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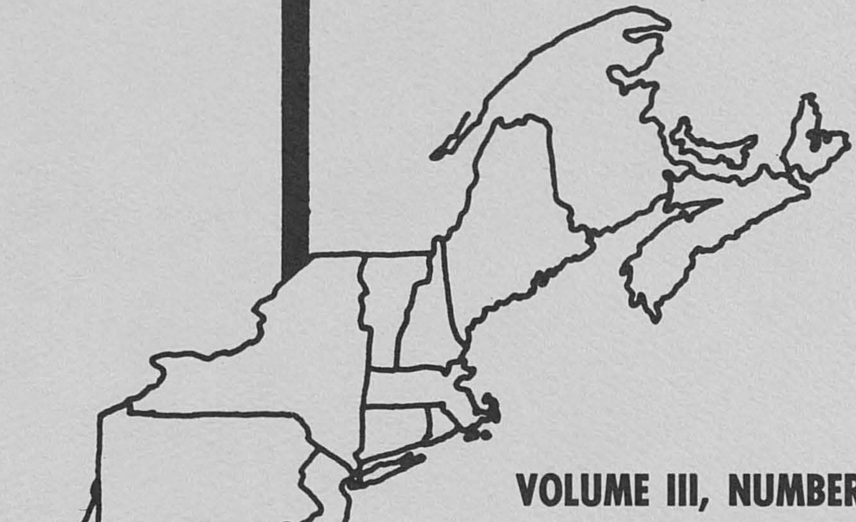

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SALES RESPONSE TO GENERIC PROMOTION EFFORTS AND SOME IMPLICATIONS OF MILK ADVERTISING ON ECONOMIC SURPLUS

by

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Each year various agricultural commodity groups spend millions of dollars advertising and promoting their respective products [7]. Typically such "demand creating" attempts have been purported as a panacea for low producer returns despite their unevaluated performance records [8, 10]. Notwithstanding the magnitude of these promotional expenditures, the literature is scarce regarding the effect of advertising on commodity sales. Such knowledge would provide an invaluable input for promotion expenditure decisions and a means to evaluate the effects of advertising and promotion on economic surplus.

A common objective of generic promotion ventures is to increase the net revenues to the producers of the promoted commodity. This objective can be achieved if the consumption patterns of the target population are sufficiently altered such that the revenue from increased sales exceeds the cost of the promotion activity. In other words, the demand curve for the commodity must be changed either by raising the existing demand function and/or changing its elasticity [25]. In a partial equilibrium analysis such demand schedule changes not only affect producer earnings but also provide important implications for consumer welfare.

The distributed lag model provides a convenient means of estimating both the short run and long run effects of advertising on sales. The usual means of obtaining these estimates has been to specify a geometrically declining model [1, 19, 24]. However, in this paper a more flexible polynomial lag formulation is specified and comparisons of its findings are made to the classical geometric model. Secondly, the results of the polynomial lag model are used to provide a means of evaluating economic surplus accruing to advertising policy.

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 and promotion expenditures. In particular, sales response to advertising is hypothesized to increase first through time and then decline. In testing this hypothesis a geometrically declining model is also estimated from the same data for comparison purposes.

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 = exogeneous variable
e = stochastic residual (assumed homoscedastic)
α = unknown intercept parameter
$\beta_o, \beta_1, \beta_2 \ldots$ are unknown parameters

In practice the inclusion of lagged variables in the model specification poses problems to the researcher [15 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 βs are often imposed. The choice of the restriction should provide a close approximation to reality1/.

Geometric Model:

In the geometric lag the corresponding restriction on the s in (1) is:

$$\beta_i = \beta \lambda^i \text{ where: } 0 < \lambda < 1 \qquad (2)$$

Incorporating this restriction into (1) and performing the appropriate transformation yields:

$$S_t = \beta_o + \beta_1 A_t + \beta_2 S_{t-1} \qquad (3)$$

Nerlove's partial adjustment model [17, 18] incorporates this geometric constraint. One shortcoming of the geoetric lag model is that it uses lagged dependent variables as regressors. Hence, the OLS estimator

1/ In this paper the procedure used to select the length-and form of the lag structure is provided in [13].

of the regression parameters are inconsistent whenever the residuals in the final autoregressive form are autocorrelated. Nonlinear estimation procedures are generally required to ensure consistency.

The polynomial lag structure is an alternative to the geometric model which can be estimated without the use of lagged dependent variables. The polynomial is considered to provide a more flexible lag shape and depends on the specific degree of the polynomial. The geometric lag is not a special case of the polynomial lag but it can be approximated quite accurately by a higher order polynomial. In contrast to the geometric lag the parameter estimates of the polynomial lag are consistent and do not require nonlinear estimation.2/

Polynomial Model

In the polynomial model the restriction placed on the lag parameters in (1) are:

$$\beta_i = \theta_o + i\theta_1 + i^2\theta_2 + \ldots i^M\theta_M \qquad (4)$$

$i = 0,1,2 \ldots N;\ M < N$

N = specified finite lag length; M = degree of polynomial

Substituting these restrictions into (1) gives:

$$S_t = a + \sum_{m=o}^{M} \theta_m \left\{ \sum_{i=o}^{N} \left[i^m A_{t-i} \right] \right\} + e \qquad (5)$$

OLS estimates of the (M + 1) unknown parameter may be computed by regression the (M + 1) weighted sums of A_{t-i} in (5) against S_t. These estimates can then be substituted into (4) to estimate the actual lag structure.

Empirical Results

Both the geometric and polynomial lag models were fit to California

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2/ Two methods of generating a polynomial lag structure are the "Simple" Polynomial and the Lagrangian Polynomial [15, pp. 293-8]. Each method involves the use of a different weighting system for the exogenous variable. Yon and Mount [27] have shown that for high degree polynomials, the multicollinearity between the weighted sums is a serious problem irrespective of the weighting system used. However, in using simulated data with varying degrees of trend Yon and Mount have found that the intercorrelation problem is generally lower using the Lagrangian interpolation polynomial.

monthly milk sales[3/] and advertising[4/] data. Monthly observations were available from March 1970 when the current promotion program was conceived until September 1973. Preliminary results showed that some of the variables not included in the final model (i.e. price, income, etc.) were statistically insignificant or not available and, hence, were excluded.

The following geometric and polynomial lag models were estimated:

$$S_t = \beta_o + \beta_1 Z + \beta_2 A_t + \beta_3 S_{t-1} \qquad (6)$$

and;

$$S_t = \alpha + \beta Z + \sum_{m=o}^{2} \theta_m \left\{ \sum_{i=o}^{5} \left[i^m \quad A_{t-1} \right] \right\} + e \qquad (7)$$

where: t = 1,2 ... 43
i = 0,1,2,3,4,5,
S = per capita daily milk sales (gallons) adjusted for the type of days in the month (i.e. number of Sundays, Mondays, etc.). March 1970 to September 1973.
A = actual per capita monthly advertising expenditures ($/cap.). March 1970 to September 1973.
Z = a matrix of eleven zero-one dummy seasonality variables.
= 1 if January; 0 otherwise
= i if February; 0 othersie
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.
.
= 0 if December

The estimated coefficients of the final polynomial lag formulation[5/] are presented in Table 1 and graphed in Figure 1.[6/] First the coefficients for the "unconstrained" lag structure were computed.[7/] The quadratic

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3/ Sales data were obtained from the California Crop and Livestock Reporting Service, Manufactured Dairy Products, Milk Production, Utilization and Prices (Sacramento), various issues.

4/ Advertising data represent actual vis a'vis budgeted monthly advertising California Milk Advisory Board.

5/ A third degree polynomial lag model was found to be unsatisfactory in preliminary analysis.

6/ In testing the complete model against a hypothesized model without advertising, the F test statistic indicated that the addition of advertising to the sales response function was highly significant.

7/ The model was unconstrained as to the length of the lag.

"unconstrained" model provides a lag structure with a "humped" shape that appears to end between 4 and 5 months after the initial advertising expenditure. Subsequent to the initial advertising expenditure the effect of advertising on milk sales increased for the first two months after the initial period and then diminished to zero between four and five months.

Table 1
Estimated Lag Structure for Milk Advertising
Using Constrained and Unconstrained
Second Degree Polynomial Models

Independent Variable	Unconstrained		Constrained[a/]	
	Coefficient	t - ratio	Coefficient	t - ratio
JAN	0.0008	1.12	0.0008	1.13
FEB	0.0014	1.83	0.0012	1.65
MAR	0.0014	1.68	1.0011	1.45
APR	0.0016	2.07	0.0014	1.92
MAY	-0.0001	-0.03	-0.0004	-0.57
JUN	-0.0022	-2.73	-0.0025	-3.59
JUL	-0.0033	-4.22	-0.0035	-5.08
AUG	-0.0023	-3.34	-0.0024	-3.55
SEP	0.0023	3.26	0.0021	3.16
OCT	0.0044	5.45	0.0041	5.53
NOV	0.0027	3.92	0.0027	3.92
At	0.0321	0.66	0.0488	1.11
At-1	0.0871	4.85	0.0745	6.63
At-2	0.0169	3.41	0.0825	5.22
At-3	0.0916	2.91	0.0727	3.10
At-4	0.0410	2.15	0.0452	2.46
At-5	-0.0449	-0.90	0.0000	0.00
CONST	.0744		.0745	
R^2	.91		.91	
DW	2.56		2.67	

a/ The constrained model is a second degree polynomial with coefficient of $A_{t-5} = 0$.

In view of the results from the unconstrained model, the restriction that the coefficient for $A_{t-5} = 0$ was imposed. An apparent movement in the results emerged as a result of the imposition of this restriction. As seen in Figure 1 the graph of the constrained model was slightly more smoothed while the general "humped" shape was maintained.

The results of the estimated geometric lag structure are found in Table 2. Both the direct OLS estimates and those corrected for first order autocorrelation are provided.

Table 2
Estimated Geometric Lag Structure for Milk Advertising
Using Ordinary Least Squares and OLS Corrected
for First Order Auto Correlation

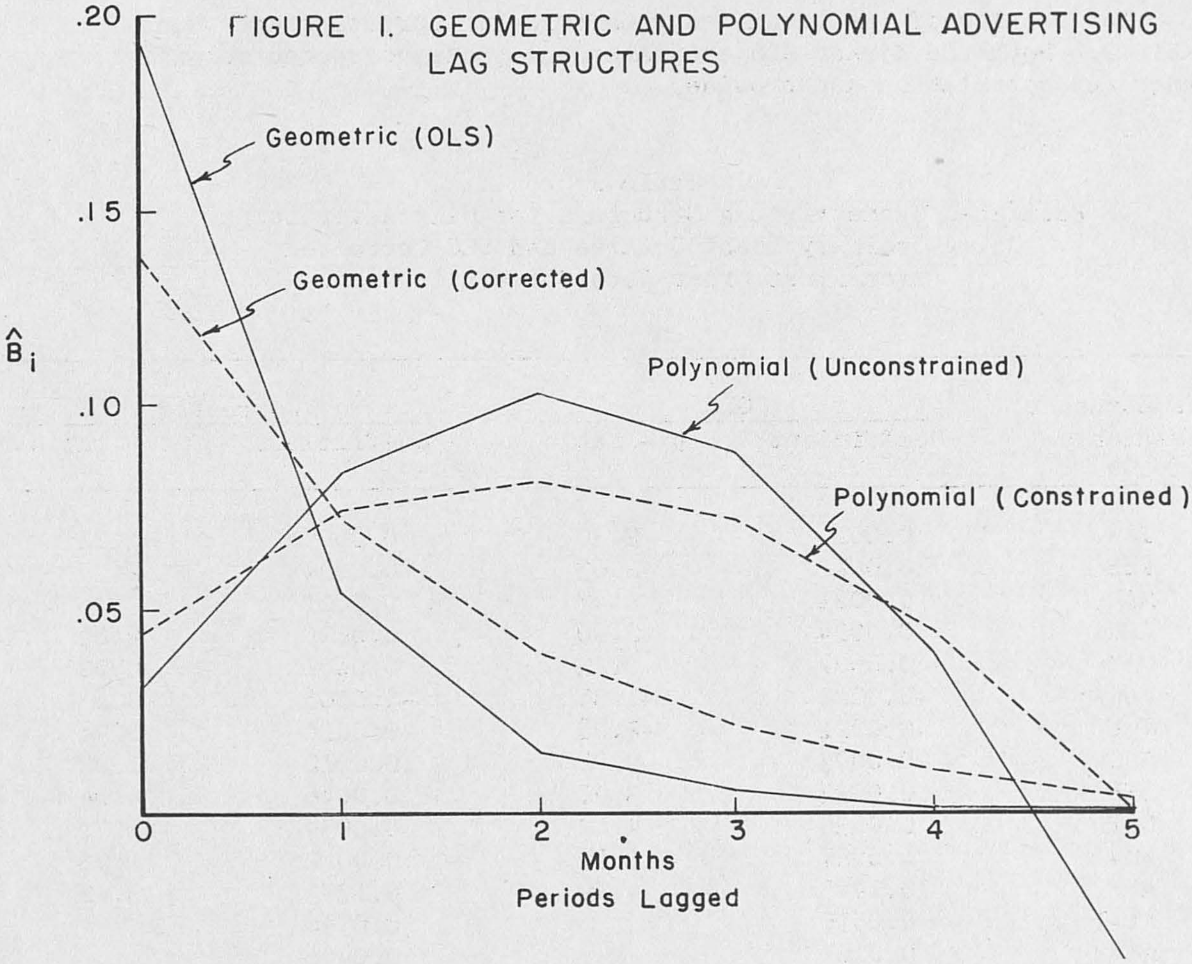
Independent Variable	OLS		Corrected	
	Coefficient	t - ratio	Coefficient	t - ratio
JAN	0.0020	2.30	0.0025	2.21
FEB	0.0022	2.63	0.0024	2.95
MAR	0.0021	2.47	0.0021	2.16
APR	0.0024	2.90	0.0025	2.82
MAY	0.0002	0.23	0.0002	0.20
JUN	-0.0012	-1.35	-0.0006	0.63
JUL	-0.0021	-2.08	-0.0010	0.98
AUG	-0.0003	-0.22	0.0012	1.02
SEP	0.0033	3.01	0.0046	4.04
OCT	0.0034	4.02	0.0039	4.70
NOV	0.0027	3.10	0.0022	1.93
At	0.1943	4.29	0.1373	3.42
At-1	0.0570		0.0746	
At-2	0.0167		0.0406	
At-3	0.0049		0.0406	
At-4	0.0014		0.0120	
At-5	0.0004		0.0065	
Yt-1	0.2936	2.06	0.5436	4.01
CONST	0.0111	4.67	0.0326	3.11
R^2		.91		.93
DW		2.38 b/		2.14

b/ DW is not meaningful with the presence of a lagged dependent variable.

Considerable statistical improvement in the estimated coefficients and Durbin-Watson statistic were found after the residuals were corrected and noticeable differences can be seen in the shapes of the lag structure in Figure 1.

Notwithstanding improved estimates after correction for autocorrelation, the imposition of the rigid geometrically declining parameter constraints shows marked differences in the shapes of the lag structures vis

FIGURE I. GEOMETRIC AND POLYNOMIAL ADVERTISING LAG STRUCTURES



a vis polynomial structure. The reader should bear in mind that there is no restriction imposed upon the quadratic polynomial that prevents it from exhibiting a geometric shape. Consequently, if the "true" lag shape is geometric, the polynomial model would also provide a close approximation to the geometric shape. However, it was shown above that the estimated polynomial model (which first increases then decreases over time) was inconsistent with the geometric specification. Therefore, it can be concluded that the results of the polynomial model more closely reflect the actual lag structure.

The short run and long run effects of advertising on milk sales are provided in Table 3. In both models the short run effect is important; however in the polynomial formulation the short run effect is substantially less important than either the corrected or uncorrected geometric model. Under all specifications, however, the long run effects are statistically significant and interestingly similar.

Table 3
Short Run and Long Run Effects of Advertising on Sales Using Alternative Estimating Procedures

	Geometric Lag		
	OLS	Corrected	Polynomial Lag
Short run effect	.1943	.1373	.0488
Long run effect	.2751	.3008	.3237

Welfare Considerations of Milk Advertising Policy

The previous analysis has provided a model from which the effects of advertising on milk sales can be determined. However, in this section an attempt is made to utilize the results of the previous analysis to approximate the net benefits accruing to the California dairy industry and the consuming public under various generic advertising policies. In this quest, the net changes in producer surplus must be weighted against the changes in consumer surplus to arrive at an evaluation of alternative advertising policy.

Under fairly restrictive assumptions,[8/] economic surplus can be used as a device for measuring the desirability of market change. Recent empirical applications have been made by Wallace [23], Johnson [14] and Tweeten and Tyner [22] on the social implications of alternative farm policy.

Consumer surplus has been defined as "the difference between the sacrifice which the purchaser would be willing to make in order to get it and the purchase price he has to pay in exchange." [5] Hence, this surplus or the consumer's "total willingness" to pay for a given quantity at a given price can be measured by the triangle area below the demand curve and above price. The "compensated" demand curve shows the quantity demanded at each price under the assumption that income is adjusted at each point such that the consumer maintains his original level of utility. It has been shown by Hicks [9] that the areas under the "compensated" demand curve and the ordinary demand curve coincide when the "income effect" is zero. However, since the income elasticity for fluid milk is not zero, a divergence between the two curves will result. As a consequence, the use of the area under the ordinary demand curve may overestimate the true consumer surplus but the degree of overestimation is an empirical question and will not be considered in this study.

8/ For a more complete discussion of these assumptions see [9, 20].

Marshall has defined producer surplus[9/] as

"The excess of the gross receipts which a producer gets for any of his commodities over their prime cost; that is, over that extra cost which he incurs in order to produce those things and which he could have escaped if he had not produced them." [16]

The traditional measure of producer surplus is the area above the product supply curve and below the price line. The empirical approximation of producer and consumer surplus under specified milk promotion policy is considered next.

The quadratic polynomial sales response model developed above serves as the basis for an analysis of the ex post welfare effects of advertising.

The long-run effect of advertising on sales of the polynomial model was used to estimate the effect on milk sales of alternative advertising policy. Linear demand and supply functions were estimated from the price elasticities of demand and supply at the mean 1972 prices and quantities.

Table 4
CHANGES IN NET CONSUMER AND PRODUCER WELFARE RESULTING FROM ADVERTISING AND PROMOTION OF MILK, CALIFORNIA 1972
(Millions of Dollars)

Demand Elasticities / Supply Elasticities	Annual Advertising Expenditures per Capita								
	10¢			17¢[a/]			30¢		
	-.2	-.3	-.5	-.2	-.3[b/]	-.5	-.2	-.3	-.5
.5	72.6	55.3	41.6	124.9	94.4	70.9	225.1	171.3	128.9
1.5[c/]	59.8	41.5	27.8	100.3	70.8	47.4	182.3	128.5	86.1
2.5	53.9	36.5	22.8	95.4	65.9	42.5	173.4	119.6	77.2

a/ Actual 1972 per capita advertising expenditures

b/ "Best estimate" demand elasticity

c/ "Best estimate" supply elasticity

9/ Producer surplus is often referred to as economic rent. For a more complete discussion see [3].

Since the elasticity estimates are valid only at the mean prices and quantities at which the functions are estimated and since no single milk supply or demand elasticity estimate has been universally adopted, various selected elasticity combinations are utilized and the results calculated therefrom.

In Table 4, the changes in net consumer and producer welfare resulting from advertising and promotion are shown. These data were calculated as net changes in consumer and producer surplus from the calculated surplus when no advertising occured <u>ceteris parabus</u>. Using the average 1972 actual advertising expenditures of $.17 per capita and the "best estimate" elasticities of demand and supply (-.30 and 1.5 respectively), a net increase in welfare due to advertising is calculated to be $70.8 million after adjustments are made for increased costs of advertising. However, if advertising expenditures were set at the lower level of $.10 per capita, under the same "best estimate" elasticities net welfare gains over no advertising were calculated to be $41.5 million. On the other hand if expenditures were increased to $.30 per capita, net welfare gains to both consumers and producers would equal $128.5 million. In general, the lower the elasticity estimates the higher the advertising expenditures the greater the potential gain. All calculations are made under supply and demand equilibrium conditions.

The reader should bear in mind that these findings are obtained from a partial equilibrium analysis and do not reflect an optimization of societal welfare in the general sense, nor do the results reflect long-run structural change, technological change, or the "second-round" effect of supply response in accordance with changes in prices received by producers. Further, increased milk sales from expanded milk advertising and promotion would imply likely changes in the consumers entire beverage consumption composition. That is, increased milk sales may obtain at the expense of decreased consumption of other beverages (e.g. soft drinks, beer, wine, coffee and tea, etc.). The welfare effects of consumer beverage composition adjustments is a moot topic and will not be considered here. Further study is needed regarding the nutritional and utility ramifications of alternative beverage substitution. However, it is clear from the above analysis that increased levels of advertising and promotion of milk can significantly augment producer and consumer welfare.

Summary

An analysis of the effects of generic advertising and promotion on commodity sales provides an important input to an evaluation of the effectiveness of advertising policy and the implications of various policy on producer and consumer welfare.

A prerequisite to the analysis of the welfare implications of milk advertising is the estimation of the effects of this advertising on milk sales. Historical milk sales and advertising data in California were used to estimate a sales response function to advertising. Since milk sales exhibit a delayed response to advertising a distributed lag formulation was specified.

The model selection is critical to the analysis of advertising policy. The selection decision was based on a comparison of two alternative lag formulations: the geometric lag and the polynomial lag. The polynomial lag model was shown to be a more flexible formulation and considered to more effectively reflect the actual lag structure.

The estimated polynomial model was used to approximate the effect of advertising policy on economic surplus. It was found that expanded milk advertising and promotion efforts shifts the demand schedule such that substantial welfare gains are realized.

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