

Estimating Threshold Effects of Generic Fluid Milk Advertising

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Most previous research examining economic impacts of commodity checkoff programs has focused on the development of econometric models aimed at isolating the causal relationship between advertising expenditures and sales of the commodity in question. To ensure that the estimated advertising parameter is unbiased and possesses as many other desirable statistical properties as possible, great effort has been exerted to 1) include in the model other important causative variables, 2) entertain alternative functional relationships between advertising and sales, and 3) experiment with different ways of accounting for advertising dynamics regarding its delay and carryover effects over time. In addition, recent studies have focused on the varying nature of advertising parameter as a way of further refining the estimated advertising-sales relationship.

Chung and Kaiser (2000), and Schmit and Kaiser (2004), for example, argue that a time-varying parameter model may provide a more accurate estimate of advertising effectiveness because consumers' response to advertising change as tastes and demographics evolve along the time continuum. Arguing that consumers do not necessarily respond at the same pace to an increase in advertising relative to a decrease in advertising, Vande Kamp and Kaiser (1999) partition an advertising goodwill variable into increasing and decreasing components and include them as explanatory variables in their fluid milk sales equation. While the method of segmenting,

ex post, the advertising variable may not be satisfactory econometrically, the idea that the sales effect of advertising depends, in part, on whether the advertising campaign is in an expansion or contraction phase is intuitive.

Allowing for threshold effects, this study focuses on another area of non-constancy in advertising parameter. A threshold delineates the level of advertising intensity (as measured, for example, by expenditure level) that has to be met to generate a specific level of sales effect. Given that promotional organizations face budget constraints, it is of particular interest to ascertain if there exists a minimum threshold that an advertising campaign has to overcome to yield a non-trivial sales effect. While rarely investigated within an appropriate estimation framework, the notion of advertising threshold is not new in the literature. For example, behavioral psychologists have argued that sales response to advertising may exhibit a threshold effect because repetitions are often needed to ingrain a stimulus in the consumer's mind before a purchase decision is made (Greenberg and Suttoni, 1973). Using a switching-regime model, Vakratsas et al. (2004) address the issue of advertising threshold for two product categories: liquid laundry detergent, a frequently purchased product in a relatively stable, mature

market; and the Sports Utility Vehicles (SUV) and passenger minivans, which are referred to as products in newly developed, competitive markets. The authors find advertising threshold effects in the SUV and minivans markets, but do not detect the same effect in the liquid laundry detergent market. For other frequently purchased products such as frozen entrées, however, Dubé, Hitsch, and Manchanda (2005) find evidence of advertising thresholds using a logit-type demand specification.

This article investigates the effect of U.S. generic fluid milk advertising programs employing quarterly data spanning over a period of 30 years. The hypothesis is that advertising-sales relationship may vary across regimes, depending on the intensity of advertising efforts. For example, one might postulate that advertising has no effect on sales in the low expenditure regime in which a minimum threshold is yet to be reached and has a large effect in the high expenditure regime, with the possibility of a third regime reflecting the eventual diminishing returns of advertising. The threshold estimation procedure developed by Hansen (1996, 1999, 2000) and Caner and Hansen (2004) is used to estimate the threshold parameters and test for the existence of the threshold effect.

Threshold Sales Response Equation

Following the framework suggested by Lancaster (1966, 1972), Stigler and Becker (1977) and Nichols

(1985), consumers maximize utility with respect to the amount of characteristics consumed. The characteristic of a market good is assumed to depend on the quantity consumed of the good, and the associated advertising expenditures, which affects product perceptions. Solving the consumer's utility maximization problem, subject to a budget constraint, the demand for the market good can be expressed as a function of the price of the good, advertising expenditures, and other demand determinants. In order to test the hypothesis of advertising threshold effects with this framework, consider the following demand equation:

$$y_t = \begin{cases} \theta^H GGW_t + \mathbf{x}'_t \boldsymbol{\beta} + \varepsilon_t & U \leq A_t \\ \theta^M GGW_t + \mathbf{x}'_t \boldsymbol{\beta} + \varepsilon_t & L < A_t < U \\ \theta^L GGW_t + \mathbf{x}'_t \boldsymbol{\beta} + \varepsilon_t & A_t \leq L \end{cases}$$

where y_t is the retail demand quantity, GGW_t is the generic advertising goodwill stock for fluid milk, \mathbf{x}_t is a vector of other demand determinants (or their nonlinear transformations) with $\boldsymbol{\beta}$ being the associated vector of regression parameters, and ε_t is the statistical error term. Note that the effect on fluid milk demand of generic advertising goodwill stock depends on the current advertising level, A_t , used as a proxy for advertising intensity. In the high intensity regime in which A_t is above an upper threshold, U , the effect on sales of goodwill stock is reflected by the magnitude of θ^H , whereas in the low intensity regime of A_t falling below a lower threshold, L , the sales effect of goodwill stock is measured by θ^L . In the middle regime of advertising intensity being between the upper and lower thresholds, the relevant parameter for generic goodwill stock is θ^M . The statistical procedure allows one to estimate the upper and lower

thresholds, the three advertising parameters associated with the three regimes, and other regression parameters such as $\boldsymbol{\beta}$. The hypothesis of a lack of threshold effects can be tested by checking if $\theta^H = \theta^M = \theta^L$. The parameter vector $\boldsymbol{\beta}$ for other demand determinants is treated as regime independent to focus attention on the threshold effects of generic advertising while conserving the degree of freedom.

Empirical specification and Preliminary estimation results

The estimations involve U.S. data from the first quarter of 1975 (1975.1) through the fourth quarter of 2004 (2004.4). Within the threshold regression framework, per capita retail demand is specified as a function of own price and substitute prices, income, consumer demographics, consumption trend, seasonality, a structural dummy variable, and three goodwill stock variables pertaining to generic fluid milk, brand cheese and soda advertising. Specifically, the own price is the consumer price index for whole milk, the substitute prices include the consumer price indices for nonalcoholic beverages, cheese, meat, and all less food, and the income figures are the per capita disposable personal income. All the price and income variables are deflated by the consumer price index for nonalcoholic beverages to impose homogeneity. The demographic variable is the percentage of the U.S. white population, the structural dummy variable has a value of 1 between 1994.1 and 2004.4 and 0 otherwise and is used to account for consumer's health concern toward the adoption of bST in milk production. Generic advertising goodwill variable for fluid milk is specified as a two-term function of current

and an exponentially distributed weighted sum of lagged advertising expenditures (Nerlove and Waugh 1961) which are measured in million dollars and deflated by an appropriate media cost index (with 2004.1 ~ 2004.4 as the base periods). Soda and branded cheese advertising goodwill variables are similarly constructed. In order to deal with own price endogeneity, an instrumental variable procedure for threshold model proposed by Caner and Hansen (2004) was adapted.

We now report some preliminary results of the analysis. The estimates of the two thresholds and their 95% asymptotic confidence intervals are reported in Table 1. The threshold estimates are 14.64 and 18.74, with the associated confidence intervals non-overlapping, suggesting that the two threshold estimates are distinct statistically. The threshold estimates indicate that if the generic fluid milk advertising expenditures (measured in 2004 media dollars) should fall below \$15 million the low intensity regime would prevail, between \$15 and \$19 million the middle intensity regime would prevail, and above \$19 million the high intensity regime would prevail. To place the above threshold estimates within a historical context of the observed data, note that the thresholds lie below the median (\$20 million) of the deflated generic fluid milk advertising expenditures. Notice also that, out of a total of 120 observations, 22 quarters fall into the low intensity regime, 27 quarters the middle intensity regime, and 71 quarters the high intensity regime.

The estimated regression parameters, including advertising coefficients for the three regimes, are reported in Table 2. All the coefficients, except for soda goodwill variable, are significant at, at least, 95 percent confidence

level. Focus first on the coefficient of generic advertising expenditure variable. The estimation results reveal how the generic advertising affects demand under alternative regimes. The largest coefficient is the one pertaining to the middle intensity regime (0.015), with the one for the high intensity (0.010) regime being smaller and the one for the low intensity regime (0.006) being not statistically different from zero. This result is interesting because it suggests a requirement of an initial build up of the generic advertising via boosting advertising intensity to reach a certain level of sales effect, but the effect diminishes as advertising expenditures continue to grow.

Turn to other regression coefficients in Table 2 which are specified as regime independent. The own price coefficients have the expected negative sign. Income coefficients are positive and highly significant. The estimation results show positive correlation between fluid milk consumption and percentage of white population, and a negative correlation with the adoption of bST. The historical pattern of a downward trend in fluid milk consumption is reflected in the signs of the trend coefficient. All the quarterly dummy variables are highly significant, indicating a strong seasonal pattern in the consumption of fluid milk. To address the problem of auto correlation in the initial equations (not reported), a first-order autoregressive [AR(1)] term for the residuals is included. Upon the

correction, the first-order Breusch-Godfrey statistic indicates that the residuals are free from serial correlation problems. Finally, the adjusted R-squared is 0.96, indicating good fit of the data.

Summary and Conclusions

While the threshold modeling approach is merely a way of introducing nonlinearity between sales and advertising, it allows researchers to capture the fact that repetitions in messages are often needed before a purchase decision is made – as Simon and Arndt (1980, p.13) aptly put it, “you’ve got to keep dripping the water onto the rock until it cracks.” From a practical viewpoint of program managers, the threshold approach is also useful as it provides unique insights toward the various ranges of advertising operation scale within each of which the marginal effect on sales of advertising remains more or less constant. Using a threshold estimation procedure, this study represents the first attempt to investigate if thresholds exist in the sales effect of U.S. generic fluid milk advertising programs.

The estimation results of the sales response equation confirm that there exist two thresholds which partition the 30-year quarterly observations in the data into three possible regimes depending on the level of advertising intensity in each period. The generic fluid milk advertising coefficient is found to be statistically not different from zero for the regime with the lowest advertising intensity, building up

to a higher level as the regime progresses, but eventually drops to lower levels as the intensity continues to grow, reflecting the eventual arrival of the diminishing returns of advertising.

Despite these positive findings, some caveats and limitations must be kept in mind. Hansen’s threshold regression model performed in this study assumes that the relationship between sales and advertising is discontinuous at the thresholds. Because of the discontinuity at the thresholds, sales can be lower even if more generic advertising expenditures were spent in the third regime (other factors held constant). While this may possibly be one of explanations to recent net decrease in fluid milk consumption regardless of increases in generic advertising questioned by Tomek and Kaiser (1999), further examination, such as optimality analysis in conjunction with threshold effects, may be necessary. The issue of dis/continuity is important not only from the viewpoints of underlying economic theory between sales and advertising, but also from statistical standpoints. The distributions appropriate for inference in a discontinuous threshold model are different from those in a continuous model (Chan and Tsay 1998, Hansen 2000). Further estimations with a continuous threshold regression model and tests to determine whether the model is dis/continuous at thresholds are currently undertaken.

Table 1. Threshold Estimates

	Estimate	95% confidence Interval	Likelihood Ratio Statistic (p-value)
Lower threshold	14.64	14.39 ~ 14.64	0.044
Upper threshold	18.74	17.80 ~ 19.63	0.002

Table 2. Estimated Regression Parameters

Variables	Coefficient	t-ratio
<u>Regime dependent parameter</u>		
Generic advertising expenditures		
Regime 1	0.006	1.04
Regime 2	0.015	2.75
Regime 3	0.010	2.07
<u>Regime independent parameters</u>		
Intercept	-11.807	-4.13
Own price	-0.561	-4.69
Cheese price	0.407	3.13
Meat price	0.076	1.76
All less food	-0.136	-1.77
Income	0.363	5.80
Generic goodwill	0.014	2.60
Cheese branded goodwill	0.017	3.13
Soda goodwill	0.005	0.60
White population	3.401	5.52
bST dummy	-0.020	-2.40
Time trend	-0.102	-6.44
Quarter dummy 1	-0.009	-2.48
Quarter dummy 2	-0.052	-9.10
Quarter dummy 3	-0.051	-12.7
AR(1)	0.541	5.96
Adjusted R-square		0.96
Breusch-Godfrey Test (p-value)		0.22

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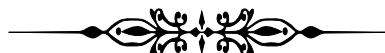
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