AN ECONOMETRIC ANALYSIS OF THE RESPONSE OF MILK SALES TO ADVERTISING IN SELECTED NEW YORK STATE MARKETS

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For many years large expenditures have been made by New York State dairy producers to advertise and promote the generic product milk. 1/ In May, 1972 an expanded New York State Dairy Promotion Order 2/ became effective with a mandatory assessment rate of five cents per hundredweight levied on milk produced in the state. 3/ Accordingly, the expanded dairy promotion program has generated substantially larger collections than the earlier "voluntary" programs.

With the advent of the Dairy Promotion Order various types of milk promotion activities were initiated or expanded. This paper specifically focuses on the program area which has experienced the greatest funding increase--media advertising. The purpose of this document is to provide relevant information to be considered in evaluating the media advertising segment of the expanded New York State Dairy Promotion Order. In this quest, first, a description of the analytical model data and definition of variables is provided; next an analysis and interpretation of the empirical findings is presented; and, finally, conclusions are stated with respect to the findings.

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1/ For a brief history of dairy promotion in New York State see (Aronson et al. pp. 1-3).

2/ The enabling legislation for the expanded program was provided by (3).

3/ Approximately 50% of the total assessment under the Dairy Promotion Program is spent on direct media advertising.

METHODOLOGY

Distributed Lag Specifications

Distributed lag models are generally applicable when there is a delayed response in a specified dependent variable due to changes in the values of one or more explanatory variables. The response of milk sales is characterized by a delayed response to the level of advertising expenditures.

The general distributed lag model can be written in a linear regression framework as:

$$S_t = \alpha + \sum_{i=o}^{\infty} \beta_i A_{t-i} + e_t \; ; \; t = 1,2,\ldots T \qquad (1)$$

where: t = time period

S = dependent variable

A = exogenous variable

e = stochastic residual (assumed homoscedastic)

α = unknown intercept parameter

β_o, β_1, β_2... are unknown parameters

In practice the inclusion of lagged variables in the model specification poses problems to the researcher [2, p. 293]. A major problem is the determination of the length of the lag structure. In the absence of an a priori theoretical structural relationship, an indication of the length of the lag can be obtained from the data by consecutively fitting longer lags and examining the significance of the coefficients at each step. Such a procedure however, can lead to either a degrees of freedom problem and/or a multicollinearity problem among the various lagged explanatory variables. In view of these difficulties, a priori restrictions regarding the form of the β's are often imposed. The choice of the restriction should provide a close approximation to reality.

Perhaps the most convenient, and as a consequence most popular, restriction is the incorporation of a geometric constraint on the parameters. The advantages and disadvantages of the geometric restriction have been empirically explored (see, Thompson).

The polynomial lag structure is an alternative to the geometric model that can be estimated without many of the shortcomings inherent in the geometric model. [4] As a consequence, the polynomial lag model is used to examine the effect of advertising on milk sales.

[4] While the polynomial model has many advantages over the geometric model, it also has its own estimation problems. However, the polynomial model has been shown to be a superior estimating technique. (Thompson)

Empirical Model and Description of the Variables

Separate polynomial lag models were estimated using monthly sales and advertising data from the New York City, Albany-Schenectady-Troy and Syracuse SMSA's. 5/ Monthly observations were available from January 1971 to March 1974; this time series includes 16 months of data prior to the expanded promotion effort.

The following polynomial lag model was estimated:

$$S_t = \alpha + \sum_{j=1}^{11} \beta_j Z_{tj} + \delta I_t + \lambda P_t + \sum_{m=0}^{M} \theta_m \{ \sum_{i=0}^{N} [i^m A_{t-i}]\} + e_t$$

where: $t = 1,2,\ldots 39$ (January 1971 to March 1974)

$i = 1,2,\ldots N$; $j = 1,2,\ldots 11$

N = specified finite lag length

M = degree of polynomial

S = per capita SMSA daily milk sales in ounces adjusted for the type of days in the month (i.e. number of Sundays, Mondays, etc.) 6/

A = Deflated actual per capita monthly advertising expenditures in dollars 7/

Z = a matrix of eleven zero-one dummy seasonality variables

Z_1 = 1 if January; 0 otherwise

Z_2 = 1 if February; 0 otherwise

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Z_{11} = 1 if November; 0 otherwise

I = Deflated (by CPI, 1967=100) per capita annual total personal income in dollars (New York State Department of Commerce and New York State Department of Health)

P = Deflated (by CPI) retail price in dollars of whole fluid milk in paper half gallons (New York State Department of Agriculture and Markets).

5/ SMSA - Standard Metropolitan Statistical Area

6/ Milk sales data within each SMSA were obtained from the New York State Department of Agriculture and Markets. Sales data adjustments were made according to procedures specified in (Schenkler, pp. 28-30).

7/ Per capita advertising figures were obtained by dividing actual advertising expenditures in a market by the estimated population of that market's media coverage area. These were then deflated by an index of the cost of prime time spot television (UDIA).

Selection of Lag Structure

Two problems inherent in estimating a polynomial lag model are the selection of the length of the lag and the degree of polynomial. Model specification was the same for each market with the exception of the length of the advertising lag. The delayed effects of advertising were empirically explored in each market, using an unconstrained model to obtain an indication of the true lag length. 8/ Accordingly, subsequent constraints on the lag structure were imposed. 9/ Also a quadratic specification (2nd degree polynomial) was found to be superior to other degree specifications.

EMPIRICAL RESULTS

Explanatory Power of the Model

The relative importance of the various model components in their ability to explain the variation in adjusted per capita daily sales (as indicated by R^2) is shown in Figure 1. 10/ Accordingly, in New York City the eleven seasonality variables explained 80 percent of the variability in per capita daily sales. The addition of both per capita income and the consumer price of milk boosted their collective explanatory power to 94.2 percent. With the further addition of the lagged advertising expenditure variables the R^2 increased to 97.2 percent. The inclusion of all the above variables in the model leaves 2.8 percent of the variation in the dependent variable unexplained.

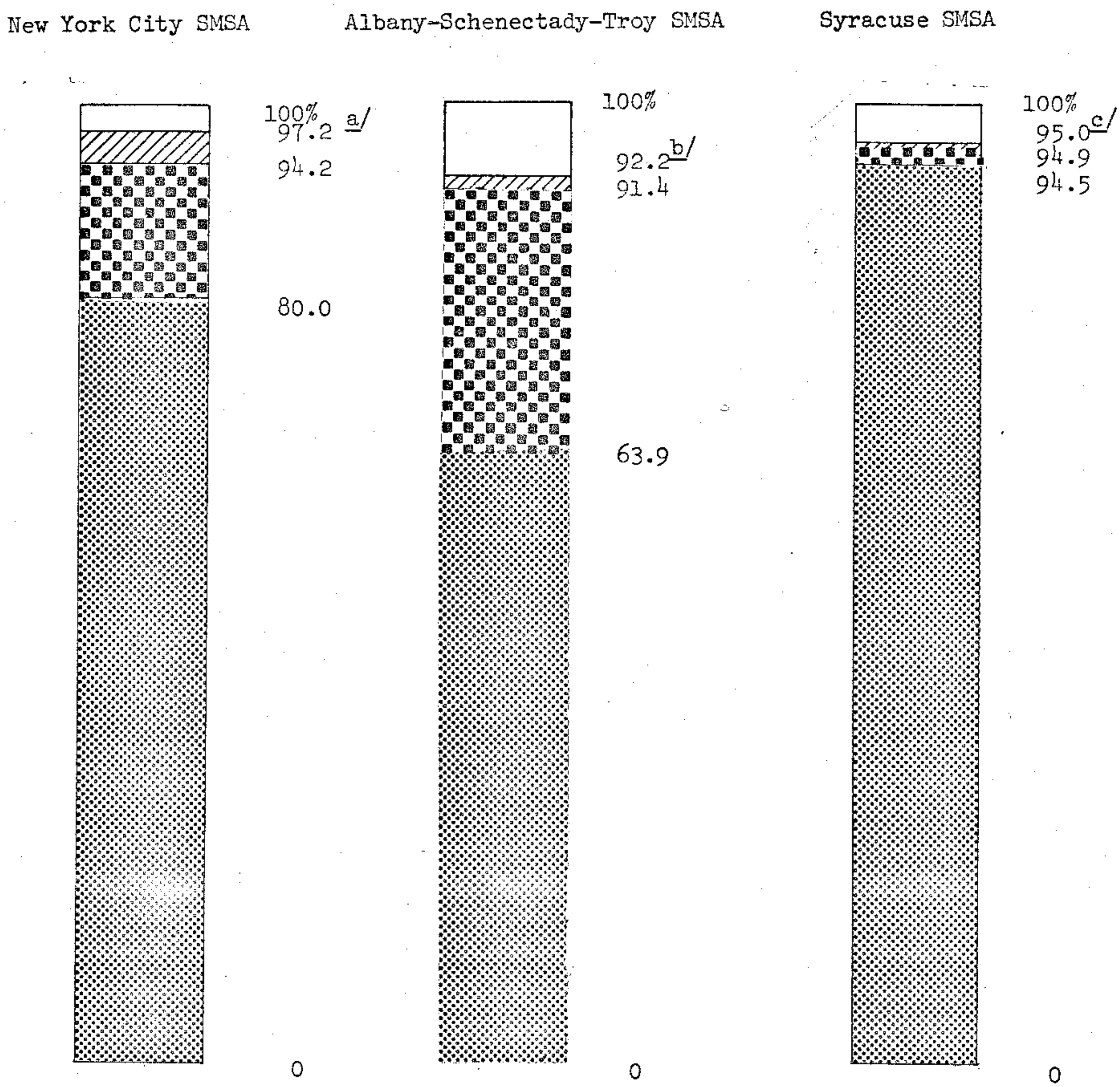
In the Albany and Syracuse markets the total explanatory power of their respective models was less than the New York City model. Also, as indicated by changes in adjusted R^2 and the t ratios of the advertising coefficients, the increase in the explanatory power due to the addition of advertising was not statistically significant.

8/ Unconstrained as to the length of the lag structure.

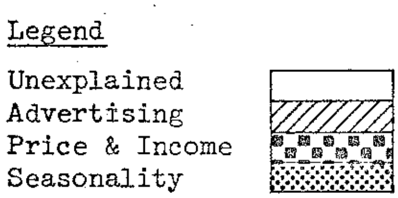
9/ The effect of advertising was constrained to be zero at 6 months in New York City, 5 months in Albany and 4 months in Syracuse.

10/ R^2 is a statistical measure of the proportion of variation in the dependent variable (per capita daily sales) associated with variation in the independent variables. $0 \leq R^2 \leq 1$.

Figure 1 Proportion of Sales Variation Explained by Model Components



a/ R^2 adjusted for number of variables in the New York City model is 94.6
b/ R^2 adjusted for number of variables in Albany model is 85.9
c/ R^2 adjusted for number of variables in Syracuse model is 91.1



Discussion of Model Variable Coefficients

Seasonality:

In examining the estimated coefficients of the polynomial model in Table 1, the eleven monthly zero-one dummy variables index the seasonality of milk sales relative to sales in December--the arbitrarily selected base month. For example, the negative coefficients for the summer months indicate that milk sales during this period are less than sales in December. Specifically, the July per capita milk sales in New York City is .88 ounces per day less than it would be in December *ceteris paribus*. The other monthly coefficients can be similarly interpreted.

Price and Income:

Price and income, as measured in dollars, were deflated by CPI in order to remove inflationary changes in prices and incomes that do not reflect "real" costs or purchasing power.

Interpreting the price and income coefficients from the New York City model (Table 1), reveals that a one dollar increase in real annual per capita income would effectively increase per capita fluid milk sales in New York City by .0006 ounce per day *ceteris paribus*. Similarly, a one cent per half gallon increase in the real price of milk would be expected to decrease per capita milk sales in New York City by .03 ounce per day. Analogous interpretation of the price and income coefficients in Table 1 can be obtained for Albany and Syracuse.

Table 1 Estimated Coefficient for Constrained Second Degree Polynomial Lag Model by SMSA

	SMSA					
	New York City		Albany		Syracuse	
Dependent Variable	Mean Value 8.69		12.01		13.75	
Independent Variable	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio
Jan	.07818	.96	.0792	-.28	.2103	1.04
Feb	.2964	3.85	.2913	1.02	.4390	2.20
Mar	.2524	3.24	.4497	1.60	.3478	1.76
Apr	.1052	1.21	.3440	1.09	-.1334	-.60
May	-.0322	-.38	.0377	.12	-.2939	-1.42
Jun	-.1753	-2.08	-.7695	-2.66	-1.0356	-5.01
Jul	-.8813	-11.67	-1.6855	-5.91	-1.8136	-8.96
Aug	-.7682	-10.08	-1.1955	-4.17	-1.5596	-7.76
Sep	-.1822	-2.42	.0207	.07	.0249	.12
Oct	.0079	.10	.4001	1.41	.4840	2.43
Nov	-.1003	-1.34	.3468	1.24	.2292	1.16
A_t	13.7712	1.80	14.8251	.79	5.7308	.45
A_{t-1}	16.9146	3.52	12.1342	1.40	3.5886	.67
A_{t-2}	17.8825	4.16	9.3062	1.07	1.9195	.27
A_{t-3}	16.6751	3.66	6.3412	.63	.7232	.12
A_{t-4}	13.2921	3.17	3.2391	.44	0.0	0.0
A_{t-5}	7.7338	2.85	0.0	0.0	0.0	0.0
A_{t-6}	0.0	0.0	0.0	0.0	0.0	0.0
Sum Coeff	86.2693	4.16	45.8459	1.44	11.9622	.67
Income	.000575	.79	.0060	7.14	.000699	1.04
Price	-2.9645	-5.66	-.7737	-.24	-1.9136	-1.16
Const	7.50	2.41	-26.89	-4.55	12.45	5.84
R^2	.97		.92		.95	
$\bar{R}^2$	.95		.86		.91	
DW	1.33		1.32		1.92	

Advertising:

In Table 1 the estimated coefficients of the advertising lag structure (i.e. A_{t-i}) portray the impact of milk advertising on sales over time. In New York City, the effect of advertising occurs not only during the month that the expenditure is made but its impact continues. In fact, the greatest impact of advertising on sales does not occur until two months after the initial expenditure. The sum of the monthly advertising coefficients shows the total response or long-run effect of the advertising expenditure.

The advertising data used in the estimation procedure were measured in terms of monthly per capita dollar expenditures. Similar to the price and income variables the advertising figures were deflated to reflect "real" media purchasing power. However, in this case a different deflation index was used to remove the effect of increasing media costs over time. 11/

Interpretation of the long-run effect of advertising in the New York City model reveals that a 1/10 cent increase in current per capita monthly advertising yields a total increase in milk sales of 1.93 ounces per capita *ceteris paribus*. 12/ Similar interpretations can be obtained from an examination of the coefficients for the Albany and Syracuse models in Table 1.

11/ For example, prime time spot television in January 1974 cost approximately 1.3 times more than in January 1971.

12/ Under the assumptions of: a) a one month increase in advertising of \$.001, b) 1.34 is the approximate 1974 cost of media deflator, c) 86.2693 is the long-run advertising coefficient, d) 30 days per month.
Then: \$.001/1.34 = .000746 real increase in advertising expenditure
(.000746) X (86.2693) = .0644 real long-run per capita daily sales increase
(.0644) X (30) = 1.93 oz. total long-run per capita sales increase

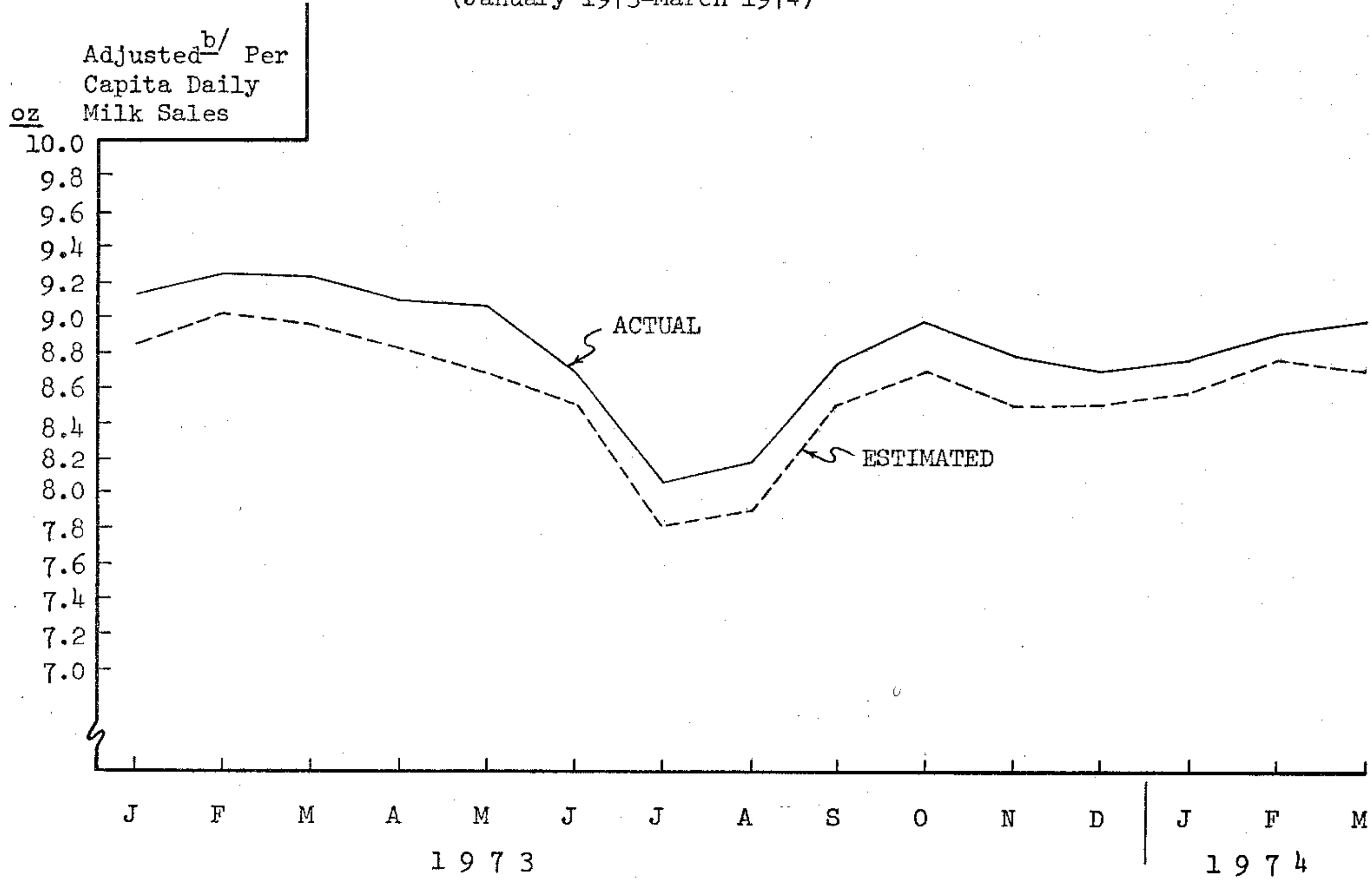
Effect on Sales of the Expanded Advertising and Promotion Program

As a result of the implementation of the Dairy Promotion Order substantial increases in the advertising expenditures were made. What is desired is an objective measure of the effect of these increased expenditures on the sales of fluid milk.

Through the application of the estimated econometric models presented in Table 1 it is possible to compare the actual sales during the period of the expanded promotion to those that would have been expected to occur had advertising expenditures remained at the pre-Order level.

Figures 2, 3 and 4 graphically depict the effect of the expanded advertising program on sales in New York City, Albany and Syracuse respectively. The solid line represents the actual per capita daily sales of fluid milk in each SMSA. The broken line provides an estimate of what sales would have been during 1973-74 had advertising expenditures remained at the 1971 (pre-Promotion Order) level. Actual prices and incomes in 1973-74 were used in estimating the broken lines in Figures 2, 3 and 4. Hence, the difference between the actual and estimated sales can be attributed to the effects of advertising and a random error component.

Figure 2 New York City: A Comparison of Actual Sales at the Actual Levels of Advertising to the Sales Estimates if Advertising had Continued at the 1971 Level[a/]
(January 1973-March 1974)

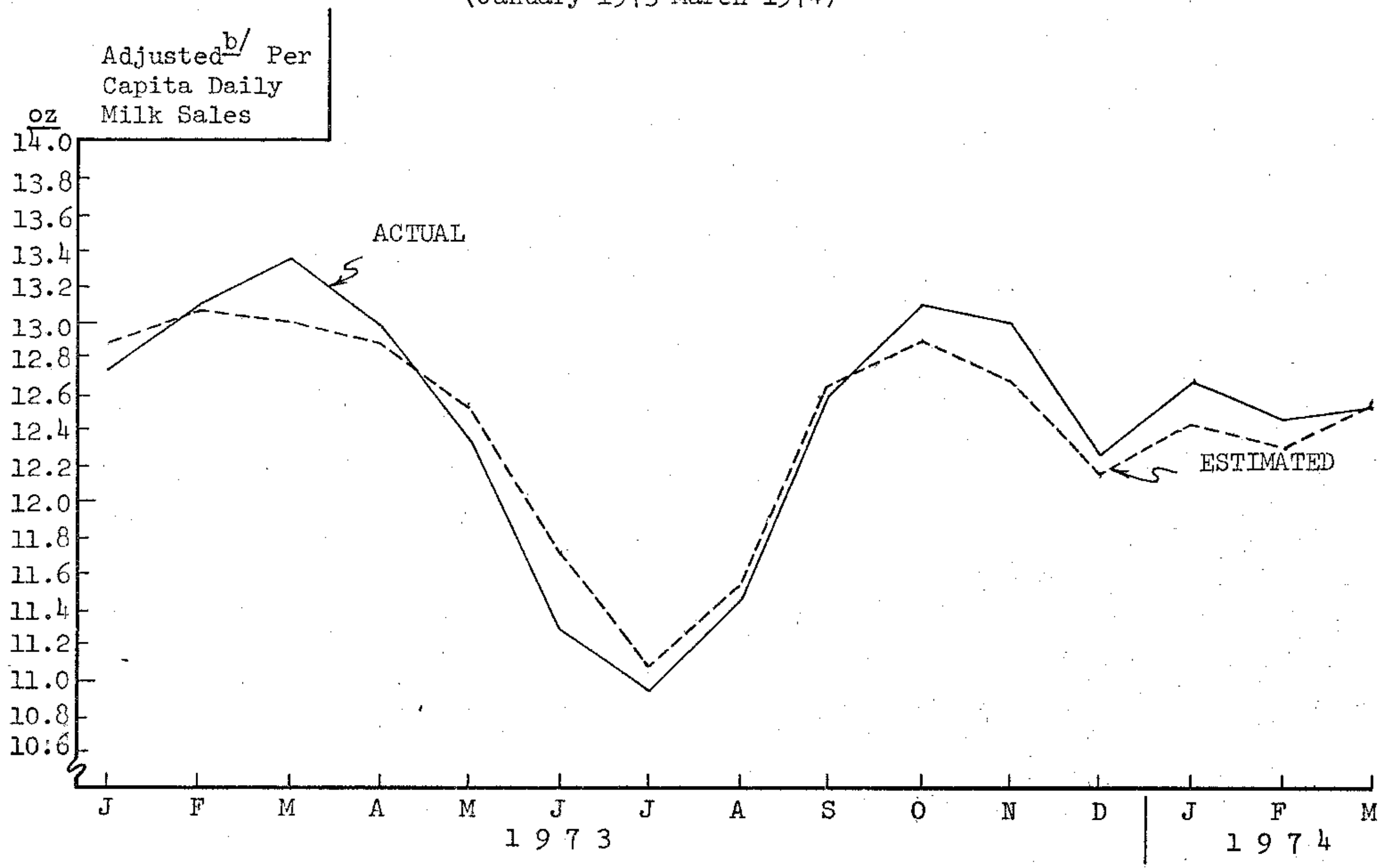


a/ The actual level of advertising during 1973 was at the annual rate of 6.93¢/person. During 1971 advertising was at the annual rate of 2.39¢/person.

b/ source: Anna Schlenker & Paul Christ, "Adjusting In-Area Fluid Milk Sales Data for Calendar Composition," in USDA Federal Milk Order Market Statistics, April 1973, pp. 28-30.

c/ Prepared by Stanley R. Thompson & Doyle A. Eiler, Department of Agricultural Economics, Cornell University

Figure 3 Albany-Schenectady-Troy: A Comparison of Actual Sales at the Actual Levels of Advertising to the Sales Estimates if Advertising had Continued at the 1971 Level[a/] (January 1973-March 1974)

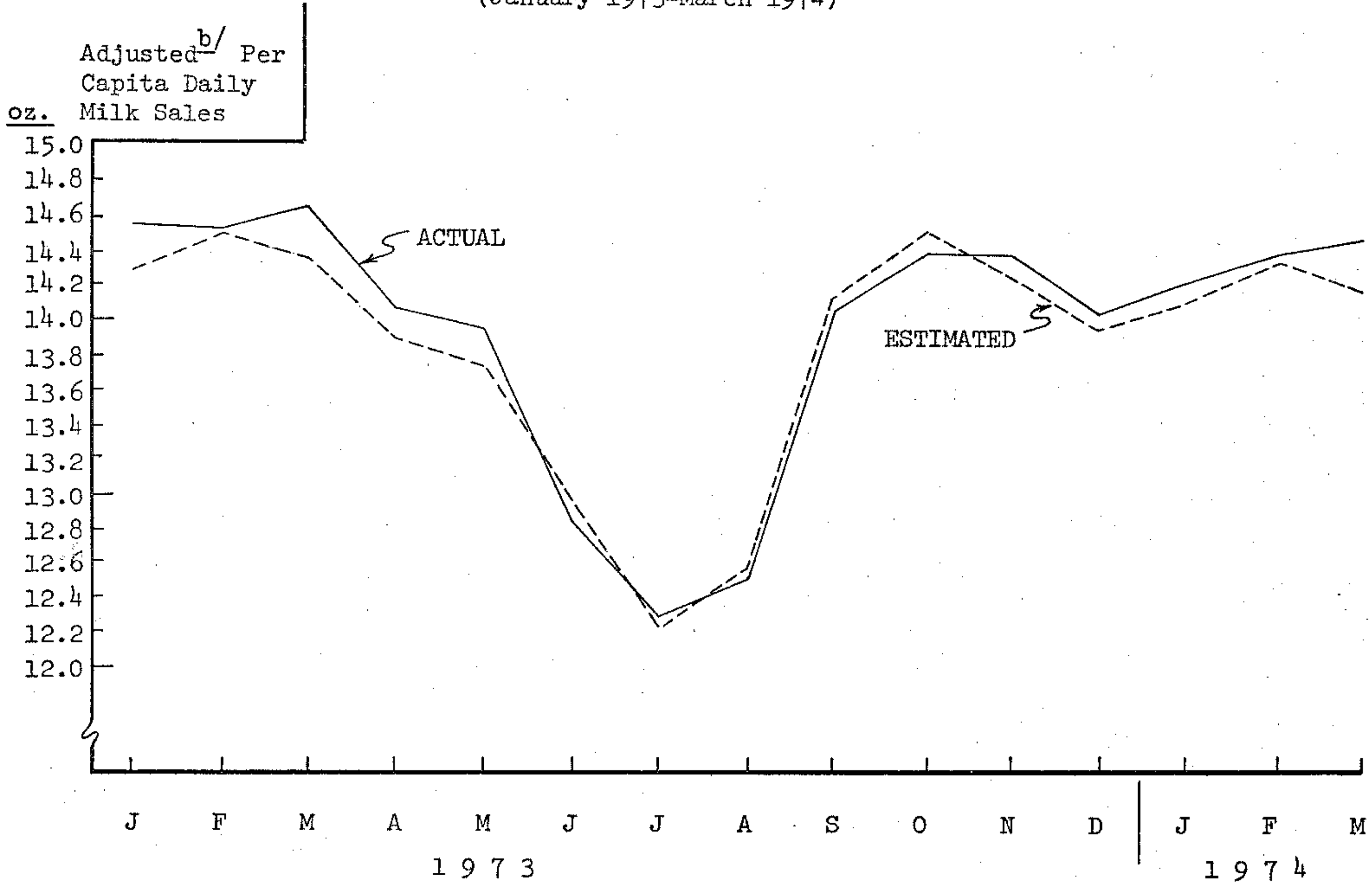


[a/] The actual level of advertising during 1973 was at the annual rate of 6.80¢/person. During 1971 advertising was at the annual rate of 2.16¢/person.

[b/] source: Anna Schlenker & Paul Christ, "Adjusting In-Area Fluid Milk Sales Data for Calendar Composition," in USDA Federal Milk Order Market Statistics, April 1973, pp. 28-30.

[c/] Prepared by Stanley R. Thompson & Doyle A. Eiler, Department of Agricultural Economics, Cornell University

Figure 4 Syracuse: A Comparison of Actual Sales at the Actual Levels of Advertising to the Sales Estimates if Advertising had Continued at the 1971 Level[a/]
(January 1973-March 1974)



a/ The actual level of advertising during 1973 was at the annual rate of 7.74¢/person. During 1971 advertising was at the annual rate of 2.47¢/person.

b/ source: Anna Schlenker & Paul Christ, "Adjusting In-Area Fluid Milk Sales Data for Calendar Composition," in USDA Federal Milk Order Market Statistics, April 1973, pp. 28-30.

c/ Prepared by Stanley R. Thompson & Doyle A. Eiler, Department of Agricultural Economics, Cornell University

Table 2 Estimated Returns from Additional Advertising by SMSA[a]

	NYC-SMSA	Albany-SMSA	Syracuse-SMSA
Sales Gain	1/73-12/73	4/73-3/74	4/73-3/74
Actual Per Capita Sales of Fluid Milk in 1973	3212 oz.	4509 oz.	5024 oz.
Estimated Per Capita Sales of Fluid Milk if Advertising had been at the 1971 Level	3117	4481	5000
Per Capita Sales Gain Attributable to Increased Advertising	95 oz.	28 oz.	24 oz.
Farm Value of Sales Gain			
Assuming no supply response and a Class I, Class II price differential of $2.40/cwt. Each additional oz. of fluid milk sales has a farm value of $.0016.			
Per Capita Farm Value of Sales Increase	15.2¢	4.5¢	3.8¢ [a]
Cost of Increased Advertising			
Per Capita Advertising Expenditure 1973	6.9¢	9.0¢	10.2
Per Capita Advertising Expenditure 1971	2.4	2.2	2.5
Increase in Advertising	4.5¢	6.8	7.7¢
Net Returns from Increased Advertising			
Farmer's Net Return Per Capita from Increased Advertising	10.7¢	-2.3¢	-3.9¢

[a] The advertising coefficients used for these estimates had a t ratio of 4.16 in NYC, 1.44 in Albany, and .67 in Syracuse

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Did the Expanded Advertising Program Pay?

In evaluating the costs and returns of the program, the value of the increased milk sales is compared to the increased cost of the expanded advertising program. The cost-return calculations for each SMSA are presented in Table 2.

With respect to program costs, it should be noted that when the Promotion Order was effectuated many different types of promotion vehicles were expanded; however, the increase in advertising reported in Table 2 includes only the Order funding increase directly channeled into media advertising. With respect to value, the farm value of the increased fluid milk sales is the difference between class I and class II milk prices. A class price differential of $2.40/cwt was assumed.[13/] The annual increases in per capita milk sales were calculated from the econometric models in Table i and are shown in Figures 2, 3, and 4.

As shown in Table 2, the increase in the farm value of milk sold in the New York City market exceeded the increased cost of the advertising program by 10.7¢ per capita. Returns for Albany and Syracuse were calculated to be -2.3¢ and -3.9¢ respectively. While the advertising expenditure pattern in these two markets may understate the returns to advertising, the negative returns for Albany and Syracuse might well have been anticipated from observing the low t ratios on their advertising coefficients in Table 1. On the other hand, the t ratios of the advertising coefficients in the New York City market were found to be substantially larger than those in either Albany or Syracuse.

CONCLUSION

With the implementation in 1972 of the New York State Dairy Promotion Order there was a dramatic increase in milk advertising. To analyze the sales impact of the increased advertising expenditure, time series data from three New York markets (New York City, Albany and Syracuse) were used to estimate separate polynomial distributed lag response models. Marked inter market differences were observed in the economic returns from the increased advertising.

13/ Potential production response impacts of a successful promotion program were not considered in this paper.

REFERENCES

(1) Aronson, Judith E., Doyle A. Eiler, Olan D. Forker, "Attitudes Toward and Consumption of Milk and Other Beverages in Selected New York State Markets, Fall 1972: Base-Line Data for Evaluating Milk Promotion," Department of Agricultural Economics, A. E. Research 73-21, Cornell University, November 1973.

(2) Johnston, J., Econometric Methods, second ed., McGraw-Hill, 1972.

(3) New York Agricultural and Markets Law, Article 21A, 258-aa(a), (McKinney Supp. 1973) [Selection, formerly 258t, was renumbered 258-aa by L. 1973, C. 831 1 effective October 1, 1973].

(4) New York State Department of Agriculture and Markets, Survey of Prices Charged for Milk on Retail Routes, Food Stores and Dairy Stores 25 Upstate Markets, Division of Milk Control, Albany, New York (various issues).

(5) New York State Department of Commerce, Personal Income in Areas and Counties of New York State (various issues and estimates).

(6) New York State Department of Health, Population of New York by Counties and Places Over 10,000 (various issues and estimates).

(7) Schenkler, Anna and Paul Christ, "Adjusting In-Area Fluid Milk Sales Data for Calendar Composition," Federal Milk Order Market Statistics, U.S.D.A.

(8) Thompson, Stanley R., "Sales Response to Generic Promotion Efforts: A Case of Fluid Milk Advertising," unpublished manuscript, Department of Agricultural Economics, Cornell University, 1974.

(9) U.D.I.A. Correspondence with Cornell University, August 20, 1974.