Egg Advertising, Dietary Cholesterol Concerns, and U.S. Consumer Demand

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A model of the domestic demand for eggs was estimated from quarterly data over the period 1987 through 1995, incorporating an index of consumer dietary cholesterol concerns and generic advertising efforts by the American Egg Board and the California Egg Commission. Empirical results indicated that most of the observed change in egg demand could be explained by dietary cholesterol concerns. Simulating the model in a constant elasticity supply framework demonstrated that advertising efforts over the past several years have resulted in net benefits to egg producers largely when considering inelastic supply responses. However, considering trade bias reduces these benefit-cost ratios substantially.

In the last decade, the Incredible Edible Egg® has suffered a barrage of negative publicity surrounding the potential link between dietary cholesterol and heart disease. Therefore, a primary aim of much of generic egg advertising has been to mitigate the negative effects of consumer health concerns. To some degree this is still apparent; however, current promotional efforts focus more on convenience and the nutritional value of eggs in a well-balanced diet. Furthermore, recent consumer tracking studies have found that consumers' negative attitudes toward eggs are no longer increasing (Smith 1993). While the flow of dietary cholesterol information is not as plentiful as in years past, it is likely that it continues to be a strong determinant of consumer eating habits. For egg producers, the most important aspect of these changes centers on how consumer perception of eggs has changed and how this has affected overall demand and producer returns.

These issues are addressed in this paper through an economic analysis of generic egg advertising in the United States. Generic advertising efforts by the American Egg Board (AEB), a national program, and the California Egg Commission (CEC), the only substantial state advertising program, are included in the analysis. The paper begins with an explanation of both advertising programs and a brief review of literature on past egg industry modeling and generic advertising studies. This section is followed by a description of the trends in price and consumption over the past several years and a discussion of structural change components in the demand for eggs. A cholesterol concern index is developed to capture the effects of dietary concerns over the sample period. The model specification and econometric results of the retail demand for eggs are discussed in the following section. Finally, benefit-cost ratios of generic advertising are computed and the implications discussed.

Generic Egg Advertising in the United States

The AEB Advertising Program

Since 1976, U.S. egg producers have paid a mandatory assessment to finance the national egg promotion program operated by the AEB. In 1994, producers voted to increase this assessment from 5 to 10 cents per 30 dozen cases marketed, representing approximately 0.35% of the wholesale egg price. Annual checkoff revenues under the revised scheme, which began in February 1995, increased from around $7 million to nearly $14 million.

In the early years of the program, checkoff revenues were allocated primarily to nutrition research and education programs. Prior to 1990, media advertising expenditures constituted no more than 10% of checkoff income, while nearly 40% was spent on research and consumer education. In fact, a minimal amount of advertising occurred in the late 1980s, with no AEB advertising expenditures in 1988 and 1989. Since 1990, the emphasis has shifted toward devoting a larger share of the budget to advertising, exceeding 50% of checkoff

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revenues for some time periods. Advertising expenditures have averaged nearly $0.8 million per quarter since 1987; they have averaged nearly $1.2 million for the 1990s and nearly $2 million per quarter for 1995.

The CEC Advertising Program

California has historically been the largest egg-producing state in the nation; however, Ohio recently surpassed California in terms of total egg production. Even so, California produces over six billion eggs per year, approximately 10% of the national total. Since 1984, the CEC has financed advertising, promotion, education, and research aimed at increasing egg consumption and enhancing returns for California egg producers. The CEC assesses producers one cent per dozen shell eggs, or liquid equivalent, sold within the state. The program operates independently of the national AEB program and focuses its advertising predominantly through state media markets.

CEC advertising expenditures have averaged over $0.85 million per quarter since 1987, and expenditures have been relatively consistent over the late 1980s through the mid 1990s. We combine both sources of advertising in the following analysis. Data for advertising expenditures since 1987 were provided by the AEB and the CEC.

Related Literature

Various studies in the 1970s and 1980s developed economic models of the U.S. egg industry (e.g., Miller and Masters 1973; Roy and Johnson 1973; Schrader et al. 1978; Chavas and Johnson 1981; Salathe, Price, and Gadson 1983; Blaylock and Burbee 1985; Stillman 1987). In 1990, Brown and Schrader estimated an econometric model of retail egg demand incorporating a cholesterol information index over the previous four decades. They found that information on the links between cholesterol and heart disease had a significant negative impact on consumer demand for eggs.

Research evaluating the impact of generic egg advertising before this time is not apparent in the literature. Generic egg advertising has been studied more recently by McCutcheon and Goddard (1992) and Chyc and Goddard (1994) for the Canadian supply-managed egg sector, where imports and production are restricted to maintain producer prices. Both studies determined that generic egg advertising in Canada had a positive impact on consumer demand.

Reberte, Schmit, and Kaiser (1996) provided a more recent model of the U.S. egg industry, similar to that of Chavas and Johnson (1981), but incorporating generic advertising effects. Similarly, Schmit, Reberte, and Kaiser (1997) conducted an analysis of California's egg promotion program. Both studies found that generic egg advertising had a positive impact on demand and producer returns. However, health-related concerns were either not included or assumed inherent in a time trend variable. This paper serves as a refinement of the earlier work by using an updated index of dietary cholesterol concern and includes contributions of both advertising programs simultaneously.

Trends in Consumption and Price

While net exports of egg products have increased considerably over the past decade, they still represent a relatively small proportion of total egg production, currently just over 4%. Therefore, the production of eggs closely follows domestic consumption patterns.[1] Over the past several years, the egg industry has been transformed into a highly vertically integrated industry, with ever-larger firms operating in the wholesale market and with considerable egg production under contract to market firms.

Per capita egg consumption of whole and processed egg products, i.e., total retail demand, has decreased roughly 6% since the beginning of 1987 to a current level of nearly 60 eggs per quarter, or 4.6 eggs per week (figure 1). After accounting for the consistent spike in consumption during the fourth quarter, one notices two general time periods: a decreasing trend from 1987 to mid 1991, and then an increasing trend, albeit less pronounced, since mid 1991. Egg consumption reached its lowest quarterly average in the second quarter of 1991, when consumption was approximately 4.4 eggs per week. While this decrease seems small, it represents a national consumption decrease of over 10% from the peak in late 1987. This downward trend was likely influenced by the abundance of new information surrounding the connection between heart disease and dietary cholesterol intake. The stabilization of consumption in the early 1990s and the current upward trend are hypothesized to be affected both by an increased advertising effort by the AEB and the CEC defending the nutritional value of eggs and by additional medical informa-

[1] Consumption is defined as the commercial disappearance of eggs, i.e., consumption equals the production of eggs less the change in stocks, net exports, and eggs used for hatching.

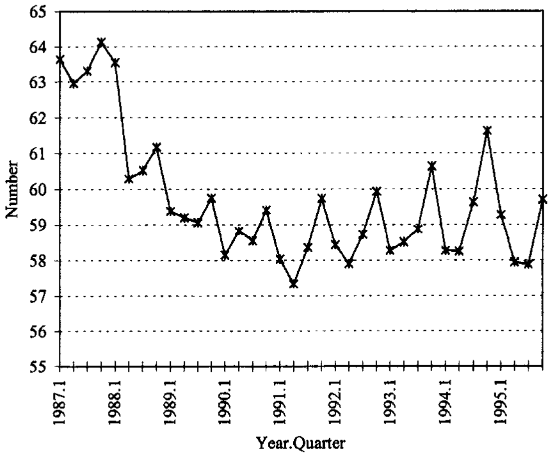

Figure 1. Domestic Per Capita Retail Demand for Eggs and Egg Products

tion on the distinction between "good" and "bad" cholesterol.

An evaluation of real retail egg prices over the same time period does not exhibit the clear decreasing and increasing trends dictated by the consumption pattern (figure 2). While real egg prices (deflated by the Consumer Price Index [CPI] for all items) did increase between mid 1988 and the end of 1989, a decreasing trend was evident through the early 1990s. Since late 1993, real egg prices have remained relatively stable, and into 1995 they have shown an increasing pattern. Even so, average real egg prices in 1995 were below mean levels in 1987.

Additional Determinants of the Demand for Eggs

With the exception of more recently introduced alternative egg products, clear substitutes for eggs

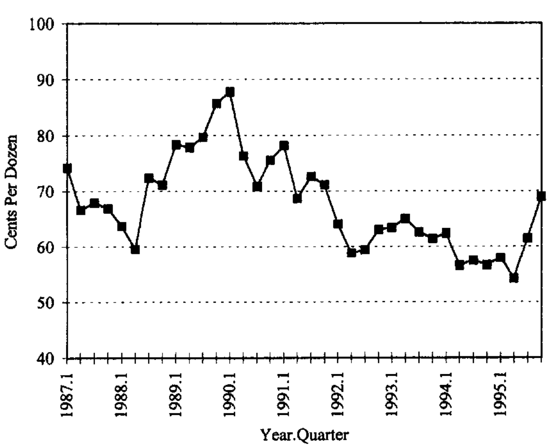

Figure 2. Real Retail Price of Eggs

are more difficult to identify than are substitutes for other products such as red meats. While previous studies, including Reberte, Schmit, and Kaiser (1996) and Schmit, Reberte, and Kaiser (1997), included red meats as substitute products, it is more difficult to hypothesize why these products (for example, a pork chop or a T-bone steak) are necessarily substitutes for eggs. Early model testing demonstrated these products were insignificant in the forthcoming demand model estimated. However, alternative breakfast foods likely fall into this category and can have important implications for the consumption and price of eggs. Breakfast cereals and bakery products are hypothesized to be substitute products for eggs. While the overall trend in egg prices over the last eight to ten years has been decreasing, prices of cereals and bakery products have been increasing. The CPI for cereals and bakery products was used as a proxy for egg substitutes.[2]

It is further hypothesized that the increase in demand for quick and convenient breakfast products has been partially due to changing family lifestyles. Since 1987, the percentage of women employed in the labor force has increased roughly 7% and is hypothesized to positively affect the demand for convenient breakfast foods.[3] The ultimate impact on egg consumption is less clear. On the one hand, prior surveys conducted for the AEB indicate that egg consumption away from home has been increasing. Thus, as the proportion of working women increases, the number of breakfasts eaten away from home should increase, which may increase overall egg consumption (Brown and Schrader 1990). On the other hand, Stillman (1987) suggested that a negative relationship may exist, since with more women working outside the home, less time is available to prepare eggs for breakfast and other, more convenient items are consumed.

In order to account for the exposure of consumers to information about dietary cholesterol, an index similar to those developed by Brown and Schrader (1990) and McGuirk et al. (1995) was constructed. Brown and Schrader's cholesterol index was constructed by counting articles in medical journals that either supported or refuted the link between dietary cholesterol and heart disease. It was hypothesized that articles in medical journals

[2] This index includes breakfast cereals, muffins, sweet rolls, doughnuts, and coffee cakes. The data we collected from the U.S. Department of Labor, Bureau of Labor Statistics, on-line database, http://www.bls.gov.

[3] Series also available from the Bureau of Labor Statistics, http://www.bls.gov.

served as a proxy for information reaching consumers from alternative sources. But to account for the fact that this dissemination of information took time, it was modeled in the demand relation by lagging it two quarters (Brown and Schrader 1990). The resulting index was the sum of articles supporting the link minus those questioning the link.

McGuirk et al. (1995) developed a similar annual index for the 1960s through the 1980s using popular press periodicals rather than medical journals. We develop a similar quarterly cholesterol index here for the sample period evaluated. The cholesterol index is assumed to have a cumulative effect so that is can be expressed as:

$$(1) \qquad H_T = \sum_{t=0}^{T} h_t,$$

where h_t represents the individual quarterly counts of articles cited in the *Reader's Guide to Periodical Literature* addressing health problems associated with dietary cholesterol, weighted by the individual periodical subscription levels (figure 3). We agree with McGuirk et al. that popular press articles may serve as a better representation of consumer cholesterol awareness than do articles in professional medical journals. For this study, we looked at the years 1987 through 1995. While the cumulative index increased relatively quickly in the mid to late 1980s, recent years display a less pronounced upward trend. It is hypothesized that the assimilation of this information takes time, and the index is therefore lagged two quarters in the forthcoming model.

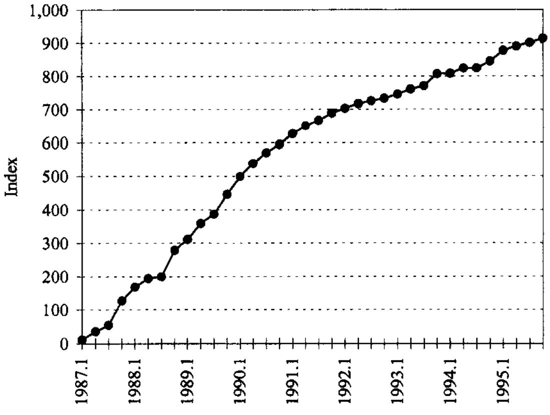

Figure 3. Popular Press Dietary Cholesterol Concern Index

The Empirical Model of Domestic Demand

The retail demand for eggs represents the commercial disappearance of eggs and egg products. The domestic demand for eggs is expressed as:

$$(2) \quad D = f(PEGG, DINCPC, PCERL, WOMEN, CHOL, ADV, Q1, Q2, Q3),$$

where D is quarterly per capita egg consumption, $PEGG$ is the real retail price of eggs, $DINCPC$ is real disposable per capital income, $PCERL$ is the real retail price index for cereal and bakery products, $WOMEN$ is the percentage of women employed in the labor force, $CHOL$ is the cholesterol concern index lagged two quarters, ADV is real advertising expenditures by the AEB and CEC per thousand people, and $Q1$, $Q2$, and $Q3$ are quarterly seasonal dummy variables.[4]

Since CEC advertising is directed almost exclusively to state media markets (e.g., television and radio), simple summing of these expenditures with AEB expenditures directed to national media will overstate the total national advertising impact. To more accurately relate advertising effects on national price and demand levels, we proportionately adjust CEC expenditures by the ratio of California to national population levels. While somewhat arbitrary, this approach does allow analysis of egg price and demand components on total generic advertising in the United States. The resulting nationally adjusted expenditures per thousand people are displayed in figure 4.

Empirical Results

The demand equation was expressed in per capita terms and modeled with a double logarithmic functional form. The Box-Cox Power Transformation technique was used to test the appropriateness of the double-log form. The results supported the use of this functional form.[5]

To account for the endogeneity of price and

[4] Income data were collected from *Economic Indicators,* prepared for the Joint Economic Committee by the Council of Economic Advisors (Washington, D.C.: U.S. Government Printing Office, January 1987–January 1996); on-line, http://www.access.gpo.gov/congress/con.002.html. Price, consumption, and production variables were collected from the USDA, Economic Research Service, *Poultry Yearbook,* no. 89007B, March 1997; on-line database, http://www.usda.mannlib.cornell.edu/data-sets/livestock/89007. All price and income variables are deflated by the CPI for all items, while advertising expenditures are deflated by a quarterly media cost index provided by Leo Burdett Media, Inc. A time trend was excluded from the initial specification because of its high correlation with other structural change component variables.

[5] The Box-Cox Power Transformation is expressed as:

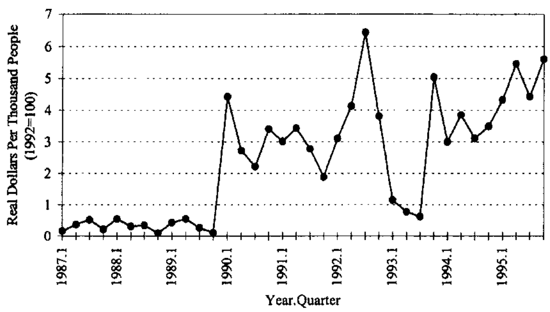

Figure 4. Real Quarterly National Equivalent Advertising Per Thousand People

quantity in demand, the original demand equation was estimated using two-stage least squares (2SLS) on quarterly data from 1987 through 1995.[6] Lagged advertising levels, population, egg production, and stock levels were included in the instrument set in addition to the predetermined variables in (2). To capture supply-side influences we also used farm-level wage rates, feed prices, chick populations, and layer productivity in the instrument set.[7]

Lagged advertising expenditures were included to account for delays in the demand response to advertising (see, for example, Forker and Ward 1993, p. 169). To mitigate the effect of multicollinearity among the lagged advertising variables, and following previous studies in generic commodity advertising (e.g., Ward and Dixon 1989), the lag weights were approximated using a second-degree polynomial with both endpoints restricted to zero. In this manner, only one advertising parameter had to be estimated.

The lag length was determined using a sequential procedure. The model was first estimated with six lags and no restrictions on the lag structure (i.e., without the polynomial and endpoint restrictions), and the null hypothesis that the coefficient on the last lag was equal to zero was tested using a t-test. Next, the lag length was sequentially reduced and the test repeated until the null hypothesis could be rejected at the 5% significance level. Based on the results of this testing procedure, three lags were included in the final model specification. In general, the advertising influences can be expressed as:

$$(3) \qquad D = \alpha + \sum_{i=0}^{3} \beta_i ADV_{t-i} + e_t,$$

subject to:

$$(4) \qquad \beta_i = \delta_0 + \delta_1 i + \delta_2 i^2 \text{ and}$$

$$(5) \qquad \beta_{-1} = \beta_4 = 0,$$

where α represents the additional parameters in the estimation outside of advertising. Equations (4) and (5) represent the polynomial distributed lag structure and endpoint restrictions, respectively. We were unable to reject the null hypothesis that the endpoint restrictions are zero using an F-test. The tail probability associated with the calculated test statistic was 1.80, compared with a critical value of 3.40 at a 5% significance level.

The resulting model (table 1) explained nearly 80% of the variation in consumption, and all the parameters had expected signs. The estimated parameter on disposable income had a positive sign, indicating eggs are a normal good, but the parameter estimate was not significantly different from zero. The women in the labor force variable seems to support Stillman's hypothesis (1987) (inverse relationship with demand); however, the estimate was insignificant as well.[8]

The relationship between consumption and price was significant and negatively related, displaying a highly inelastic response of –0.08. This value is lower (in absolute value) than that of Chavas and Johnson (1981) (–0.31), estimated from data over

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$$y^{(\lambda)} = \begin{Bmatrix} (y^\lambda - 1)/\lambda & \lambda \neq 0 \\ \ln y & \lambda = 0 \end{Bmatrix}.$$

Likelihood ratio tests (Judge et al. 1988) reject the hypothesis that the transformation is linear ($\lambda = 1$) but fail to reject the hypothesis that the transformation is logarithmic ($\lambda = 0$) at the 5% significance level. Test statistics are 10.57 and 0.29, respectively, with a chi-square critical value of 3.84.

[6] The exogeneity of price was tested by estimating the reduced-form equation by ordinary least squares (OLS), treating all variables as predetermined. The residuals from this estimation were added as another regressor in the structural equation, and then the auxiliary model was estimated by OLS. The null hypothesis that the parameter of the residual variable is zero, i.e., price is exogenous, was rejected at a 5% significance level, supporting the use of 2SLS estimation.

[7] The additional instrumental variables were collected from the USDA, Economics and Statistic System, *Poultry Yearbook*, no. 89007B, March 1997, online database; and the USDA National Agricultural Statistics Service, Revised Prices Received and Paid Indexes, *Statistical Bulletin* 917, January 1995, http://usda.mannlib.cornell.edu/data-sets/crops/95917, and Agricultural Prices, monthly January 1993–January 1996, http://mann77.mannlib.cornell.edu/reports/nassr/price/pap-bb/.

[8] The Durbin-Watson statistic of 1.62 was in the inconclusive region of the test. We estimated an auxiliary specification including the original equation's vector of residuals, lagged one quarter. The null hypothesis of no autocorrelation for a given equation is rejected if the coefficient on the lagged residual is significant based on a t-test (Godfrey 1988, pp. 181–82). The t-test failed to produce a significant estimate on the lagged residual ($\alpha = 0.05$), so first-order autocorrelation was assumed not to be a significant problem. We test for heteroskedasticity by evaluating whether autocorrelation in the variances exists. This test was conducted for two- and three-period lags, where the residuals squared were regressed on lagged residuals squared, lagged one and two, and one, two, and three periods, respectively. In both cases, the calculated F-statistics (0.04 and 0.02, respectively) were well below the critical F-statistic of 4.54.

Table 1. Estimated Model Results of National Per Capita Egg Demand[a,b]

Variable	Description	Parameter	Std Error	t-Statistic
Intercept		0.411	1.547	0.27
DINCPC	Disposable per capital income	0.179	0.213	0.84
PEGG	Retail price of eggs	−0.083	0.025	−3.30
PCERL	Retail price index for cereal and bakery products	0.832	0.358	2.33
Q1	Quarter 1 dummy variable	−0.030	0.005	−6.50
Q2	Quarter 2 dummy variable	−0.041	0.005	−8.42
Q3	Quarter 3 dummy variable	−0.029	0.005	−6.20
WOMEN	Percentage of women employed in labor force	−0.307	0.266	−1.15
$CHOL_{-2}$	Cholesterol concern index	−0.048	0.011	−4.59
ADV[c]	Advertising expenditures	0.0013	0.0006	2.01
ADV_{-1}		0.0019	0.0009	2.01
ADV_{-2}		0.0019	0.0009	2.01
ADV_{-3}		0.0013	0.0006	2.01
R^2	0.849			
Adjusted R^2	0.783			
DW	1.62			

[a]All variables are transformed by their natural logarithm. The dependent variable represents quarterly per capita egg consumption.
[b]All price and income variables are deflated by the Consumer Price Index for all items. Advertising expenditures are deflated by a quarterly media cost index provided by Leo Burdett Media, Inc.
[c]Advertising expenditures are expressed as a quadratic polynomial distributed lag with both endpoints restricted to zero; the above coefficients are calculated from the estimated parameter.

twenty years earlier. However, the elasticity estimate is within the range given by Brown and Schrader (1990) (−0.02 to −0.17), and is nearly identical to Wohlgenant's estimate (1982) calculated from a complete demand system of farm output.

The coefficient on the price index for cereals and bakery products was positive, indicating that the grouping is a substitute for eggs, and exhibited an inelastic response of 0.83. While inelastic, the estimate is substantially higher than own-price elasticity of demand (in absolute value). The quarterly dummy variables parameter estimates were all significant and indicated that demand was highest in the fourth quarter, due in large part to the holiday season late in the calendar year.

The concern regarding dietary cholesterol was shown to exhibit a significant, negative relationship with the demand for eggs, with an elasticity of −0.05. This result is consistent with Brown and Schrader's estimates (1990), which ranged from −0.05 to −0.11 for eggs, and with the estimates from McGuirk et al. (1995) for beef, pork, and chicken, which were −0.01, 0.01, and 0.02, respectively. Even though the elasticity measure is relatively small, one needs to look at both the elasticity as well as the change in the level of the index to determine the overall effect. For example, between 1988 and 1995, the cholesterol concern index increased approximately 400% (figure 3). Multiplying this increase by the associated cholesterol elasticity results in a predicted decrease, *ceteris paribus*, in egg consumption of 19%. Actual consumption over this same time period decreased approximately 10% (figure 1). Thus, it appears that most of the observed change in egg demand can be explained by dietary cholesterol concerns. This result is consistent with Brown and Schrader (1990), who estimated that cholesterol information decreased per capita egg consumption by 16% between 1955 and 1987.

Finally, the estimated coefficient for generic advertising had a positive and significant effect on per capita egg demand over the time period evaluated.[9] The elasticity was calculated as the sum of the current and lagged advertising coefficients, and resulted in an overall elasticity of 0.006. Since both the advertising and cholesterol elasticities relate to information (good versus bad), it is useful to compare them. Dividing the cholesterol information elasticity by the advertising elasticity results in a value of −7.5, suggesting that consumers are over seven times more sensitive to negative information

[9] Given the large increase in advertising expenditures after 1989, a Chow test for equality of regression coefficients between the pre-1990 and post-1989 time periods was conducted. Results indicated that the advertising coefficients do differ between the two time periods at a 5% significance level (computed F-statistic of 9.5). However, the model estimated here is comparable to previous studies and, given limited degrees of freedom, we elected not to use a time-varying parameter model. The estimated model was assumed adequate for benefit-cost ratio simulation.

than to positive information. These results are consistent with a test of attribution theory by Chang and Kinnucan (1991) for the case of butter consumption, where they found that consumers were about four times more sensitive to negative information than to positive information.

Estimating Benefit-Cost Ratios to Advertising

While the estimated results indicated a positive and statistically significant impact of generic egg advertising on consumption, what remains a key concern to egg producers is the impact advertising has had on producer returns, i.e., a benefit-cost analysis of generic advertising. To evaluate this impact, an estimate of the supply response by egg producers is necessary.

Defining the Supply Response

Efforts were made to estimate a system of equations incorporating both the supply and demand for eggs; however, a number of unexpected signs and high standard errors resulted. As a result, supply-side variables were included as instruments in the demand specification, and the supply response was incorporated using a constant elasticity form. Subsequently, sensitivity analysis was conducted on a range of own-price supply elasticities.

The simulation procedure begins on the demand side, where predicted quantities of egg demand (Q_t*) were estimated from the demand above.[10] Then, using a procedure similar to that in Alston et al. (1996), supply was defined in constant elasticity form and equated with the predicted demand quantities, accounting for the other exogenous determinants of supply. Changes in demand due to advertising then affects the level of production and resulting producer price. Specifically, the supply function was defined as:

$$(6) \qquad Q_t = A_t R_t^{\varepsilon},$$

where $A_t = (Q_t^* + CS_t + NX_t + HU_t)/R_t^{\varepsilon}$ and

$$(7) \qquad R_t = P_t - \delta_t,$$

where R_t is the producer return per dozen eggs in quarter t, ε is the supply elasticity, and δ_t is the assessment rate required to finance the advertising expenditures. The change in stocks (CS_t), net exports (NX_t), and eggs used for hatching (HU_t) are included as exogenous factors to close the model. The defined value, A_t, varies by quarter and ensures that, given the actual values of prices and other variables, the supply equation passes through the quantity defined by Q_t*. This allows combining the supply response and estimated demand model to simulate past prices and quantities.

To estimate a supply response, an estimate of the own-price elasticity of supply was necessary. Reberte, Schmit, and Kaiser (1996), and Schmit, Reberte, and Kaiser (1997) estimated supply elasticities of 0.02 and 0.05 for national and California egg production, respectively. These estimates are consistent with estimates by Schrader et al. (1978) and Salathe, Price, and Gadson (1983) in the late 1970s and early 1980s; however, Chavas and Johnson (1981) estimated a long-run supply elasticity of nearly one. Given the high degree of vertical integration in the poultry sector, some would argue that the supply of eggs is quite sensitive to changes in price. However, egg production under contract to market firms or carried out as only one phase within vertically integrated operations may contribute less elastic responses to changes in price (Salathe, Price, and Gadson 1983). Furthermore, empirical estimates of supply elasticities are generally lower for products with few alternative uses (Tomek and Robinson 1990, p. 61); therefore, high capital investment suitable only for egg production may prohibit large production adjustments. Given this ambiguity regarding the ''actual'' price elasticity of supply, ε is varied over a wide range of values, from 0.5 to 5.0.[11]

Simulated Results

Since we are concerned with net effects at the margin, the defined model above was simulated under two alternative scenarios to calculate marginal benefit-cost ratios of advertising: (1) with actual, inflation-adjusted advertising expenditures, and (2) with a 1% increase in advertising expenditures.[12] Following this simulation, the change in net economic benefits due to the 1% increase in advertising was computed for each quarter in the sample period as the difference in producer surplus between the two scenarios, i.e.:

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[10] Technically, the natural logarithm of per capita egg demand was estimated. This value was then converted to level terms and multiplied by the resident population to determine total egg consumption.

[11] While the lower bound supply elasticity estimate is above those estimated in previous research, the resulting benefit-cost ratios would provide even higher estimates than those described in table 2. Furthermore, the estimated parameters associated with the supply elasticities in both Reberte, Schmit, and Kaiser (1996) and Schmit, Reberte, and Kaiser (1997) were insignificant. In any case, estimated responses around Chavas and Johnson's estimate (1981) of 0.94 are deemed appropriate.

[12] The model was simulated in SAS using the simulation procedure in PROC MODEL.

Table 2. Generic Egg Advertising Constant Elasticity Benefit-Cost Ratios from Model Simulations

	Supply Elasticities						
Item	0.5	1.0	1.5	2.0	3.0	4.0	5.0
	$	$	$	$	$	$	$
0% Compounding							
Change in producer surplus	2,689	1,345	896	672	448	336	269
Change in advertising	218	218	218	218	218	218	218
Benefit-cost ratio	12.31	6.16	4.10	3.08	2.05	1.54	1.23
Bias correction factor[a]	6.03	3.24	2.22	1.68	1.14	0.86	0.69
Trade adjusted benefit-cost ratio	6.28	2.92	1.88	1.40	0.91	0.68	0.54
5% Compounding							
Change in producer surplus	3,154	1,577	1,051	788	525	394	315
Change in advertising	255	255	255	255	255	255	255
Benefit-cost ratio	12.36	6.18	4.12	3.09	2.06	1.54	1.23
Bias correction factor[a]	6.03	3.24	2.22	1.68	1.14	0.86	0.69
Trade adjusted benefit-cost ratio	6.33	2.94	1.90	1.41	0.92	0.68	0.54

[a]The bias correction factor (B) is based on Kinnucan and Christian (1997) to account for trade ignored in the model, where $B = \delta_a(V/A_d)/(\epsilon-\eta_d)$; δ_a is the domestic advertising elasticity (0.006), V is farm revenue ($2,752 million annual average), A_d is total advertising expenditures ($4.72 million annual average), ϵ is the own-price elasticity of supply, and η_d is the domestic demand elasticity (−0.08).

(8) $$\Delta PS_t = \frac{R_t'Q_t' - R_tQ_t}{1+\varepsilon}.$$

the dynamic simulation of the model accounted for both the impact of the checkoff assessment on producers' costs and the production response to changes in egg price from advertising.[13] It was assumed that any funds necessary to increase advertising expenditures resulted from a compensating adjustment in the assessment rate. Since these benefits could have been further invested to generate interest income, the past benefits and costs were compounded forward to the present. Net returns were calculated using compounding rates of 0 (simple sum over t periods) and 5%, a reasonable range of returns for long-term, secure rates of interest.

Benefit-cost ratios of advertising ranged from 12.3 to 1.2 over the entire range of supply elasticities (table 2). Since these values represent the ratio of marginal benefits to marginal costs, values greater than 1 represent scenarios where additional returns exceed the additional costs of the program. Although the benefit-cost ratios vary widely by the assumed level of supply elasticity, it should be important to egg producers that the estimated returns were above 1 over the entire range. By compounding past benefits and costs to the present, marginal returns increased only slightly, so our remaining attention will be directed toward the 0% compounding results.

On the one hand, assuming a unitary elastic supply response by egg producers to a change in price ($\varepsilon = 1.0$), the benefit-cost ratio is over 6. On the other hand, assuming more elastic responses, benefit-cost ratios decrease from 3.1 ($\varepsilon = 2.0$) to 1.2 ($\varepsilon = 5.0$). Consistent benefit-cost ratios over 1 indicate that the advertising programs operated by the AEB and the CEC have benefited producers and positively affected national price and consumption levels.

However, further attention must be directed toward these return levels, especially given that export trade was ignored in the calculations. Even though net exports are modest (4% of production), ignoring trade will cause returns to advertising to be overstated (Kinnucan and Christian 1997). Kinnucan and Christian derived a procedure to estimate the returns bias from ignoring trade, which can be expressed as:

(9) $$B = k_x\delta_a(V/A_d)(\varepsilon - \eta_x)/[(\varepsilon - \eta_d)(\varepsilon - k_d\eta_d - k_x\eta_x)],$$

where B is the bias from ignoring trade (positive for normal-sloping supply and demand curves), k_d and k_x are the proportions of production sold in the domestic and export markets, δ_a is the domestic advertising elasticity (0.006), V is farm revenue ($2.752 million annual average), A_d is total domestic advertising expenditures ($4.7 million annual average), ε is the domestic supply elasticity, and

[13] As noted by a reviewer, this return formula fails to take into account tax shifting, which would be significant for the higher supply elasticity estimates and highly inelastic demand. As supply elasticities are decreased from the upper level of 5.0, this incidence is reduced. We chose to avoid this consequence for this paper, but it should be considered for future model applications and considered when interpreting simulation results.

η_d and η_x are the domestic and export demand elasticities. As detailed in Kinnucan and Christian, if we assume that the United States is a small-country exporter, then $\eta_x = -\infty$ and (9) simplifies to:

$$B = \delta_a(V/A_d)/(\varepsilon - \eta_d). \quad (10)$$

Thus, as can be seen by equations (9) and (10), if the advertising intensity (A_d/V) is low, as is the case for eggs, the bias can be substantial, even if export shares and advertising elasticities are small (Kinnucan and Christian 1997). Based on these formulae, bias correction factors were estimated for each supply elasticity assumed in table 2. Bias correction factors ranged from around six at low supply elasticities to just over one-half at the upper end of the range. At the unitary supply elasticity level, the bias correction factor was 3.2, reducing the benefit-cost ratio from 6.2 to 2.9. As such, benefit-cost ratios dropped below 1 once the supply elasticity exceeded 2. Even so, the earlier conclusion is reinforced with this benefit-cost ratio adjustment; i.e., positive returns to advertising exist, but they are highly dependent on the level of producer response to price. At supply elasticities above 2, negative returns to advertising occurred.

Since the benefit-cost ratios also depend on the magnitude of the advertising parameter estimates in the demand model, which in turn have a standard error associated with them, one can estimate confidence intervals of the benefit-cost ratios. Specifically, we adjusted the advertising parameter estimates in the model by subtracting (adding) from (to) them the standard error estimates multiplied by the corresponding t-statistic to estimate the lower (upper) bound of advertising net benefits.[14] In this case, benefit-cost ratios drop considerably for the lower bound of advertising. In fact, benefit-cost ratios are consistently below 1 in the elastic range of own-price supply response (table 3). However, if own-price elasticities of supply are inelastic or are approximately unitary elastic, the benefits of advertising exceed its costs throughout this interval. While this depicts a lower bound on returns, it does indicate that net positive effects to advertising are highly dependent on the assumed producer reaction to changes in price. Furthermore, if we apply the bias correction factor derived by Kinnucan and Christian (1997) to the lower bound estimates, benefit-cost ratios are consistently below 1 for all elasticities evaluated.

[14] Specifically, given the polynomial distributed lag structure with endpoints restricted to zero, only one parameter is estimated in the model. From this, parameter estimates and the associated standard errors were calculated for the current and lagged advertising variables. Then the standard errors for the individual advertising coefficients were used to adjust the parameter estimates as described above. The "revised" model was then used to predict the change in returns.

Table 3. Benefit-Cost Ratios over a 95% Confidence Interval of Advertising[a]

	Supply Elasticity		
Descriptor	1.00	1.50	2.00
95% Confidence interval range[b]			
Lower bound			
Change in producer surplus	293	196	147
Change in advertising	218	218	218
Benefit-cost ratio	1.34	0.90	0.67
Upper bound			
Change in producer surplus	2,427	1,616	1,212
Change in advertising	218	218	218
Benefit-cost ratio	11.11	7.40	5.55

[a]The 95% confidence interval estimates are based on adding and subtracting the advertising standard error estimates multiplied by the respective t-statistic to the original parameter estimates and simulating the model based on the revised advertising parameters.

[b]Although not shown here, for all elasticity values, all lower bound return estimates drop below one when accounting for trade based on the Kinnucan and Christian (1997) bias correction factor; however, all upper bound estimates remain above one.

Conclusions

A statistical model of the domestic demand for eggs and egg products was estimated from quarterly data from 1987 through 1995, incorporating an index of consumer dietary cholesterol concerns and generic advertising efforts by the American Egg Board and the California Egg Commission. To defend the egg's place in the consumer diet, national generic egg advertising efforts have increased considerably since the late 1980s.

Econometric results indicated a significant negative relationship between the per capita demand for eggs and both cholesterol concern and the price of eggs. Empirical results indicated that most of the observed change in egg demand could be explained by dietary cholesterol concerns over the time period evaluated. Net of this effect, generic advertising expenditures were shown to have a significant positive, although inelastic, effect on the per capita demand for eggs. Comparing the cholesterol (−0.05) and advertising (0.006) elasticities indicated that consumers are over seven times more sensitive to negative information than to positive information.

Simulating the estimated demand model in a constant elasticity supply framework demonstrated that national generic advertising expenditures positively affected net producer returns, but the level was highly dependent on the assumed level of supply response. Benefit-cost ratios were shown to be above one for elasticities of supply up to five; however, when accounting for the bias from ignoring trade in the model these ratios drop below one at elasticities above two. Benefit-cost ratios calculated on a 95% confidence interval of advertising's parameter estimates indicated a lower bound of positive net producer benefits being depleted at supply elasticities above one. When trade bias was considered, benefit-cost ratios were consistently below one over all supply elasticities evaluated.

In light of the barrage of negative publicity in the past, advertising efforts over the past several years have brought net benefits to egg producers largely when inelastic supply responses are considered. Considering trade bias reduces benefit-cost ratios substantially. Future research and model developments on generic advertising and changes in producer returns should include trade flows, tax-shifting effects, and estimated supply responses to more accurately estimate net producer benefits.

References

Alston, J.M., J.A. Chalfant, J.E. Christian, E. Meng, and N.E. Piggott. 1996. "The California Table Grape Commission's Promotion Program: An Evaluation." In *Economic Evaluation of Commodity Promotion Programs in the Current Legal and Political Environment,* pp. 33–62. Proceedings of the NEC-63 Fall Meeting, October 8, Monterey, Calif.

Blaylock, J., and C. Burbee. 1985. *Consumer Demand for Eggs and Market Implications.* Washington, D.C.: USDA, Economic Research Service, AGES 850924. November.

Brown, D.J., and L.F. Schrader. 1990. "Cholesterol Information and Shell Egg Consumption," *American Journal of Agricultural Economics* 72:548–55.

Chang, H.-S., and H.W. Kinnucan. 1991. "Advertising, Information, and Product Quality: The Case of Butter." *American Journal of Agricultural Economics* 73:1195–1203.

Chavas, J.-P., and S.R. Johnson. 1981. "An Econometric Model of the U.S. Egg Industry." *Applied Economics* 13: 321–35.

Chyc, K.M., and E.W. Goddard. 1994. "Optimal Investment in Generic Advertising and Research: The Case of the Canadian Supply-Managed Egg Market." *Agribusiness* 10: 145–66.

Forker, O.D., and R.W. Ward. 1993. *Commodity Advertising: The Economics and Measurement of Generic Programs.* New York: Lexington Books.

Godfrey, L.G. 1988. *Misspecification Tests in Econometrics: The Lagrange Multiplier Principle and Other Approaches.* New York: Cambridge University Press.

Judge, G.G., R.C. Hill, W.E. Griffiths, H. Lutkepohl, and T.-C. Lee. 1988. *Introduction to the Theory and Practice of Econometrics.* 2d ed. New York: John Wiley and Sons, Inc.

Kinnucan, H.W., and J.E. Christian. 1997. "A Method for Measuring Returns to Nonprice Export Promotion with Application to Almonds." *Journal of Agricultural and Resource Economics* 22:120–32.

McCutcheon, M.L., and E. Goddard. 1992. "Optimal Producer and Social Payoff from Generic Advertising: The Case of the Canadian Supply-Managed Egg Sector." *Canadian Journal of Agricultural Economics* 40:1–24.

McGuirk, A., P. Driscoll, J. Alwang, and H. Huang. 1995. "System Misspecficiation Testing and Structural Change in the Demand for Meats." *Journal of Agricultural and Resource Economics* 20:1–21.

Miller, B.R., and G.C. Masters. 1973. "A Short-Run Price Prediction Model for Eggs." *American Journal of Agricultural Economics* 55:484–89.

Reader's Guide to Periodical Literature. 1987–96. Bronx: H.W. Wilson Company. Various issues.

Reberte, J.C., T.M. Schmit, and H.M. Kaiser. 1996. "An Ex Post Evaluation of Generic Egg Advertising in the United States." In *Economic Evaluation of Commodity Promotion Programs in the Current Legal and Political Environment,* pp. 83–100. Proceedings of the NEC-63 Fall Meeting, October 8, Monterey, Calif.

Roy, S.K., and P.N. Johnson. 1973. "Econometric Models for Quarterly Shell Egg Prices." *American Journal of Agricultural Economics* 55:209–13.

Salathe, L.E., J.M. Price, and K.E. Gadson. 1983. "The Food and Agricultural Policy Simulator: The Poultry- and Egg-Sector Submodel." *Agricultural Economics Research* 35: 23–34.

Schmit, T.M., J.C. Reberte, and H.M. Kaiser. 1997. "An Economic Analysis of Generic Egg Advertising in California, 1985–1995." *Agribusiness* 13:365–73.

Schrader, L.F., H.E. Lanzelere, G.B. Rogers, and O.D. Forker. 1978. "The Egg Subsector of U.S. Agriculture: A Review of Organization and Performance." NCR Research Publication no. 258, NC-117 Monograph no. 6. June.

Smith, R. 1993. "AEB, ENC Getting OK for Consumers to Eat More Eggs." *Feedstuffs* 65:1, 4.

Stillman, R.P. 1987. *A Quarterly Forecasting Model of the U.S. Egg Sector.* Washington, D.C.: USDA, Economic Research Service, Technical Bulletin no. 1729. September.

Tomek, W.G., and K.L. Robinson. 1990. *Agricultural Product Prices.* 3d ed. Ithaca: Cornell University Press.

Ward, R.W., and B.L. Dixon. 1989. "Effectiveness of Fluid Milk Advertising since the Dairy and Tobacco Adjustment Act of 1983." *American Journal of Agricultural Economics* 71:730–40.

Wohlgenant, M.K. 1982. "Demand for Farm Output in a Complete System of Demand Functions." *American Journal of Agricultural Economics* 71:250–51.