Dynamic effects of Peanut Butter Advertising on Peanut Butter Demand

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Abstract

Using error correction approach and nonlinear three-stage-least-squares, long-run and short-run effects of aggregate brand advertising on the U.S. demand for peanut butter are estimated. Results indicate that demand for peanut butter is more responsive to advertising in the long-run. Moreover, demand is responsive to price only in the short-run.

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Advertising is widely practiced to promote consumption of processed agricultural products. While farmer organizations and governments invest resources in generic commodity advertising programs, businesses that produce branded processed foods invest in brand advertising. Peanut butter manufacturers in the United States (U.S.) spend millions of dollars on peanut butter advertising. The U.S. peanut butter industry, with its annual sales exceeding 1.3 billion dollars, spent about thirty million dollars on brand peanut butter advertising in 1994. The majority of this brand advertising is promoted by the top three peanut butter manufacturers, viz. Procter and Gamble Inc., CPC International Inc., and ConAgra who manufacture Jif, Skippy, and Peter Pan brands respectively. Most of the brand advertising appears on spot, network and cable television and some in magazines and newspapers.

With millions of dollars being spent on peanut butter advertising, is advertising being effective in generating demand for peanut butter? Does it lead to increase in aggregate demand or just brand substitution? Peanut butter manufacturers would certainly like to know whether or not investment in advertising expenditure boosts their sales. Similarly, peanut farmers would also be interested in knowing this since demand for peanuts is a derived demand. Peanut butter being a high-protein, high-fiber, no-cholesterol, and low-saturated fat product, it is also important from the food policy perspective, to know whether or not a generic peanut-product promotion program can be successful. So far, no study has been conducted on the effects of peanut butter advertising on peanut butter demand.

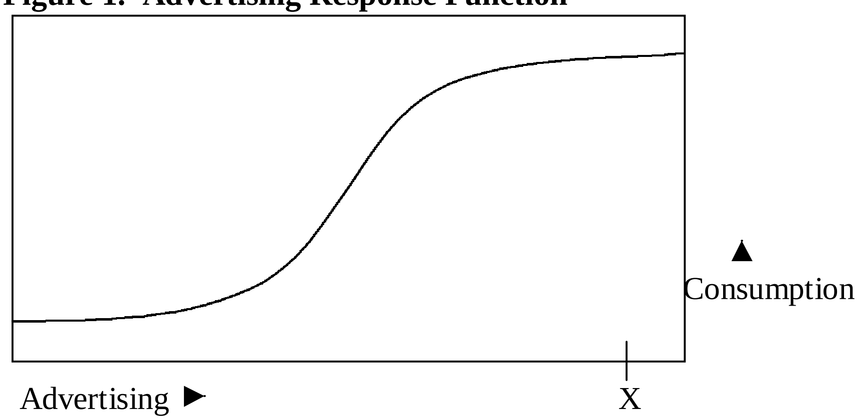
The purpose of this paper is to examine the relationship between peanut butter advertising and peanut butter consumption at the aggregate level. There have been a number of studies on the effects of advertising on agricultural products. However, two features distinguish this paper from the rest. First, most of the studies on returns to advertising in agricultural products have focused on generic agricultural commodity promotions (e.g., Jensen and Schroeter; Funk, Meilke, and Huff; and Forker and Ward). We study the effect of aggregate brand advertising by peanut butter manufacturers on aggregate peanut butter demand. While the generic promotions may have impact only on aggregate demand, the effect of aggregate brand advertising on aggregate demand may not be as pronounced due to brand substitution.

Second, none of the studies have taken into consideration the possibility of nonstationarity of time series data. If the time series data used in the estimation procedure are nonstationary, then the usual asymptotic theory may not apply to the regression equation in levels (Davidson and Mackinnon). We use an error correction methodology (ECM) that not only corrects the nonstationarity problem but also estimates the short-run and the long-run effects of advertising on peanut butter consumption. In the first section, methodological issues regarding advertising are discussed. The second section presents the model used, the third discusses the data and the results, and, finally, the fourth section summarizes and draws conclusions.

Methodological Issues

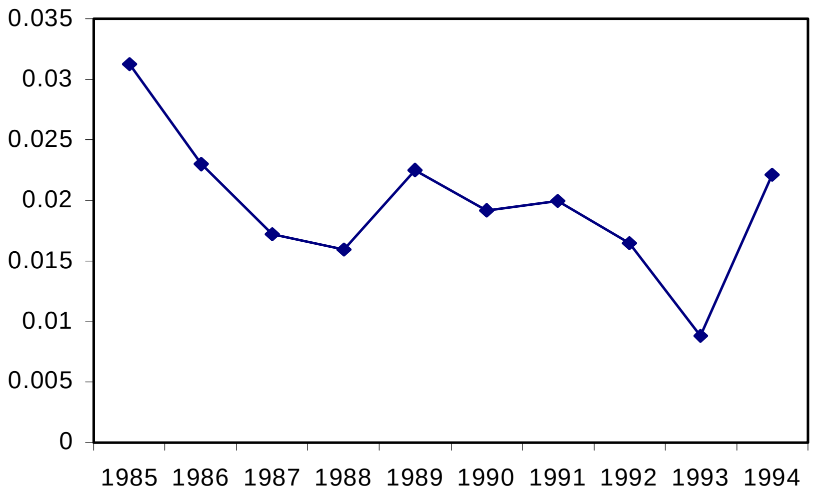
The relationship between advertising and consumption is described as the response function. In the present context, an industry-level response function shows the relationship between aggregate brand advertising and aggregate peanut butter consumption. *Ceteris Paribus*, this response function assumes that industry advertising increases market size, and that the effect is subject to diminishing returns. For example, with an annual advertising budget of more than $ 1 billion, alcohol and cigarette industry in U.S. is heavily advertised, and it is argued that the industry response function falls in the flat, near-zero marginal returns range. As indicated by Saffer, this corresponds to a range around X in Figure 1. Not surprisingly, empirical studies show no effect of advertising on alcohol consumption (Saffer). In this study, on account of moderate advertising expenditures in the peanut butter industry, we hypothesize that aggregate brand advertising will have a statistically significant effect on aggregate peanut butter consumption. I.e., the range of marginal returns to advertising will be substantially to the left of X in Figure 1.

Figure 1. Advertising Response Function



It is argued by some economists (e.g. Schmalensee) that firms adjust advertising budgets so that advertising expenditures is a fixed percentage of sales. At the same time, it is a common knowledge that firms undertake advertising to increase sales. These assumptions imply that advertising too is an endogenous variable, and, therefore, effects of advertising expenditures on demand may turn out to be biased in a single-equation demand function. One will also need to formulate a structural advertising equation to avoid this problem. For peanut butter advertising, however, we do not find that advertising expenditure is a fixed percentage of peanut butter sales. The advertising expenditure to sales ratio depicted in Figure 2 indicates that yearly advertising expenditure has fluctuated from 0.8 percent to 3.1 percent of total peanut butter sales during the period 1985-1994. The fluctuation for the quarterly time series for the same period is even higher. It has varied from 0.1 percent to more than 3.6 percent. Therefore, in this paper, we estimate a single-equation demand function econometrically.

Figure 2. Advertising Expenditure to Sales Ratio



Another important feature of the estimation of relationship between demand and advertising is the temporal aggregation of data. Aggregation over a long interval such as a year obscures the variance in the dependent and explanatory variables. Firms engage in expenditure pulsing which amounts to spending an annual advertising budget in short intense intervals of advertising rather than spending a fixed sum throughout the year.

The effects of such expenditure pulsing linger for many months. For example, effects of fluid milk advertising last roughly six months (Kinnucan). In this paper, we were able to secure quarterly time series data for all the variables used.

The Model

Consider the following linear demand equation:

(1) $$Q_t = a_0 + a_1 P_t + a_2 Y_t + a_3 I_t + a_4 B_t + \varepsilon_t ,$$

where Q_t is the aggregate quantity of peanut butter consumed, P_t is the price of peanut butter, Y_t is the peanut butter advertising expenditure[1], I_t is the per capita income, and B_t is the price of a substitute good. The above formulation has two limitations. First, by ignoring the lagged values of the variables, it ignores the dynamic effects of habit formation on demand. We incorporate this by using the autoregressive distributed lag (ADL) method. Second, time series data for the above variables may be nonstationary in levels, but stationary in first differences, i.e., integrated of order 1, I(1). As a result, the usual asymptotic theory may not apply to the regression equations in levels (Davidson and Mackinnon). On the other hand, if differenced data is used, one cannot capture the short-run dynamics of the data. However, if the variables are I(1), and a linear combination of these variables in levels is stationary, then it is possible to capture both the short-run and long-run dynamics in the data by employing the ECM approach.

The demand equation (1), with one lag and no intercept term, can be represented by the ADL form[2]:

(2) $$\begin{aligned} &Q_t = a_{01} P_t + a_{02} Y_t + a_{03} I_t + a_{04} B_t + \\ &a_{11} P_{t-1} + a_{12} Y_{t-1} + a_{13} I_{t-1} + a_{14} B_{t-1} + a_{15} Q_{t-1} + \varepsilon_t . \end{aligned}$$

By adding and deleting Q_{t-1}, $a_{01} P_{t-1}$, $a_{02} Y_{t-1}$, $a_{03} I_{t-1}$, $a_{04}B_{t-1}$, rearranging the terms and using the difference operator, equation (2) can be written in the ECM format as follows:

$$\text{(3)} \quad \begin{aligned} \Delta Q_t &= a_{01}\Delta P_t + a_{02}\Delta Y_t + a_{03}\Delta I_t + a_{04}\Delta B_t + \\ &(1-a_{15})\left[\begin{aligned} &\frac{(a_{01}+a_{11})}{(1-a_{15})}P_{t-1} + \frac{(a_{02}+a_{12})}{(1-a_{15})}Y_{t-1} + \frac{(a_{03}+a_{13})}{(1-a_{15})}I_{t-1} + \\ &\frac{(a_{04}+a_{14})}{(1-a_{15})}B_{t-1} - Q_{t-1} \end{aligned}\right] + \varepsilon_t . \end{aligned}$$

The generalized form of this equation for k lags and an intercept term is as follows:

$$\text{(4)} \quad \begin{aligned} \Delta Q_t &= a_{00} + \sum_{i=0}^{k-1} a_{i1}\Delta P_{t-i} + \sum_{i=0}^{k-1} a_{i2}\Delta Y_{t-i} + \sum_{i=0}^{k-1} a_{i3}\Delta I_{t-i} + \\ &\sum_{i=0}^{k-1} a_{i4}\Delta B_{t-i} + \sum_{i=1}^{k-1} a_{i5}\Delta Q_{t-i} + \\ &m_0\left[m_1 P_{t-k} + m_2 Y_{t-k} + m_3 I_{t-k} + m_4 B_{t-k} - Q_{t-k}\right] + \varepsilon_t , \end{aligned}$$

where $m_0 = (1 - \sum_{i=1}^{k} a_{i5})$, and $m_j = \dfrac{\sum_{i=0}^{k} a_{ij}}{m_0}$, $j = 1,2,3,4.$

If all the variables are I(1), then all the summations in equation (4) are stationary. Moreover, if the variables are cointegrated, the ECM term, i.e., the linear combination of variables represented in brackets, is also stationary. The summations capture the short-run dynamics, and m_j coefficients represent the stationary long-run impacts of the right-hand-side variables. The parameter m_0 measures the rate of adjustment of short-run deviations towards the long-run equilibrium. Having described the model, we estimate equation (4) econometrically for the U.S. peanut butter industry, using nonlinear-three-stage-least-square (NL3SLS) procedure. In the following section, details about the data on peanut butter industry, results of the stationarity and cointegration tests, and econometric estimation of the demand equation are presented.

Data and Empirical Results

Quarterly data on variables was available from the third quarter of the 1984 marketing year to the second quarter of the 1994 marketing year[3]. Data on U.S. consumption of peanut butter (Q_t) was collected from the various issues of *Peanut Stocks and Processing* published by the U.S. Department of Agriculture (USDA). Data on peanut butter price (P_t), and price of substitute good, bologna (B_t) were collected from the various issues of the publication, *Average Retail Prices*, published by the U.S. Department of Labor (USDL). Data on U.S. per capita disposable income (I_t) were collected from various issues of the publication, *Survey of Current Business*, published by U.S. Department of Commerce (USDC). Data on peanut butter advertising expenditure were collected from *Leading National Advertiser* (LNA). In addition, data on consumer price index used to deflate nominal variables was collected from the publication, *CPI Detailed Report, Consumer Price Index* published by USDL (September 1996), where 1982-84 is considered to be the base year. The definitions of variables in levels, and their descriptive statistics are presented in Table 1.

All the variables were tested for stationarity and cointegration. Using Dickey-Fuller and Phillips-Perron tests, we conclude that the variables were nonstationary in levels but stationary in first differences, i.e., variables were integrated of order I(1). Moreover, using the Johansen trace test (Johansen and Juselius) we show that variables in the demand equation are cointegrated in levels. Further, the optimal number of lags were selected based on modified Q-statistics for the hypothesis that all autocorrelations of higher order are zero[4]. A lag of two quarters is consistent with the findings of Kinnucan for generic milk advertising. Seasonality was taken into account by using quarterly seasonal dummies, D_1, D_2, D_3 in the NL3SLS regression estimation. Another dummy variable, D_4, is used to account for the major drought during the 1990-1991 marketing year. The results of all the tests performed above are reported in Table 2, Table 3, and Table 4. Regression results are reported in Table 5.

As the results suggest, model specification fits the data well. The R^2 value for the demand equation is 0.84 and many coefficients are statistically significant at the 0.01, 0.02 and 0.05 levels. Since the Durbin-Watson statistic is not applicable when explanatory variables contain lagged endogenous variable, we performed the Durbin's *m* test (Durbin). The coefficient of the lagged error term was statistically insignificant and we could not reject the null that the first-order autocorrelation is zero. The value of m_0, 0.5, is within the theoretical bounds, 0 to 1, and indicates that there is a gradual adjustment of short-run deviations to the long-run values. While a value of 0 indicates that short-run deviations do not converge to any long-run equilibrium, a value of 1 indicates that there is an instant adjustment to long-run equilibrium.

Regression results in Table 5 show that effects of peanut butter advertising on peanut butter demand are statistically significant both in the short-run and in the long-run. However, the effect is more pronounced in the long-run. Coefficients of the advertising variable multiplied by the average real retail price of peanut butter indicate that at the margin, a dollar spent on peanut butter advertising generates a revenue of 10.67 dollars in the long-run and 4.77 dollars in the short-run. Comparable marginal return for fresh cut flowers is 6.62 dollars (Ward) and $6.90 in producer profits for generic egg advertising (Schmit *et al.*) The long-run advertising elasticity of demand, evaluated at mean is 0.21, however, the short-run elasticity is extremely low at 0.09. This indicates that in the short-run, brand advertising may result in brand substitution, and, in the long-run, it will boost the aggregate demand. Similarly, the price coefficients indicate that the effect of price on aggregate demand is statistically significant in the short-run but not in the long-run. Thus, while peanut butter demand is more responsive to price in the short-run, it is more responsive to advertising in the long-run. Coefficients of the income variable I_t and the price of substitute product, Bologna, B_t have the correct signs, however, only the effects of income variable are statistically significant.

Summary and Conclusion

Our objective was to estimate the effect of peanut butter advertising on the U.S. peanut butter demand. Many studies have been conducted that estimate the effect of commodity promotion on demand, but few have studied the effects of aggregate brand advertising on demand. Also, none of the studies have addressed the nonstationarity and cointegrating characteristics of the data. We use the ECM methodology to estimate the long-run and short-run effects of peanut butter advertising on peanut butter demand.

The estimated demand equation shows that effects of advertising on peanut butter demand are statistically significant. Unlike alcohol advertising, the level of advertising expenditures is not in the flat, near zero range of the advertising response function. In fact, a dollar spent on peanut butter advertising generates more than 8 dollars in peanut butter revenues. The effect of advertising is not that pronounced in the short-run due to the possibility of brand substitution. On the other hand, our results also indicate that demand is not responsive to prices in the long-run, but it is elastic in the short-run.

Based on the results, we conclude that peanut butter advertising is effective in generating peanut butter demand. Our finding has a baring on policy decisions of many groups associated with the peanut industry. First, it will be reassuring to the peanut butter manufacturers that their advertising efforts are not being wasted. Second, since it is demonstrated that the brand peanut butter advertising is effective, and, since demand for peanuts is a derived demand, peanut farmers may want to promote generic advertising of peanut products. This way, peanut farmers can avoid any brand substitution effects that might hamper the growth of aggregate demand for peanut products, and, hence, for peanuts. Finally, through generic advertising, federal health and nutrition agencies too can use the advertising effectiveness to promote nutritionally high-protein, high-fiber, cholesterol-free and low-saturated-fat peanut products.

Table 1. Descriptive Statistics

Variable	Description	Mean	Std. Deviation
Q_t	Quantity of Peanut Butter, thousand pounds.	195660.00	22155.51
P_t	Real Price of peanut butter, dollars/pound.	1.44	0.11
Y_t	Real Advertisement Expenditure, dollars/quarter	5510.57	2120.00
I_t	Per Capita Disposable Personal Income,bn.dollars.	12123.00	588.30
B_t	Real Price of Bologna, dollars/pound.	1.83	0.14

Table 2. Stationarity Tests for I(0)

	Dickey-Fuller		Phillips-Perron	
Variable	Statistic	P-value[a]	Statistic	P-value[a]
Q_t	0.09	0.71	-0.08	0.66
P_t	-0.69	0.42	-0.19	0.64
Y_t	-0.98	0.30	-1.96	0.33
I_t	1.30	0.95	0.19	0.73
B_t	-1.56	0.41	-0.25	0.63

[a] P-values show the significance level required to reject the null hypothesis based on critical values of the two tests. Values higher than 0.05 indicate insignificance both at 1% and 5% level.

Table 3. Stationarity Tests for I(1)

	Dickey-Fuller		Phillips-Perron	
Variable	Statistic	P-value[a]	Statistic	P-value[a]
Q_t	-3.40	0.001	-49.20	1.1E-6
P_t	-3.05	0.002	-22.68	0.001
Y_t	-5.10	6.7E-7	-52.22	5.2E-7
I_t	-2.27	0.02	-27.74	0.0002
B_t	-2.32	0.02	-32.34	0.0001

[a] P-values show the significance level required to reject the null hypothesis. Values lower than 0.01 indicate significance at 5% and 1% level, and values lower than 0.05 indicate significance at 5% level.

Table 4. Johansen Trace Test for Cointegration

Cointegrating vectors: r	λ_{trace}	P-value[a]
H_0: r ≤ 1	279.86	2.3E-28
H_0: r ≤ 2	139.35	5.5E-14
H_0: r ≤ 3	5.12	0.83
H_0: r ≤ 4	1.91	0.16

[a] P-values show the significance level required to reject the null hypothesis. Values lower than 0.01 indicate significance at 1% level.

Table 5. NL3SLS Regression Estimate

Variable	Estimated Coefficient		t-statistic
Constant	a_{00}	-212230.00	-1.71
ΔP_t	a_{01}	-214630.00[b]	-2.54
ΔY_t	a_{02}	3.31[a]	3.54
ΔI_t	a_{03}	14.09	0.82
ΔB_t	a_{04}	2650.19	0.04
ΔP_{t-1}	a_{11}	-143924.00	-1.73
ΔY_{t-1}	a_{12}	3.06[b]	2.45
ΔI_{t-1}	a_{13}	32.69[c]	2.39
ΔB_{t-1}	a_{14}	37480.90	0.65
ΔQ_{t-1}	a_{16}	-0.80[a]	-5.27
$-Q_{t-2}$	m_0	0.50[a]	3.35
P_{t-2}	m_1	-16748.90	-0.14
Y_{t-2}	m_2	7.41[b]	2.66
I_{t-2}	m_3	27.37[c]	2.25
B_{t-2}	m_4	142531.00	1.33
D_1	ad_1	14029.20[a]	3.32
D_2	ad_2	-3479.01	-0.80
D_3	ad_3	-5625.34	-1.13
D90-91	$ad_{90\text{-}91}$	-623.19	-0.19

$R^2 = 0.84$, and coefficient of lagged error term, $\rho_1 = 0.15$, with t-statistic 0.23.

[a] Significant at 0.01 two-tail test, [b] significant at 0.02 two-tail test, [c] significant at 0.05 two-tail test.

Footnotes

1. Realistically, advertising messages affect the demand. The implicit assumption is that the price of a unit of advertising message is fixed at unity.

2. Equations (2) (3) and (4) are originally presented by Steen and Salvanes.

3. It may be noted that the second quarter of the 1994 marketing year extends to January of 1995 calendar year. Monthly data was available for peanut butter price and quantity, however, quarterly data was constructed for these variables since only quarterly data was available for most of the other variables including advertising expenditures.

4. For two lags in Q_t, the χ^2 value of the Q-statistic was 9.76 and we could not reject the hypothesis of zero higher order autocorrelations at 0.995 confidence level. We also ran regressions with one lag and three lags; however, lower R^2 and insignificant regression coefficients were reported as compared to the model with two lags.

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