms of the sales response equation will be compared.

To compute optimum advertising levels, the sales response equations estimated earlier were condensed to the following expressions:

linear: $q = \alpha_1 + \beta_1 a$	$\alpha_1 = 9.4029$ $\beta_1 = 182.8971$	(1)
Logarithmic: $q = e^{\alpha_2} a^{\beta_2}$	$\alpha_2 = 19.5411$ $\beta_2 = 0.1214$	(2)
Semilogarithmic: $q = \alpha_3 + \beta_3 \ln a$	$\alpha_3 = 17.1040$ $\beta_3 = 1.2876$	(3)
Log-inverse: $q = e^{\alpha_4} - \beta_4/a$	$\alpha_4 = 2.4969$ $\beta_4 = 0.000829$	(4)
Inverse $q = \alpha_5 - \beta_5/a$	$\alpha_5 = 12.0051$ $\beta_5 = 0.00875$	(5)

The intercept terms (α_i) are computed by multiplying the regression coefficients by the mean values of corresponding variables (except advertising) and then taking the sum of these products. The slope terms (β_i) are the sum of the regression coefficients pertaining to the advertising variables in each equation.

Because the equations represent the per capita quantity of milk sold (in fluid ounces) on a daily basis and per capita monthly sales revenue (in 1967 dollars) is required each equation was multipled by the following conversion factor

$$C = 30 \text{ days/month} \times PD/100 \text{ lbs.} \times 100 \text{ lbs}/1488.372 \text{ oz} \times 1/2.35 \qquad (6)$$

The PD is the Class I-Class II price differential for the Niagara Frontier Milk Market (NYDAM) and is used to place a farm value on the additional milk sold because of advertising.17/ The 1488.372 places the PD on a price per fluid ounce basis (one lb. of 3.5 test milk approximately equals 14.88372 fluid ounces). The 2.35 is the average 1980 level of the Buffalo area Consumer Price Index.

Equations (1) - (5) were then used to simulate monthly per capita sales revenue (at the farm level) generated when advertising expenditure are varied over some range. The marginal revenue at each successively higher level of advertising was approximated as the difference between sales revenue at the current level of advertising and sales revenue at the next lower level of advertising. The marginal cost of advertising is computed in a similar manner: the difference in expenditure between the current level of advertising and the immediately preceding lower level. Thus optimum level of expenditure is determined as the point where the marginal expenditure on advertising equals the marginal revenue product of advertising.

The results obtained by applying this procedure indicate that optimal milk advertising expenditures does indeed vary significantly depending on the functional form of the sales response function (table 8). Specifying the advertising variable in a logarithmic form results in an optimal level of advertising which is at least twice as large as is the optimal level based on a reciprocal specification of the advertising variable.18/ Furthermore, these differences are magnified at higher levels of the Class I-Class II price differential. For example, when the Class I-Class II price differential is $2.14 per hundredweight (the lowest observed level during 1980) the logarithmic equation gives an optimal advertising level which is 2.2 times greater than the optimal level computed from the log-inverse equation. This differential increases to 2.6 for a Class I - Class II price differential of $2.87 per hundredweight (the highest observed level during 1980).

17/ The Class I-Class II milk price differential during 1980 varied from $2.14 in October to $2.87 in June for an annual average of 2.54. The corresponding factors computed by equation (6) are 0.018355 ($2.14), 0.024616 ($2.87), and 0.021786 ($2.54).

18/ The linear functional form implies that advertising, under the given price levels, could be increased indefinitely and still be profitable. The implausibility of this result flows from the implausibility of the assumption implicit in the use of the linear functional form: that marginal returns from advertising are constant regardless of the level of the expenditure. For this reason optimality estimates based on the linear form were not computed.

Table 8. OPTIMAL NONBRAND ADVERTISING LEVEL FOR FLUID MILK COMPUTED FROM ALTERNATIVE FUNCTIONAL FORMS OF THE SALES RESPONSE EQUATIONS, Buffalo, New York, 1980

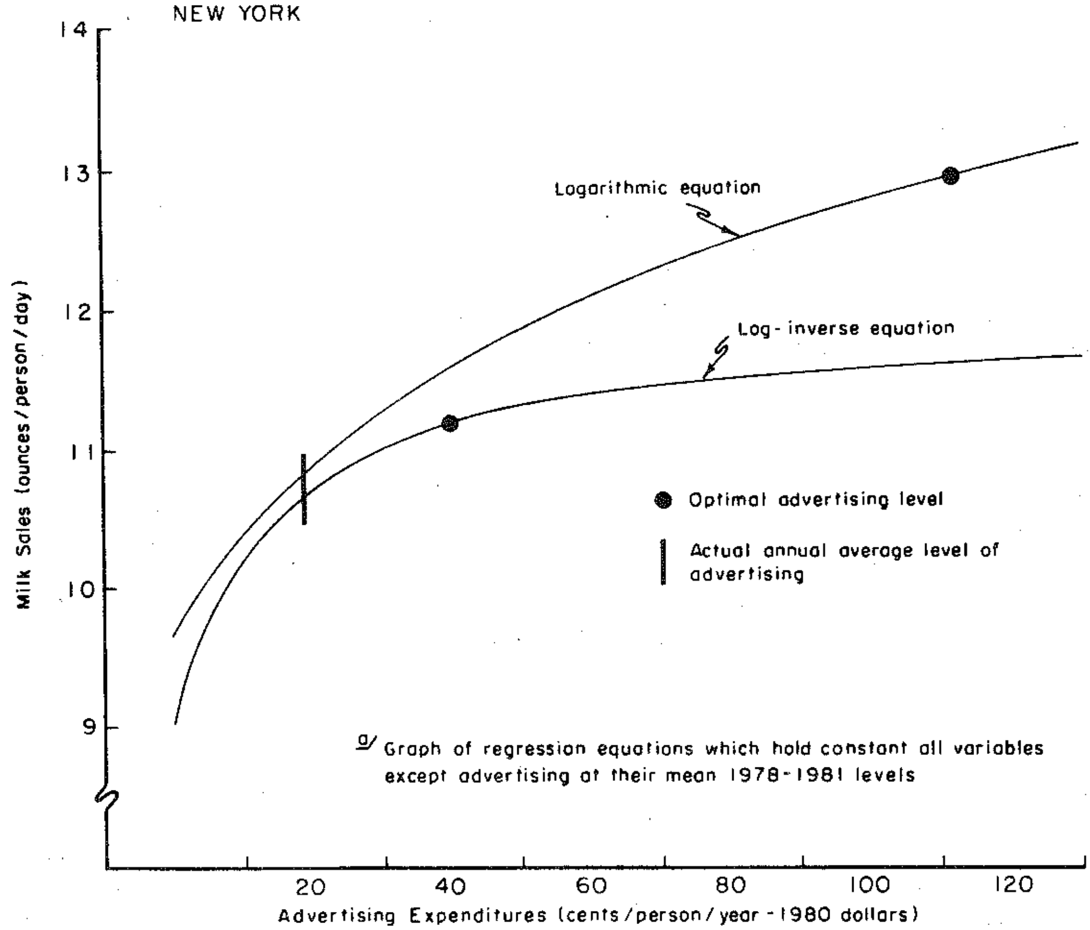
Functional Form	Optimal Advertising Level When The Class I - Class II Price Differential is:[a/]		
	$2.14	$2.54	$2.87
	($/person/year - 1980 dollars)		
Logarithmic	1.008	1.224	1.404
Semilogarithmic	0.855	1.017	1.152
Log-inverse	0.469	0.513	0.547
Inverse	0.459	0.499	0.529

a/ The actual annual per capita level of advertising during 1980 was $0.260 and ranged from $0.172 to $0.302. The three price differentials represent the low, annual average and high level for 1980, respectively.

Estimates of the average annual optimal level of milk advertising in Buffalo for 1980 (based on the annual average Class I-Class II price differential of $2.54) range from $0.499 (per capita - 1980 dollars) to $1.224. The actual annual level of milk advertising during 1980, by comparison, was $0.25. Thus, depending on the functional form of the sales response equation, the level of nonbrand milk advertising during 1980 in Buffalo could have profitably been expanded twofold to fivefold in the short-run.

As alluded to earlier in the discussion on the choice of functional form, the reason for the widely varying estimates of the optimal level of advertising arising from the different functional forms can be traced to the behavior of the marginal product of advertising implied by the use of the different functional forms. Functional forms which exhibit a more rapid decline in the marginal product of advertising yield lower optimum levels because in these equations the point where marginal costs equals marginal revenue is achieved more quickly as the advertising expenditure level increases. Figure 4 illustrates this phenomenon. The graphs are net regressions corresponding to the logarithmic and log-inverse functional forms. The graph of the logarithmic equation, which exhibits a fairly moderate rate of decline in the marginal product of advertising, rises at about the same rate as the log-inverse equation at the lower levels of expenditure, but beyond a $.40 per capita expenditure the graph of the two equations diverge significantly. As a result, quite different sales responses to the increased levels of advertising are implied by the two equations. For example, a $1.00 investment level for the logarithmic equation implies a per capita daily milk consumption of 12.9 ounces--20 percent above the actual level 10.8 ounces. By comparison, a $1.00 advertising investment would yield 11.6 ounces in sales according to the log-inverse relation. The more conservative estimate provided by the log-inverse equation is directly attributable to the fact that it exhibits a faster rate of decline in the marginal product of advertising than does the logarithmic equation.

FIGURE 4. MILK SALES - ADVERTISING RESPONSE SURFACES[a] GENERATED BY ALTERNATIVE FUNCTIONAL FORMS OF THE ADVERTISING RESPONSE FUNCTION, BUFFALO, NEW YORK



Limitations

In addition to the caveats cited earlier relating to the interpretation of the regression estimates of the advertising effect, a number of other important limitations which should be borne in mind when interpreting the results. First, the sales response functions used to estimate the goodwill effect of milk advertising do not include variables pertaining to the advertising behavior of competitive beverage manufacturers. Given the intensity of the promotional efforts of soft drink, coffee, beer and wine producers and the resulting probable negative effects on milk consumption, ignoring this factor may seriously bias the estimated milk advertising effect.19/ However, because of the multicollinearity problems associated with the specification of additional advertising variables in the model (see Thompson et al., 1976), there appears to be little hope of satisfactorily overcoming this difficulty within the context of currently existing econometric methodology. In the meantime, to the extent that biases arising from this source are consistent in size and magnitude, meaningful comparisons of milk advertising effects (when estimated without regard to competitive advertising effects) across markets can still be made.

Another potential limitation of the study is the use of a trend variable to represent the effects of changing demographics on the demand for milk. Given the importance that a changing age structure and/or ethnic mix has on milk sales in a market (see Kinnucan 1982b) and the complexity with which these changes occur, a simple trend variable specification is probably an inadequate treatment of these effects. As a consequence, the estimated advertising effect probably contains some bias, although it may be in the direction of providing a more conservative estimate of the actual effect. Furthermore, nonmedia promotional activities conducted by the American Dairy Association such as point-of-sale materials, "real" seal labeling, nutrition education, and food service merchandising are not explicitly taken into account in the model. To the extent that expenditures on these activities are encouraging milk consumption and are positively correlated with advertising expenditures, the estimated effect of the media advertising component of the promotional program would be overstated.

Finally, this study falls short of providing a comprehensive set of results on the important subject of functional form selection. Only results pertaining to the functional forms commonly used in studies of food demand analysis are presented. Given the sensitivity of the computed level of optimal advertising to functional form selection, further research on this topic seems warranted. A fruitful line of research in this connection may be the general transformation-of-variables approach (see Zarembka, p.83) or the use of the generalized logistic function developed by Johansson.

19/ The direction of the bias depends on the direction of correlation between milk advertising and competitive beverage advertising. If this correlation is negative and competitive beverage advertising has a significant negative effect on milk sales, then excluding competitive beverage advertising from the model would result in an upward bias in the estimated milk advertising effect; under the same conditions a positive correlation would produce a downward bias.

Conclusions

Bearing in mind the limitations enumerated above, some conclusions can be drawn. First the nonbrand milk advertising program conducted in the Buffalo area over the period January 1978 through June 1981 appears to have been very effective, both in terms of increasing per capita milk sales and in yielding a favorable return on the media advertising investment to affected dairy producers. According to the econometric model, nonbrand milk advertising increased per capita milk sales at least 1.2 to 1.6 gallons per year (4.0 to 5.5 percent) over what would have occurred had advertising remained at its lowest monthly level for the entire sample period. This increase translates into an average return of $16.85-$22.52 per additional dollar invested in direct media advertising.

Moreover, the statistical results indicates that the Buffalo market is very responsive to milk advertising; moreso, in fact, than any other New York market examined thus far. Specifically, in terms of long-run advertising elasticities, the Buffalo response to nonbrand milk advertising ($\eta^{s.a}$=0.12) is 2.4 times greater than the New York City response, six times greater than the Rochester response, and about 24 times larger than the responses for Albany and Syracuse (Thompson 1978, 1979, Kinnucan 1982b). While an unequivocal explanation for the larger response in Buffalo cannot be given, the higher level of milk advertising in Buffalo (at least three times higher on a per capita basis than in the other markets) combined with a more even monthly advertising expenditure pattern (and possibly a more effective set of commercials) may in part explain the difference. The apparent success of the milk advertising campaign in the Buffalo market dramatically emphasizes the notion suggested by previous research that there might be substantial differences among markets. It contradicts the implicit conclusion made earlier that perhaps all other markets in New York State are not nearly as responsive as New York City.

The results presented in this paper indicate that the functional forms chosen by the researcher to represent the sales-advertising relationship can condition the outcome of the analysis in some important respects. Estimated advertising elasticities differed by as much as 220 percent along a demand curve depending on the functional form used. The estimated rate of return on the advertising investment differed by 34 percent and the optimal level of advertising expenditures by 149 percent because of the use of different functional forms. The widely varying results that arise from alternative functional forms has several implications. First, much of the recent emphasis in the theoretical literature on the importance of the lag structure in optimizing advertising expenditures (see e.g., Mann) may be misplaced; errors caused by functional form misspecification may be much more serious.20/ Second, greater attention may have to be devoted to theoretical underpinnings of the sales-advertising response relation in question in order to gain some insight into appropriate a priori restrictions to place on the functional form. Third, when the theory and available empirical evidence is insufficient to narrow the choice of functional form a priori, research results based on a variety of functional forms should

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20/ The contention that alternative lag structures do not result in significantly different values for the optimal level of advertising is supported by the study of Bultez and Naert who state (p.460): "Different lag structures will not lead to very different implications for decision making."

be presented. If not, the researcher should state categorically why one functional form was chosen over another in conducting the analysis.

The computed, optimal level of nonbrand fluid milk advertising in Buffalo for the calendar year 1980 exceeds the actual level of investment (26¢/person) by a factor of 1.9 to 4.7 depending upon the choice of functional form (see table 8). Thus, although the computed optimum is very sensitive to the type of functional form used to represent the sales-advertising relationship, as a practical matter it may be a moot point in the case of the Buffalo market. Even to achieve the most conservatively estimated optimal level of advertising, producers supplying the market would have to invest about $855,000 (in 1980 dollars) per year. This level of expenditure would require either doing away with currently existing nonmedia advertising programs funded with promotional dollars21/ or increasing producer assessments from 8¢ per cwt. to 16¢ per cwt. Because neither of these actions are likely to take place in the foreseeable future, the practical implications of wrong functional form selection with respect to the Buffalo market are probably innocuous.

The results presented in this study indicate that the fluid milk nonbrand media advertising campaign in Buffalo was very effective. Managers of milk promotional funds may want to take a closer look at the Buffalo program to identify additional factors that may be responsible for its apparent success.

21/ In 1978 about 54% of the Milk for Health on the Niagara Frontier, Inc., budget went for advertising, with the remainder of the funds going to support the Niagara Frontier Dairy Council (18.4%), the American Dairy Association and Dairy Council of New York (1.3%), the Ontario Milk Marketing Board (1.0%) and Administration (3.2%) (Stavins and Forker, p.105).

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APPENDIX TABLES

Appendix Table 1. MILK SALES, GENERIC ADVERTISING EXPENDITURES, INCOME, MILK PRICE, COLA PRICE AND COFFEE PRICE DATA, Buffalo, New York, January 1978 - June 1981.

		FLUID MILK SALES[1] (OZ./PERSON/DAY)	MILK ADVERTISING EXPENDITURES[2] (¢/PERSON/MONTH-1967 DOLLARS)	PER CAPITA PERSONAL INCOME[3] (1967 DOLLARS)	RETAIL FLUID MILK PRICE[4] (¢/½ Gal. - 1967 DOLLARS)	RETAIL COLA PRICE INDEX[5] (1967 = 100)	RETAIL COFFEE PRICE INDEX[6] (1967 = 100)
1978	JAN	11.7098	0.922043	3821.07	46.5988	111.998	242.689
	FEB	11.4071	0.852919	3836.29	46.4	112.267	240.107
	MAR	11.2754	0.895561	3850.41	46.1906	113.406	237.059
	APR	11.4659	0.677925	3864.45	47.0402	114.588	228.964
	MAY	10.9326	0.918381	3854.6	46.5847	113.478	222.246
	JUNE	10.1253	0.719186	3844.97	46.1379	113.323	215.448
	JULY	10.195	0.525232	3854.36	46.9556	113.21	210.784
	AUG	9.82453	0.638155	3878.52	46.7386	113.2	199.692
	SEPT	11.0046	0.639762	3889.57	46.3694	112.815	192.459
	OCT	11.5602	1.15225	3900.5	47.0172	112.942	187.968
	NOV	11.2226	1.0245	3912.3	47.8228	112.761	186.559
	DEC	11.3144	1.11988	3924.03	47.619	112.982	184.762
1979	JAN	11.1284	0.837547	3917.13	48.1868	114.307	180.328
	FEB	11.2648	0.712205	3909.53	47.7597	115.017	176.022
	MAR	11.4321	0.773029	3897.35	47.2825	113.965	169.778
	APR	10.7268	0.699091	3885.44	47.7799	113.32	165.83
	MAY	10.5863	0.811059	3901.78	47.4934	113.888	163.684
	JUNE	10.2895	0.726301	3917.97	47.2103	113.448	165.618
	JULY	10.0478	0.521392	3905.3	46.5882	112.141	177.176
	AUG	10.1856	0.529154	3882.95	46.9113	111.101	191.222
	SEPT	10.9889	0.648046	3881.66	46.5545	111.869	196.313
	OCT	11.4451	0.974539	3880.4	47.118	112.717	197.804
	NOV	10.9192	1.01784	3898.26	46.8928	112.679	199.454
	DEC	10.8872	1.01367	3915.97	47.5759	112.007	199.683
1980	JAN	10.9743	0.721851	3888.8	46.8123	109.897	196.211
	FEB	10.9056	0.839822	3853.57	46.9504	111.277	191.663
	MAR	11.3299	0.72461	3834.36	46.4007	110.755	187.468
	APR	10.6587	0.669811	3815.6	45.8637	111.487	184.484
	MAY	10.4983	0.761058	3845.08	46.5912	112.503	183.8
	JUNE	10.0182	0.615847	3874.41	47.3146	113.853	182.95
	JULY	9.40449	0.539938	3906.93	47.224	112.997	183.918
	AUG	9.81976	0.476941	3939.33	47.1337	116.645	182.76
	SEPT	11.1304	0.49308	3956.54	46.8651	116.065	178.636
	OCT	11.0623	0.626247	3973.57	47.4391	117.38	171.83
	NOV	10.8929	0.655589	3954.93	47.5796	117.336	163.633
	DEC	11.019	0.833996	3936.84	46.9005	117.21	157.504
1981	JAN	10.7084	0.72157	3939.07	47.2823	116.468	152.112
	FEB	11.097	0.71209	3941.28	47.6572	117.381	144.293
	MAR	11.4374	0.779597	3955.24	47.3726	117.357	141.322
	APR	10.8726	0.562211	3969.06	47.0914	116.106	139.493
	MAY	10.5047	0.790236	3979.59	46.7767	114.976	137.775
	JUNE	10.0215	0.749232	3990.	47.2472	114.487	136.08

1/ Sales figures pertain to the following Buffalo area counties: Allegany, Cattaraugus, Chautauqua, Erie, Niagara, Orleans, and Wyoming. They are adjusted for the calendar composition of the month i.e., the number of Mondays, Tuesdays, etc. (see Appendix Table 2, footnote 5). The Dairy Division of the New York Department of Agriculture and Markets provided the sales figures.

2/ Includes expenditures for television, radio, billboard, newspaper, and media. In general about 75 percent of the expenditures were for television, 19 percent for radio, with the remaining 6 percent going to billboards and newspapers. Expenditures are invoiced - not budgeted - amounts. Per capita amounts pertain to the Media Coverage Area (see Appendix 2, footnote 2) and are deflated by a national combined Media Cost Index (see Appendix Table 2, footnote 4). Source of the advertising data is Lyle Newcomb, Division of Dairy Industries, New York Dept. of Agr. and Markets.

3/ Annual total personal before tax personal income for the Buffalo SMSA counties for 1977-1979 were obtained from the NYS Bureau of Business publications Personal Income in Areas and Counties. 1980 and 1981 income figures were extrapolated from their past values. Seasonally adjusted total personal income figures for the State of New York (source: NYS Bureau of Business Researchers Quarterly Summary of Business Statistics, various issues 1978-1981) were used to distribute the annual Buffalo income figures throughout the year on a quarterly basis using the following formula: Buffalo income in year t quarter i = New York State income in quarter i x Buffalo income in year t / New York State income in year t. Monthly values are then obtained as linear interpolations of the quarterly figures.

4/ Prices pertain to whole milk in paper half-gallon containers sold by food stores in Buffalo. They are deflated by the Buffalo area Consumer Price Index (see Appendix Table 2, footnote 3). Source: NYS Dept. of Agr. and Markets. Survey of Prices Charged for Milk on Retail Routes, Food Stores and Dairy Stores 24 Upstate Markets. Monthly issues 1978-1981.

5/ Cola and coffee price indices are based on U.S. city average prices for their beverages.

6/ Prices of their beverages specific to the Buffalo area are unavailable from published sources for the time period in question. Indices are deflated by the Buffalo CPI for all items. Source: U.S. Dept. of Labor. The Consumer Price Index - U.S. City Average and Selected Areas and CPI Detailed Report.

Appendix Table 2. POPULATION, MEDIA COST INDEX, CONSUMER PRICE INDEX, AND CALENDAR COMPOSITION ADJUSTMENT FACTOR, Buffalo, New York, January 1978 - June 1981

		SMSA POPULATION[1/] (1000 PERSONS)	MEDIA COVERAGE AREA (MCA) POPULATION[2/] (1000 PERSONS)	CONSUMER PRICE INDEX-BUFFALO[3/] (1967=100)	MEDIA COST INDEX[4/] (1967=100)	CALENDAR COMPOSITION ADJUSTMENT FACTOR[5/]
1978	JAN	1627.28	1755.18	186.7	227.	0.9823
	FEB	1626.06	1753.78	187.5	226.	1.
	MAR	1624.85	1752.39	188.35	223.	1.0129
	APR	1623.64	1750.99	189.2	236.	0.9751
	MAY	1622.42	1749.59	191.05	237.	1.0099
	JUNE	1621.21	1748.2	192.9	243.	1.0147
	JULY	1620.	1746.8	193.8	242.	0.9832
	AUG	1619.13	1746.15	194.7	252.	1.0094
	SEPT	1618.27	1745.49	196.25	247.	1.0126
	OCT	1617.41	1744.84	197.8	250.	0.9823
	NOV	1616.54	1744.19	198.65	254.	1.0057
	DEC	1615.68	1743.53	199.5	256.	0.9833
1979	JAN	1614.81	1742.88	201.3	257.	1.0087
	FEB	1613.95	1742.23	203.1	263.	1.
	MAR	1613.09	1741.57	205.15	255.	1.0201
	APR	1612.22	1740.92	207.2	264.	0.9771
	MAY	1611.36	1740.27	208.45	266.	1.0098
	JUNE	1610.49	1739.62	209.7	271.	1.0128
	JULY	1609.64	1738.96	212.5	272.	0.9839
	AUG	1609.28	1738.31	215.3	288.	1.0122
	SEPT	1608.92	1737.66	216.95	282.	0.9743
	OCT	1608.56	1737.	218.6	278.	1.0087
	NOV	1608.2	1736.35	219.65	292.	1.0167
	DEC	1607.84	1735.7	220.7	287.	0.9817
1980	JAN	1607.48	1735.04	224.3	289.	1.0098
	FEB	1607.12	1734.39	227.9	300.	1.0451
	MAR	1606.76	1733.74	230.6	295.	0.9817
	APR	1606.4	1733.09	233.3	297.	1.0022
	MAY	1606.05	1732.44	233.95	302.	1.0201
	JUNE	1605.69	1731.79	234.6	311.	0.9771
	JULY	1605.33	1731.14	235.05	305.	1.0098
	AUG	1604.97	1730.49	235.5	326.	0.9836
	SEPT	1604.61	1729.84	236.85	314.	1.0131
	OCT	1604.25	1729.19	238.2	294.	1.0122
	NOV	1603.89	1728.54	241.7	296.661	0.9743
	DEC	1603.53	1727.89	245.2	299.346	1.0087
1981	JAN	1603.17	1727.24	247.45	302.055	1.0187
	FEB	1602.81	1726.59	249.7	304.789	1.
	MAR	1602.46	1725.94	251.2	307.548	0.9831
	APR	1602.1	1725.29	252.7	310.332	1.0025
	MAY	1601.74	1724.64	254.4	313.141	0.9861
	JUNE	1601.38	1723.99	256.1	315.975	1.0118

1/ The Standard Metropolitan Statistical Area is defined to include the counties listed in Appendix Table 1, footnote 1. The July figures for 1977 and 1978 are derived from county totals and were obtained from U.S. Dept. of Commerce, Bureau of Census, Federal - State Cooperative Program for Population Estimates, Series P-26 annual issues. The 1979 July figure was provided by NYS Dept. of Commerce. The 1980 March figure was obtained from the Bureau of Census publication 1980 Census of Population and Housing PHC 80-V-34 (March 1981). The 1981 June figure is based on an extrapolation of these past values. Monthly figures were then interpolated from the annual figures.

2/ The Media Coverage Area is the population viewing television stations of a given market. In Buffalo the MCA includes, in addition to the SMSA counties listed in Appendix Table 1, footnote 1, Genesee County in New York and the Pennsylvania counties of McKean and Potter. (Source: Broadcast Yearbook, Storer Broadcasting Co., Washington D.C.). The sources and procedures used to estimate the MCA population are identical to those described in Appendix Table 1, footnote 1.

3/ A CPI figure for the Buffalo metropolitan area is available only on a quarterly basis. Figures for the intervening months are interpolated values of these quarterly estimates. Source: New York Commerce Dept. Business Statistics New York State - Quarterly Summary. Various issues 1978-1981.

4/ McCann - Erickson combined media cost index. Source: U.S. Dept. of Commerce. Survey of Current Business. Various issues.

5/ Milk sales vary according to the day of the week e.g., milk sales are typically much larger on Saturday than on Sunday. The number of times a particular day occurs in any given month can vary from year-to-year. For example, in 1973 January had five Mondays but only four Mondays in 1974. If consumers buy more milk on Mondays than other days of the week then we would expect the January 1973 sales to be higher than the January 1974 sales, *ceteris paribus*. Dividing monthly in-area milk sales by the calendar composition adjustment factor removes the effect of monthly milk sales variation attributable to year-to-year differences in the monthly occurrence of Mondays, Tuesdays, Wednesdays, etc. The adjusted figure reflects what the sales in the month would have been if all days were average sales days. The basic source for these adjustment factors is: U.S.D.A., A.M.S. Federal Order Market Statistics (FMOS). Adjustment factors for specific years were taken from the following issues: 1978-FMOS #233, 1979-82-FMOS #243.

Appendix Table 3. ONTARIO TV "SPILL IN" TO BUFFALO IN '000 CANADIAN $

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1975													25.0
1976													47.5
1977													47.5
1978													50.0
1979	4.9	4.7	4.2	5.8	5.7	2.5	4.6	3.7	5.3	6.7	4.8	6.5	58.5
1980	3.4	3.4	8.5	6.8	6.8	4.3	3.6	4.3	5.7	7.5	9.4	5.5	69.4
1981	9.5	5.6	10.5	3.9	10.0	3.9	4.0	5.8	9.0	7.1	13.1	5.4	87.8
1982	5.2	4.4	4.4	9.0	9.2	6.8	5.9	7.1	4.7	11.1	10.8	6.3	84.5

SOURCE: Michael Pearce, Director, The Ontario Milk Marketing Board, Toronto, Ontario.

Appendix Table 4. REGRESSION ESTIMATES OF THE LOGARITHMIC MILK DEMAND EQUATION WITH ALTERNATIVE MILK PRICE AND ADVERTISING VARIABLES, Buffalo, New York, January 1978-June 1981 Data

	Functional Form							
Independent Variable	Regression No. 1		Regression No. 2		Regression No. 3		Regression No. 4[c/]	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Intercept	-2.844	-0.68	-3.645	-0.85	-1.236	-0.32	-1.159	-0.30
cos_1	0.048	6.47	0.048	6.44	0.048	6.32	0.048	6.03
$sine_2$	-0.036	-5.06	-0.036	-5.00	-0.036	-4.93	-0.036	-4.54
cos_2	-0.028	-4.62	-0.029	-4.66	-0.028	-4.40	-0.029	-4.68
cos_3	-0.016	-3.30	-0.017	-3.37	-0.015	-3.08	-0.015	-3.11
cos_4	0.014	3.00	0.014	3.03	0.014	2.98	0.014	3.00
Income	0.351	.67	0.472	0.87	0.199	0.39	0.241	0.48
Whole Milk Price	-0.730	-1.41	-1.199	-1.56	--	--	--	--
Lowfat Milk Price	--	--	0.428	0.83	--	--	--	--
Whole & Lowfat Milk Price[a/]	--	--	--	--	-0.465	-1.02	-0.433	-0.98
Cola Price	0.512	1.60	0.476	1.47	0.466	1.42	0.388	1.24
Trend	-0.0005	-1.30	-0.0008	-1.52	-0.0004	-1.06	-0.0005	-1.33
a_t	-0.0014	-0.05	-0.0040	-0.14	-0.0001	-0.00	0.0014	0.05
a_{t-1}	0.0291	1.18	0.0259	1.03	0.0264	1.05	0.0263	1.03
$\bar{a}$[b/]	0.0938	3.36	0.0995	3.44	0.0876	3.14	0.0944	3.13
Sum	0.1243	--	0.1214	--	0.1139	--	0.1221	--
R^2	0.914		0.917		0.911		0.913	
$\bar{R}^2$	0.870		0.868		0.865		0.868	
DW	1.90		1.89		1.89		1.95	
F	20.5		18.7		19.6		20.2	

a/ The whole and lowfat milk price variable is a weighted average of the whole milk price and the lowfat milk price. The weights are computed on the basis of the respective market shares for the two types of milk (see Appendix Table 5, footnote b).

b/ The $\bar{a}$ variable is a weighted average of past advertising expenditures beginning with a_{t-2} and extending through to a_{t-6}. The weights are 0.6615, 0.2239, 0.0758, 0.0257 and 0.0087 for the a_{t-2}, a_{t-3},....a_{t-6} variables, respectively.

c/ This regression is identical to regression no.3 except that the advertising variables are measured to include the Ontario TV "spill in" into the Buffalo market (see Appendix Tables 3 and 5).

Appendix Table 5. LOWFAT MILK PRICE, WHOLE MILK MARKET SHARE, AND NONBRAND ADVERTISING DATA, Buffalo, New York, January 1978 - June 1981

		RETAIL PRICE OF LOWFAT MILK (¢/½ gal. - 1967 dollars)1/	WHOLE MILK AS A PROPORTION OF TOTAL FLUID SALES2/	AMENDED MILK ADVERTISING EXPENDITURES3/ ($/person/mo. - 1967 dollars)
1978	JAN	0.439207	0.549	0.010116
----	FEB	0.437333	0.566	0.00943
----	MAR	0.445978	0.551	0.009869
----	APR	0.428119	0.55	0.007643
----	MAY	0.434441	0.55	0.010045
----	JUNE	0.430275	0.536	0.008032
----	JULY	0.428277	0.532	0.006097
----	AUG	0.426297	0.532	0.007193
----	SEPT	0.42293	0.529	0.007226
----	OCT	0.429727	0.522	0.012341
----	NOV	0.453058	0.517	0.011051
----	DEC	0.43609	0.518	0.011999
1979	JAN	0.442126	0.499	0.009305
----	FEB	0.438208	0.512	0.007994
----	MAR	0.433829	0.483	0.008534
----	APR	0.439189	0.5	0.008064
----	MAY	0.436556	0.498	0.009157
----	JUNE	0.433953	0.499	0.007714
----	JULY	0.428235	0.494	0.006041
----	AUG	0.431955	0.498	0.00592
----	SEPT	0.42867	0.493	0.0074
----	OCT	0.434584	0.469	0.010925
----	NOV	0.432506	0.483	0.010983
----	DEC	0.439511	0.493	0.011246
1980	JAN	0.432457	0.46	0.007795
----	FEB	0.434401	0.462	0.008954
----	MAR	0.429315	0.44	0.008659
----	APR	0.424346	0.448	0.007821
----	MAY	0.440265	0.445	0.008715
----	JUNE	0.439045	0.438	0.006837
----	JULY	0.438205	0.454	0.005979
----	AUG	0.437367	0.465	0.005417
----	SEPT	0.434874	0.428	0.005823
----	OCT	0.440806	0.434	0.007516
----	NOV	0.442697	0.44	0.008114
----	DEC	0.444535	0.427	0.009244
1981	JAN	0.440493	0.423	0.008763
----	FEB	0.444533	0.414	0.008025
----	MAR	0.441879	0.396	0.009477
----	APR	0.439256	0.393	0.006241
----	MAY	0.436321	0.395	0.009476
----	JUNE	0.441234	0.391	0.008101

1/ Prices pertain to 1% and 2% milk sold by foodstores in Buffalo. They are deflated by the Buffalo area CPI (see Appendix Table 2, footnote 3.). Source: N.Y.S. Dept. of Agr. and Markets, Survey of Prices Charged for Milk on Retail Routes, Food Stores and Dairy Stores 24 Upstate Markets. Monthly issues 1978-1981.

2/ Source: N.Y.S. Dept. of Agr. and Markets. Niagara Frontier Milk Marketing Area Annual Statistical Report, 1979 and 1981 issues.

3/ This series is constructed by adding the Canadian milk advertising dollars (Appendix Table 1, column 3) using the following procedure: First, the 1978 Canadian expenditure was placed on a monthly basis by evenly distributing the $50,000 (Canadian $) over the year, i.e., $4,166 was allocated to each month. Second, because Canadian dollars were worth roughly 85% of U.S. dollars, the Canadian series was multiplied by .85 to obtain a U.S. dollar equivalent expenditure. Third, Canadian series was then placed on a per capita basis expressed in terms of 1967 dollars by deflating it by the Media Coverage Area population and the Media Cost Index (see Appendix Table 2, columns 2 and 4). Fourth, the per capita Canadian expenditures were then added to the per capita U.S. expenditures to obtain the amended advertising series.