Economic Evaluation of Commodity Promotion Programs in the Current Legal and Political Environment

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An Ex Post Evaluation of Generic Egg Advertising in the U.S.

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Since 1976, U.S. egg producers have paid a mandatory assessment to finance the national egg promotion program operated by the American Egg Board (AEB). In 1994, producers voted to increase this assessment from 5 to 10 cents per 30 dozen cases marketed and to raise the producer exemption level from 30,000 to 75,000 laying hens.[1] Annual checkoff revenues under the revised scheme, which started in February 1995, are expected to increase from around 7 million to nearly 14 million dollars.

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 percent of checkoff income, while nearly 40 percent was spent on research and consumer education. Since 1990, the emphasis has shifted towards a larger share of the budget devoted to advertising. Annual nominal advertising expenditures, which exceeded $3 million in 1990 and 1991, increased to more than $5.5 million in 1992 (Figure 1). After a drop to $2.4 million in 1993, expenditures increased to over $4.8 million in 1994, and through the first three quarters of 1995 totaled almost $5.8 million. More than 50 percent of assessment revenues are now allocated to advertising efforts.

Egg advertising has been, and continues to be, developed under a defensive strategy to counter negative publicity stemming from the relatively high level of cholesterol in eggs. The fact that per capita consumption has remained stable over the past several years despite declining real egg prices casts doubt on the program's success. Recent consumer tracking studies, however, have found consumers' negative attitudes towards eggs are no longer increasing (Smith). The sharp increase in egg advertising expenditures in recent years, coupled with conflicting evidence about the program's effectiveness, stress the need for economic analysis of the AEB's advertising efforts. Measuring the impact of generic egg advertising on producer profits is particularly crucial as the AEB

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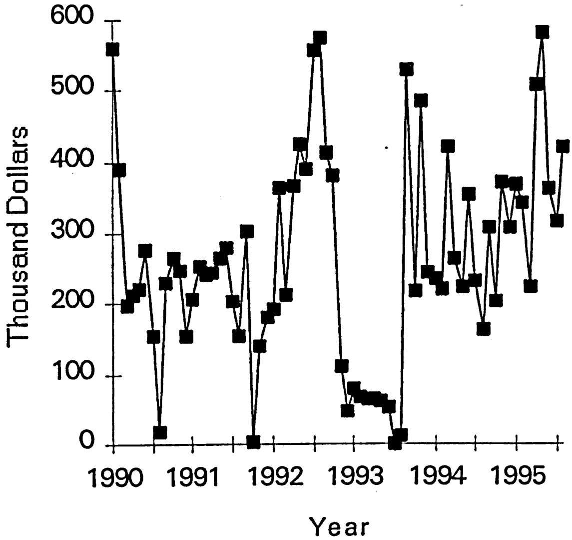
[1] Currently, the checkoff assessment amounts to about 0.75 percent of the farm price.

determines how to allocate the additional assessment revenues generated by the recent increase in the checkoff rate.

Figure 1. Real AEB Monthly Expenditures (1984=100)



Various studies in the 1970s and 1980s developed economic models of the U.S. egg industry (e.g., Miller and Masters; Roy and Johnson; Chavas and Johnson; Salathe et. al.; Blaylock and Burbee; Stillman). As the concern over cholesterol heightened, Brown and Schrader estimated an econometric model for the egg industry and found that information on the links between cholesterol and heart disease had a significant, negative impact on consumer demand for eggs. Since generic egg advertising expenditures were negligible before 1990, none of these studies measured the impact of promotion on farm-level prices and producers' profits. Generic egg advertising has been studied recently by McCutcheon and Goddard, and Chyc and Goddard. But these studies have dealt with the Canadian supply-managed egg sector. This paper addresses the need for a more current analysis of the U.S. egg industry incorporating the influence of the AEB's advertising program.

The Model, Data, and Econometric Results

The econometric model estimated here is similar in structure to the one developed in Chavas and Johnson--arguably the most complete model of the U.S. egg industry in the literature. A major difference with the Chavas and Johnson study is how the present model incorporates generic egg advertising expenditures. Also, the model is estimated using monthly data from 1990 through the third quarter of 1995 to provide a current analysis of the U.S. egg sector.[2] Table 1 displays the model along with the estimated parameters, t-values, and selected elasticities. Table 2 presents the variable definitions and data sources. All prices and income were deflated by the consumer price index (1982-84=100). Advertising expenditures were deflated by a media cost index.

The structural model includes production (along with the prices and consumption components) of the industry for both whole and processed egg products. It is assumed that production is predetermined at each time period and that production decisions are based on naive price expectations. The prices and consumption component of the model contains seven behavioral equations and one identity. Prices, breaking egg production, and stocks are simultaneously determined in this segment of the model. Following Chavas and Johnson, and Stillman, it is assumed that wholesale prices lead farm and retail prices.

Based on the above considerations, the price, breaking egg production, and stocks equations were estimated using three stage least squares (3SLS). The procedure suggested by Godfrey (pp. 181-182) was used to test for first-order autocorrelation. This procedure requires first obtaining each equation's vector of residuals and then re-estimating the model including the corresponding lagged residual as an additional regressor in each equation. 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. The results of this testing procedure

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[2] The AEB allocated only $12,500 to generic egg advertising in 1987. In 1988 and 1989 there were no AEB advertising expenditures.

indicated that the residuals of the egg production, wholesale price of frozen eggs, and demand for hatching eggs equations exhibited autocorrelation. A first-order autocorrelation correction procedure was subsequently used to estimate these equations.

Production is specified as a function of hatching, the average feed price and farm price of eggs for the previous five months, 11 monthly dummy variables, a time trend, and layer productivity. Egg production is a sequential process: from the primary breeder flock, chicks are placed into the hatchery supply flock, which in turn produces the chicks for the laying flock. The number of egg-type chicks hatched in past periods serves both as a measure of production capacity and of the composition of the laying stock. The lag structure imposed on the hatching variable reflects the time pattern of egg production. About a month accrues between the shipment of eggs to the hatchery and placement of chicks in the laying flock. Egg production begins five months later and continues for 12 months on average. As detailed in Chavas and Johnson, the average layer productivity changes over the production cycle. Production begins at a relatively low level, peaks by the third month of production, and falls steadily until the end of the production cycle, around the twelfth month. This cycle was imposed via exact restrictions on the lag coefficients of the hatching variable and the equation was estimated using restricted least squares (RLS).[3] The feed price is a weighted average of the prices of corn and soybean meal assuming a 85/15 blend ratio. Although this imparts some rigidity on the model, it eliminates the collinearity problem associated with the corn and meal price series. The inclusion of the five months moving averages of the feed price and farm price of eggs is dictated by the naive price expectations assumption and by the fact that there is a five month lag between placement of chicks in the laying flock and the beginning of the production cycle. The time trend serves as a proxy for technological change.

As expected, the estimated coefficients show that egg production is positively related to hatching, the farm price in the previous periods, and layer productivity, and negatively related to the feed price. The value of the production

[3] The restrictions are based on productivity changes throughout the layer cycle as provided by Chavas and Johnson (see footnote 2, p.325). Quarterly restrictions were extrapolated to fit the monthly data used in this study.

elasticity with respect to farm price at sample mean levels (0.014) suggests a highly inelastic supply curve. This finding is not surprising given the biological and economic constraints that limit production adjustments (Salathe, Price, and Gadson).

The farm and retail price equations reflect the wholesale price leader assumption by including both current and lagged wholesale prices as explanatory variables. In Chavas and Johnson's words (p. 333), the farm and retail prices are "derived" from wholesale prices through margin equations. The positive and highly significant coefficients on wholesale prices coupled with R^2 values above 0.90 for both equations seem to support this approach. There is no obvious explanation for the positive and significant coefficient on the time trend in the farm price equation, considering the steady decline in real egg prices over the last two decades. The farm price appears to be more responsive to changes in wholesale prices rather than retail price. This finding reflects the direct connection between the farm and wholesale levels. The latter is the major market where the producer sells the product. Also, a large proportion of eggs are marketed through a vertically integrated system and egg producers tend to price their product near their cost of production.

The wholesale shell eggs price equation models the demand for eggs in price dependent, mixed form. The explanatory variables in this equation include the total domestic consumption of whole eggs and egg products, and various consumer demand shifters: disposable income, retail prices of beef and pork, monthly dummy variables, the proportion of women in the workforce, and the natural logarithm of generic advertising expenditures by the AEB.[4] All estimated coefficients exhibit expected signs. Consumption and wholesale price are negatively related. The estimated parameter on disposable income is positive,

[4] In preliminary estimation, two additional variables were included in this equation to model the impact of health and nutritional concerns about cholesterol on eggs consumption: a) an index, constructed by Ward based on survey data, which measures the percentage of consumers expressing strong or moderate concern about cholesterol in their diets; and b) a time trend. Both variables exhibited positive coefficients when they were included jointly or separately. Also, in each case, the coefficient on the consumption variable became positive. Thus, a decision was made to drop both variables from the final model specification.

indicating eggs are a normal good. Retail beef and pork prices exhibit positive coefficients, indicating that both products are substitutes for eggs. A plausible explanation for the positive coefficient on the proportion of women in the workforce is that when the number of working women increases, so does the number of breakfasts eaten away from home (Brown and Schrader). Recent surveys for the AEB indicate that consumers are more likely to have eggs for breakfast when they eat this meal away from home.

Generic egg advertising expenditures are included in logarithmic form to allow for diminishing marginal returns to advertising. Lagged expenditures are included to account for delays in the demand response to advertising (see, for example, Forker and Ward, 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), the lag weights were approximated using a second degree polynomial with both endpoints restricted to zero. Then, only one advertising parameter had to be estimated. The lag length was determined using a sequential procedure. The model was first estimated with 12 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 10 percent significance level. Based on the result of this testing procedure, ten lags were included in the final model specification. Finally, after imposing the polynomial restrictions, the endpoint restrictions were tested using an F-test. The tail probability associated with the calculated test statistic was .92, indicating nonrejection of the null hypothesis of restrictions adequacy.

The estimated coefficients on advertising expenditures indicate that the AEB advertising program has had a positive and significant impact on egg demand. The long run advertising elasticity, obtained by summing the advertising elasticities evaluated at sample mean levels over all lags, is 0.02. That is, the total impact of a 1 percent increase in advertising expenditures is an increase of 0.02 percent in the wholesale shell egg price. The impact of advertising expenditures on the farm price, farm supply, and producers' profits is discussed below.

The next three behavioral equations involve the egg products component of the industry: wholesale price of frozen eggs, breaking egg production, and ending stocks of frozen eggs. At any given time, wholesalers can market whole eggs, store them, or break them. Broken eggs can be sold or stored as frozen or dried egg products. Again, the wholesale price of shell eggs is assumed to drive the wholesale price of frozen eggs. It is also assumed to influence breaking production decisions. Other explanatory variables in these equations are monthly dummy variables and a time trend. In addition, the breaking egg production equation incorporates the wholesale price of frozen eggs and total egg production. The signs on the estimated coefficients in both equations conform to prior expectations. Wholesale price of shell eggs has a positive impact on the wholesale price of frozen eggs and a negative impact on breaking egg production. A higher breaking price induces an increase in the amount of eggs broken commercially. Breaking egg production appears to be quite inelastic with respect to both prices. Finally, as total egg production increases so does breaking egg production.

The ending stock of frozen eggs is specified as a function of beginning frozen and shell stocks, breaking egg production, monthly dummy variables, and a time trend.[5] An expected price change variable is also included to account for speculative factors affecting the decision to store eggs. Agents are assumed to base their decisions on naive price expectations. Accordingly, the expected price change variable is defined as the difference between the current and previous month price. Beginning inventories and breaking egg production have a positive influence on frozen egg stocks. The coefficient on the expected price change variable is positive, i.e., the larger the expected price increase (decrease) the larger (smaller) the volume of eggs speculators store.

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[5] The model initially included an equation for ending stocks of shell eggs. Most of the coefficients in that equation were insignificant and/or had signs inconsistent with prior expectations. Moreover, the equation exhibited a very poor in-sample predictive performance (i.e., low R^2 and large percent root mean square simulation error). Given these poor estimation results, shell egg stocks are treated as exogenous in the final model specification. Since whole eggs can be kept in cold storage for up to 30 days and still be considered "fresh," shell egg stocks constitute only a small fraction of total egg production (less than 0.8 percent of total production on average over the sample period).

The final estimated equation is the total demand for hatching eggs (for both egg-type and broiler-type chickens). Quantity demanded is specified simply as a function of hatching egg-type and broiler-type chicks, along with monthly dummy variables and a time trend. As expected, the number of egg and broiler-type chicks hatched has a positive impact on the demand for hatching eggs.

The egg utilization identity completes the model. This identity defines total domestic consumption of eggs as the sum of total egg production and the change in storage stocks, less net exports and eggs used for hatching.

Model Validation

To determine the predictive ability of the estimated model, a dynamic in-sample simulation was conducted to measure how well the model replicated the historical values of the endogenous variables.[6] Table 3 presents the percent root mean square simulation error (%RMSE), the mean square simulation error (MSE), and Theil's U^m, U^r, and U^d prediction decomposition measures for all endogenous variables. The %RMSE measures are, in general, acceptable; all variables have %RMSE's below 10 percent. Table 3 also shows an acceptable distribution of the MSE decomposition proportions. For most variables, the proportions corresponding to the bias (U^m) and regression (U) components are quite small. These results indicate that the estimated model is adequate for simulation purposes.

Farm-Level Impacts

The estimation results discussed above show that generic egg advertising had a positive impact on *gross* producers' revenues over the sample period. However, the relevant measure of the effectiveness of a generic commodity promotion program is the magnitude of its impact on *net* producers' revenues. To measure the latter, the estimated model was simulated under two alternative scenarios: (1) with actual, inflation-adjusted advertising expenditures, and (2) with a 1 percent increase in expenditures. Then, the change in net economic benefits due to the 1 percent

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

increase in advertising was computed for each month in the sample period as the difference in producers surplus between the two scenarios, i.e.:

$$\Delta PS_t = \Delta GR_t - \Delta C_t$$

where ΔPS is the change in producers' surplus for time period t, ΔGR is the change in gross revenues, and ΔC is the change in production costs. It is worth noting that 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 the farm price due to advertising.[7]

Table 4 shows the average farm price and production for the two simulation scenarios. While a 1 percent change in advertising expenditures resulted, on average, in a .014 percent increase in the farm price, total egg production increased only by .0001 percent. The modest increase in production was due to the small own-price elasticity of supply.

Finally, to evaluate the economic benefits of the AEB promotion program over the 1990-95 period, the marginal internal rate of return (IRR) to advertising was calculated. The IRR is used in this study because it is often used in *ex post* evaluation of research projects and it allows ranking alternative programs in terms of their profitability (Alston, Norton, and Pardey). The marginal IRR to advertising expenditures is the solution to:

[7] To account for the impact of the checkoff assessment on farm supply, the per unit levy was subtracted from the simulated farm price. Note that this approach implies that the simulated gross revenues are net of checkoff payments. The effect of the checkoff charge on producers' costs and the increase in farm production in response to higher prices have been neglected in some empirical studies of generic advertising. For example, the studies by Ward, and Wohlgenant and Clary did not account for supply responses to higher farm prices due to advertising-induced shifts in demand. To our knowledge, no published empirical study has considered the shift in supply due to the checkoff assessment.

$$0 = \sum_{t=0}^{n} \frac{\Delta PS_t - AE_t}{(1 + IRR)^t}$$

where *AE* denotes the change in advertising expenditures (i.e., the dollar amount corresponding to a 1 percent increase in expenditures in period *t*) .[8] Using the above formula, a monthly marginal IRR of 49.1 percent was generated.[9] A program is considered profitable if its IRR exceeds the opportunity cost of the invested funds.

Many studies of commodity promotion programs have calculated marginal returns on investment to advertising simply by dividing the change in gross or net revenues by the change in investment on advertising over the entire period of interest. Since promotion programs have costs and benefits that accrue over time, it would seem more appropriate to calculate returns to advertising by discounting the stream of benefits and costs. However, to facilitate comparisons with results obtained in other commodity promotion studies, marginal returns on investment to advertising were also calculated. For the period from 1990 through the third quarter of 1995, a 1 percent change in advertising expenditures amounts to $0.178 million, and the corresponding change in producers' surplus is $0.836 million. Thus, the farm level marginal return to advertising is 4.69:1, i.e, each additional dollar spent on advertising generates $4.69 in producers' profits. By way of comparison, the rate of return reported by Liu et al., and Ward for the U.S. generic dairy advertising program and the U.S. beef checkoff program were, respectively, 4.77:1 and 6.71:1.

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[8] Since the AEB must cover overhead costs to run the advertising program, they should be included in the IRR calculation. Unfortunately, data on those costs are not available.

[9] It has been noted that the per unit checkoff assessment operates as an excise tax, which implies that part of the costs of the AEB promotion program are borne by consumers (Chang and Kinnucan; Alston, Carman, and Chalfant). For this reason, it may be argued that the IRR calculated in this study underestimates the economic benefits of generic advertising to producers. However, the approach followed here is justified because the AEB had the opportunity to spend the checkoff funds on programs other than advertising (e.g., nutrition research and education).

Summary

A model of the U.S. egg industry was estimated to evaluate the impact of the AEB generic advertising program on producers' returns over the 1990-95 period. The estimated model was simulated under two alternative scenarios: a) with advertising expenditures set at historical levels in real terms, and b) with a 1 percent increase in expenditures. Based on these simulations, changes in producers' surplus due to advertising and marginal returns to advertising expenditures were calculated. Econometric results indicated that the national generic egg promotion program had a substantial impact on wholesale and farm prices. This translated into an estimated marginal IRR of 49.1 percent, and a marginal rate of return on advertising investment of 4.69:1. One limitation of the IRR as a measure of success of the AEB's investment strategy is that IRRs for other AEB programs are not available.[10] Therefore, while the estimated IRR suggests that the AEB's investment on advertising performed well, it is not possible to evaluate the profitability of the advertising program relative to those of alternative programs.

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[10] This is due mainly to the lack of data on the amount of funds allocated to other AEB programs.

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APPENDIX

Table 1. Structural Form And Estimation Resultsa

Egg Production (RLS)

$$PRODN = -46.460 + 0.104\ CHIK_{-6} + 0.119\ CHIK_{-7} + 0.133\ CHIK_{-8} + 0.147\ CHIK_{-9}$$
(-0.75) (1.57) (1.57) (1.57) (1.57)

$$+\ 0.144\ CHIK_{-10} + 0.140\ CHIK_{-11} + 0.137\ CHIK_{-12} + 0.133\ CHIK_{-13} + 0.129\ CHIK_{-14}$$
(1.57) (1.57) (1.57) (1.57) (1.57)

$$+\ 0.126\ CHIK_{-15} + 0.122\ CHIK_{-16} + 0.119\ CHIK_{-17} - 0.151\ AVFEED$$
(1.57) (1.57) (1.57) (-1.36)
[-0.03]

$$+\ 0.162\ AVFARMPR - 1.363\ JAN - 4.422\ FEB - 2.998\ MAR - 5.789\ APR - 7.569\ MAY$$
(0.68) (-1.21) (-0.88) (-1.64) (-2.66) (-4.57)
[0.014]

$$-\ 9.897\ JUN - 9.732\ JUL - 8.319\ AUG - 6.047\ SEP - 2.299\ OCT - 1.346\ NOV$$
(-4.08) (-6.34) (-5.48) (-2.49) (-1.71) (-0.80)

$$+\ 0.479\ TIME + 22.252\ PRDTVTY$$
(6.74) (10.28)
[0.94]

$R2 = 0.99$ $\rho b = -0.884$ (-15.90)

Farm Price (3SLS)

$$FARMPR = -7.293 + 0.744\ WHLPRMET + 0.162\ WHLPRMET_{-1} - 0.067\ JAN + 0.945\ FEB$$
(-3.12) (17.10) (4.28) (-0.12) (1.67)
[0.88] [0.19]

$$+\ 0.592\ MAR + 1.250\ APR + 2.766\ MAY + 2.117\ JUN - 0.201\ JUL - 0.845\ AUG$$
(1.14) (2.12) (4.18) (3.64) (-0.37) (-1.60)

$$-\ 0.724\ SEP + 0.239\ OCT + 0.485\ NOV + 0.043\ TIME$$
(-1.35) (0.41) (0.94) (4.61)

$R2 = 0.96$

Table 1 (Continued).

Retail Price (3SLS)

$$RETPGRDA = \underset{(4.95)}{23.732} + \underset{\substack{(5.75)\\ \lbrack 0.41 \rbrack}}{0.503}\ WHLPRMET + \underset{\substack{(5.05)\\ \lbrack 0.31 \rbrack}}{0.376}\ WHLPRMET_{-1} + \underset{(1.27)}{1.428}\ JAN + \underset{(1.01)}{1.181}\ FEB$$

$$+ \underset{(1.66)}{1.786}\ MAR + \underset{(0.73)}{0.880}\ APR + \underset{(1.45)}{1.970}\ MAY + \underset{(2.25)}{2.789}\ JUN - \underset{(2.32)}{2.244}\ JUL + \underset{(1.99)}{3.882}\ AUG$$

$$+ \underset{(3.55)}{2.289}\ SEP + \underset{(2.08)}{1.734}\ OCT + \underset{(1.43)}{1.363}\ NOV - \underset{(-5.32)}{0.101}\ TIME$$

R2 = 0.92

Wholesale Price Shell Eggs (3SLS)

$$WHLPRMET = \underset{(-3.16)}{-231.850} - \underset{\substack{(-0.83)\\ \lbrack -0.54 \rbrack}}{0.067}\ CONTOT + \underset{\substack{(1.04)\\ \lbrack 0.93 \rbrack}}{0.00001}\ TOTINC + \underset{\substack{(4.37)\\ \lbrack 2.07 \rbrack}}{0.534}\ PBEEF + \underset{\substack{(1.19)\\ \lbrack 0.47 \rbrack}}{0.170}\ PPORK$$

$$- \underset{(-1.78)}{3.314}\ JAN - \underset{(-2.07)}{9.519}\ FEB - \underset{(-1.38)}{2.625}\ MAR - \underset{(-3.10)}{9.018}\ APR - \underset{(-5.73)}{14.686}\ MAY - \underset{(-3.56)}{11.553}\ JUN$$

$$- \underset{(3.67)}{8.106}\ JUL - \underset{(-2.28)}{4.812}\ AUG - \underset{(-1.99)}{5.258}\ SEP - \underset{(-2.72)}{5.272}\ OCT - \underset{(1.60)}{3.310}\ NOV$$

$$+ \underset{(1.24)}{2.467}\ WOMEN + \underset{(2.08)}{0.0250}\ ln(ADV) + \underset{(2.08)}{0.0455}\ ln(ADV)_{-1} + \underset{(2.08)}{0.0614}\ ln(ADV)_{-2}$$

$$+ \underset{(2.08)}{0.0727}\ ln(ADV)_{-3} + \underset{(2.08)}{0.0795}\ ln(ADV)_{-4} + \underset{(2.08)}{0.0818}\ ln(ADV)_{-5} + \underset{(2.08)}{0.0795}\ ln(ADV)_{-6}$$

$$+ \underset{(2.08)}{0.0727}\ ln(ADV)_{-7} + \underset{(2.08)}{0.0614}\ ln(ADV)_{-8} + \underset{(2.08)}{0.0455}\ ln(ADV)_{-9} + \underset{(2.08)}{0.0250}\ ln(ADV)_{-10}$$

R2 = 0.74

Wholesale Price Frozen Eggs (3SLS)

$$WHLPFRZW = \underset{(4.00)}{21.006} + \underset{\substack{(5.95)\\ \lbrack 0.54 \rbrack}}{0.357}\ WHLPRMET + \underset{(1.37)}{0.786}\ JAN + \underset{(1.76)}{1.423}\ FEB + \underset{(1.10)}{0.916}\ MAR$$

$$+ \underset{(0.36)}{0.346}\ APR + \underset{(1.25)}{1.455}\ MAY + \underset{(0.51)}{0.543}\ JUN + \underset{(0.28)}{0.281}\ JUL + \underset{(0.69)}{0.652}\ AUG + \underset{(1.24)}{1.105}\ SEP$$

$$+ \underset{(2.87)}{2.344}\ OCT + \underset{(2.19)}{1.249}\ NOV - \underset{(-1.85)}{0.081}\ TIME$$

R2 = 0.92 ρb = 0.777 (10.90)

Table 1 (Continued).

Breaking Egg Production (3SLS)

BROKN = -122.482 - 0.912 WHLPRMET + 0.846 WHLPFRZW + 0.452 PRODN+ 3.153 JAN
(-2.17) (-2.53) (2.08) (4.08) (0.95)
[-0.44] [0.26] [2.10]

\+ 14.099 FEB + 3.567 MAR + 9.443 APR + 5.675 MAY + 22.675 JUN + 11.789 JUL
(1.88) (1.30) (2.21) (1.19) (4.22) (3.10)

\+ 14.717 AUG + 16.638 SEP + 9.693 OCT + 6.624 NOV + 0.159 TIME
(4.13) (3.51) (2.56) (1.91) (1.72)

R2 = 0.84

Frozen Egg Stocks (3SLS)[b]

EFROZN = -2.706+ 0.605 BFROZN + 1.365 BSHEL + 0.101 BROKN + 0.155 DIFWHLPZ
(-1.28) (5.62) (1.41) (3.13) (1.59)
[0.59] [0.04] [0.83] [0.002]

\+ 0.552 JAN + 0.608 FEB - 0.544 MAR - 0.499 APR - 0.478 MAY - 0.330 JUN
(0.84) (0.92) (-0.80) (-0.74) (-0.69) (-0.40)

\+ 0.413 JUL - 1.140 AUG -1.232 SEP - 0.509 OCT- 0.475 NOV + - 0.041 TIME
(0.58) (-1.50) (-1.80) (-0.61) (-0.74) (-2.00)

$R^2 = 0.55$

Demand for Hatching Eggs (OLS)

HATUSE = 15.121 + 0.053 CHIK + 0.072 BROIL - 0.191 JAN - 0.888 FEB + 0.583 MAR
(3.72) (1.64) (7.71) (-0.90) (-1.62) (1.78)
[0.03] [0.04]

\+ 0.147 APR + 0.630 MAY - 1.329 JUN + 0.064 JUL - 0.005 AUG - 2.012 SEP
(0.43) (1.63) (-4.41) (0.24) (-0.02) (-5.11)

\- 2.165 OCT + 0.778 NOV + 0.059 TIME
(-5.38) (1.49) (2.83)

$R^2 = 0.99$ $\rho^b = -0.461$ (-4.93)

Egg Utilization Identity:

CONTOT = PRODN + BSHEL + BFROZN - ESHEL - EFROZN + EGGIMPRT - EGGEXPRT
- HATUSE

---

[a] Parameter estimates are given with their estimated t-ratios (in parentheses) and selected elasticities (flexibilities) evaluated at mean levels for the variables [in brackets]. AVFEED and AVFARMPR are five-months moving averages of the feed price and farm price of eggs, respectively.
[b] Denotes the autoregressive parameter.
[c] The frozen stock equation contains an expected price change defined as:
$DIFWHLPZ = WHLPFRZW - WHLPFRZW_{-1}$

Table 2. **Variable Listing, Definitions, and Data Sources**

Variable	Description	Unit	Source[a]
Exogenous Variables:			
JAN - DEC	Monthly dummy variables	---	
TIME	Time trend (1 for January 1987)	---	
FEED	Real weighted average feed price	1990-92 $/ton	3, 4
TOTINC	Real disposable income	1987 $	7
PBEEF	Real retail price of choice beef	1982-84 ¢/pound	3, 4
PPORK	Real retail price of pork	1982-84 ¢/pound	3, 4
ADV	Real AEB advertising expenditures	1982-84 $ Thousands	6
BFROZN	Beginning frozen egg storage stocks	Million dozen	1, 2
BSHEL	Beginning shell egg cold storage stocks	Million dozen	1, 2
ESHEL	Ending shell egg cold storage stocks	Million dozen	1, 2
BROIL	Chicks hatched: broiler-type in commercial hatcheries	Millions	1, 2
EGGIMPRT	US egg imports, including egg products	Million dozen	1, 2
EGGEXPRT	US egg exports, including egg products	Million dozen	1, 2
PRDTVTY	Layer productivity: egg production per layer	Eggs/month	1, 2
CHIK	Chicks hatched: egg-type in commercial hatcheries	Millions	1, 2
WOMEN	Proportion of women in the labor force	---	8
Endogenous Variables:			
PRODN	Table and hatching egg production	Million dozen	1, 2
FARMPR	Real prices received by farmers	1982-84 ¢/dozen	1, 2
RETPGRDA	Real retail price for Grade A large eggs	1982-84 ¢/dozen	1, 2
WHLPRMET	Real wholesale price for 12 metro area	1982-84 ¢/dozen	1, 2
WHLPFRZW	Real wholesale price frozen whole eggs	1982-84 ¢/pound	1, 5
BROKN	Breaking egg production	Million dozen	1, 2
EFROZN	Ending frozen egg storage stocks	Million dozen	1, 2
HATUSE	Hatching egg production	Million dozen	1, 2
CONTOT	Total consumption of shell eggs and egg products	Million dozen	1, 2

[a]Data Sources:

1. USDA, ERS, *Poultry Yearbook*, Statistical Bulletin No. 927, December 1995.
2. USDA, ERS, *Poultry Outlook*, Quarterly 1995.
3. USDA, NASS, *Agricultural Prices*, Monthly 1987-1995.
4. USDA ERS, *Livestock, Dairy, and Poultry Situation and Outlook*, Monthly 1987-1995.
5. USDA, AMS, Poultry Division, Poultry Market News Branch, *Monthly Summary*, 1995.
6. Grey Advertising, Unpublished Information, Received January 1996.
7. US Government Printing Office, *Economic Indicators*, Washington, D.C., Monthly 1987-1995.
8. US Dept. of Labor, Bureau of Labor Statistics, *Computer File WWW*, Washington, D.C. 1987-1995.

Table 3. Simulation % RMSE, MSE, and MSE Decomposition Proportions Inequality Coefficients

			Bias	Reg	Dist
Variable	%RMSE	MSE	(UM)	(UR)	(UD)
PRODN	1.278	40.338	0.050	0.192	0.758
HATUSE	0.819	0.262	0.038	0.176	0.786
FARMP	9.258	26.764	0.077	0.002	0.921
RETP	7.065	31.397	0.055	0.016	0.929
WHOLPM	8.778	32.656	0.069	0.002	0.929
WHOLPZ	8.427	13.032	0.072	0.286	0.642
BROKN	6.509	38.498	0.038	0.114	0.848
EFROZS	7.418	0.957	0.007	0.000	0.993
CONTOT	1.407	35.203	0.043	0.052	0.905

Table 4. Average Farm Price and Production Under Two Alternative Simulation Scenarios

	Farm Price		Egg Production	
Advertising Level	Mo. Average (cents/dozen)	Percent Change	Mo. Average (million dozen)	Percent Change
Historic	43.350		495.437	
1% Increase	43.356	0.014	495.438	0.0001