A Short-Term Egg Price Forecasting Model

by

Lee F. Schrader and David A. Bessler

A SHORT-TERM EGG PRICE FORECASTING MODEL

Lee F. Schrader and David A. Bessler*

The objectives of this paper are to present a family of models which has been used to forecast egg prices for the past 15 years, to evaluate a subset of these forecasts, and to present the most recent version of the model. The model will continue to evolve.

Forecasts of egg prices are generated to serve primarily as an aid to production planning and cash flow projection. Thus, monthly forecasts for a minimum of one year ahead are desired. In fact, an 18-month forecast would be the most useful. But, as one can imagine, the error level at 12 months is already rather high.

The Commodity System

All things considered, the egg subsector is relatively simple to model. It takes three weeks to hatch an egg and six months to grow a pullet chick to production age. Once a pullet enters the laying flock,

*Lee F. Schrader is a professor and David A. Bessler is assistant professor of Agricultural Economics, Purdue University. The forecasts and econometric model are those of the senior author. The ARIMA model (Appendix) and suggestions on analysis were contributed by the junior author.

she remains in production for about 12 months unless a molt and rest period are induced to allow a second or even third laying cycle. If molted, the first cycle would be only about 10 months and subsequent cycles about eight months. Each molt means an idle period of about 45 days. An estimate 18 percent of the August 1, 1981, laying flock had completed at least one molt. The trend has been toward greater use of forced molting.

Nevertheless, the number of egg-type chicks hatched in the 12 months ending six months earlier is the single best indicator of egg production potential. Hatchery production is seasonal, and use of a 12-month total avoids the seasonality problem. The relevant hatch total does not define production, but it does reflect what producers intended to do. It would define the production level, if production practices were constant.

Producers vary output by changing molting practices or simply by lengthening or shortening the lay period of existing flocks. The normal pattern of production for a layer is to reach peak egg production at about 28-32 weeks of age after which the rate of lay declines until the bird dies, is sold for slaughter, or is molted. Subsequent cycles follow a similar pattern at a somewhat lower level. Feed consumption per day is fairly constant throughout the cycle. Thus, at very low egg/feed price relationships the layer becomes a loser at an earlier stage, but at high egg/feed price ratios the cycle may be extended particularly if replacements are not available.

It has been believed to be necessary to allow for a changing relationship over time and specifically to account for the advent of a vaccine to control Marek's Disease. The vaccine was approved for use after January 1971. Marek's Disease had been a major problem causing high death loss and limiting production of entire flocks. The vaccine is administered to chicks and its impact on production accumulated over a period of about 15 months after June 1971. That is, layers entering the flock in mid-1971 were the first to be affected by the disease control, and it took about 15 months for the entire flock to be composed of treated birds.

The short-term egg supply relationship is represented by

(1) QS = F(PE, PF, HA, MD, T, SS),

where

QS = quantity of commercial eggs produced in the current month,

PE = price of eggs, grade A large, New York, cents per dozen,

PF = estimated cost of feed per dozen eggs, cents per dozen average of prior 3 months,

HA = sum of egg type chicks hatched 6-17 months earlier in millions,

MD = 100 prior to June 1971 and increased 1 per month to 115,

T = serial time, January 1960 = 100, and

SS = a set of 11 monthly seasonal shifters.

The apparent inconsistency of using current egg price and lagged feed price is more the result of convenience than logic. This will be clear later.

Eggs are a unique product. There are few closely related foods. As a consequence, the price of other goods is adequately represented by the consumer price index. Income and egg price along with a seasonal and trend round out the demand relationship.

The demand relationship is

(2) QD = g(PE, I, SS, T),

where

QD = quantity demanded, all uses for commercial eggs, and

I = personal income, billion $ annual rate.

Exports have been too small in the past to justify explicit consideration. This is no longer the case, but the new situation has not existed long enough for extensive analysis.

This simple model is closed by the addition of the identity

(3) QS = QD.

The Forecasting Equation

The full model has not been estimated for two reasons. First, being interested in forecasting, there was no need to go beyond the reduced forms. And, second, until 1980 the production of commercial (food) eggs was not reported separately from eggs produced for hatching. A further step of estimating use for hatching would be needed to derive the food egg production and use data.

The following reduced form equation has been used for forecasting:

(4) PE = h(HA, I, PF, MD, T, SS).

In the earlier years of using this basic model, the equation was fitted as a log transformation. The logic of a multiplicative relationship still seems appealing, but when tested, the forecasting performance of the log transformation was no better than or inferior to the linear model. Thus, more recently it has been used in the linear form.

The monthly model estimated by ordinary least squares exhibits serial correlation, which, until preparation of this paper, has been ignored. This now appears to have been an error.

The model was generally refitted on a semi-annual basis, when revised and new data were available. The model has been used as the basis for published forecasts with some modification based on judgment. The model was abandoned for a time in 1973 and early 1974 in favor of pure judgment. Feed costs were added at this stage. These costs were recognized as important but had varied little prior to the 1972-73 period.

Forecast Performance

The senior author has published monthly price forecasts of egg prices for a year ahead since 1967. Feed cost estimates were based on then current futures prices for corn and soybean meal. Hatch was estimated using judgment. The set of forecasts, six months and one year ahead for the 96 months, January 1973 through December, 1980, were used in a performance analysis. With the exception of the late 1973-74 period, when it was not used at all, the model generated forecasts were published as such or modified somewhat based on judgment.

A set of forecasts were generated using a univariate autoregressive integrated moving average (ARIMA) model of egg prices for comparison. The ARIMA model was applied such that only data which were available prior to the forecast date were used (Appendix).

Simple correlations between actual and forecast prices are shown in Table 1. A comparison with price a year earlier is shown to represent the naive model for the year ahead forecast. This lag is relevant for decision-making as well as providing the only simple comparison, given the large amount of seasonal price variation present. The ARIMA model resulted in less bias but the econometric/judgment

Table 1. Monthly Egg Price Forecasts, Means, Standard Deviations and Correlation with Realized Price 1973-80

	Mean	Standard deviation	Correlation with realized
Realized price	63.71	8.11	1.00
Forecast 6 mo. ahead[a]	61.56	9.62	.41
Forecast 12 mo. ahead[a]	59.58	11.13	.49
ARIMA 6 mo. ahead	63.07	14.19	.21
ARIMA 12 mo. ahead	63.24	11.15	.40
Price lagged 12 mo.	59.93	11.72	.32

[a]The econometric model and senior author's judgment.

model showed the closer correlation at both the six months and 12-month forecasting horizons. Both appear to have performed better for 12-month forecasts than for six-month forecasts. Root mean squared errors computed for the alternative forecasts indicate that the total errors were smaller for the six-month forecast horizon (Table 2). The low bias for the econometric/judgment model may be due to underestimation of inflation and to some tendency to adjust the highest numbers downward. The trade prefers pleasant surprises.

Combination forecasts have received recent attention (Brandt and Bessler). Actual prices were regressed on the two 12-month horizon forecasts and the actual price lagged 12 months. The equation, fitted using the Cochrane-Orcutt iterative technique because of evidence of serial correlation, follows.

$$\text{Combined forecast} = \underset{(2.82)}{19.86} + \underset{(3.64)}{.411}\ \text{Econometric}$$

$$+ \underset{(3.02)}{.298}\ \text{ARIMA} + \underset{(.075)}{.009}\ \text{Price lagged 12.}$$

Numbers in parentheses are t statistics. Statistics computed based on the use of these coefficients and undifferenced data were as follows.

$R^2 = .299$ RMSE = 7.14.

One would like to find that the coefficients on the alternative forecasts to sum to one and that the constant term equals zero. Clearly, neither condition exists in this case. The small and

Table 2. Root Mean Squared Errors for Alternative Egg Price Forecasts 1973-80

Forecast	Root Mean Squared Error
Forecast 6 mo. ahead	9.92
Forecast 12 mo. ahead	10.84
ARIMA 6 mo. ahead	10.84
ARIMA 12 mo. ahead	14.79

statistically insignificant coefficient on price lagged 12 months does indicate that lagged price contributes no information about current price which was not already contained in the two forecasts. While it might appear that the combined forecast is superior to the econometric forecast alone (R^2 = .30 vs. .24), such a conclusion is not justified. This method of combining forecasts can be used only after the fact. A combined forecast using equal weights for the econometric/judgment and ARIMA models resulted in a root mean squared error of 11.05 cents, which is higher than that of the econometric based forecast alone.

The Present Model

Revision of the model during the summer of 1981 was more extensive than usual. Alternative hatch lags were investigated and methods to correct for serial correlation have been employed. Thus, the version presented here may be a superior performer.

The major change resulting from use of the Cochrane-Orcutt method of estimation was to diminish the coefficient of feed cost.

Earlier versions indicated that a change in feed cost of one cent per dozen resulted in a greater than one cent change in egg price, an illogical result.

Investigation of alternative lags on the hatch variable (a 12-month total) indicated a slightly improved performance at a 12-month lag rather than the more logical six-month lag used earlier. Indeed the hatch total 6-17 months earlier is a better indicator of flock size and egg production than is the sum 12-23 months earlier. Perhaps this indicates that prices have a habit component which operates within a range of prices which might clear the market in any given time period. In a period as short as a month that range of price may be as much as plus or minus two cents, particularly when the New York price is used to represent the national price.

The model was also fitted using only data from 1972 forward. When using the shorter sample period, the Marek's Disease variable and tendencies were dropped from the model. Much of the impact of Marek's Disease control was already realized by 1972. The trend influence was not clearly separable from income and seemed less necessary for the shorter time series. The results of estimation using both July 1966 - June 1981 data and January 1972-June 1981 data with both the six-month and 12-month lags for hatch are presented in Table 3. All parameters were estimated using the Cochrane-Orcutt iterative method.

The version of choice for current use is that of the 12-month hatch lag and shorter estimation period. The estimation first order serial correlation of errors (ρ) may be accounted for in the forecast

Table 3. Estimated Coefficients of the Egg Price Model for Alternative Lags and Sample Periods

	1966-1981		1972-1981	
Sample period constant	149.31*	102.63*	110.27*	116.65*
HA (lag 6)	-.16736*		-.16726*	
HA (lag 12)		-.14006*		-.17815*
I	-.00156	-.00029	.00867*	.00785*
PF	.94956*	.81929*	.83328*	.85765*
MD	-.50611	-.15960		
T	.14627	.12033		
JAN	5.10*	5.56*	5.32*	5.85*
FEB	.07	.54	.90	1.23
MAR	.45	.73	.94	1.06
APR	-3.69*	-3.83*	-3.63*	-3.74*
MAY	-7.95	-8.34*	-7.97	-8.31*
JUN	-6.27*	-6.80*	-6.55*	-7.01*
JUL	-1.04	-1.55	-2.21	-2.72
AUG	.60	.17	1.03	.74
SEP	2.92*	2.71	1.66	1.47
OCT	-1.73	-1.62	-2.18	-2.11
NOV	3.42*	3.84*	3.51	3.86*
DEC	8.12	8.59	9.18	9.68
R^2**	.906	.899	.840	.876
F	202.39	197.25	79.07	84.35
RMSE	4.52	4.68	4.73	4.09
RHO	.705	.718	.703	.628

*t > 3.0.

**Relation between actual price and fitted value using untransformed data.

for month t using the following adjustment where b is the time period for the last available actual data, PE_t^* is the model forecast for time period t and PE_t^{**} is the adjusted final forecast.

$$PE_t^{**} = PE_t^* + (\rho)^{(t-b)}(PE_b^* - PE_b)$$

This type of adjustment has been used in the past by adjusting forecasts to reflect diminishing amounts of recent error over a six-month period. Given $\rho = .628$ the influence of past error using the formula above is reduced to six percent of the original in six months.

Conclusion

Room for improvement remains. It is encouraging that nearly 90 percent of the variation in the highly variable egg prices can be represented in the 17 dimensions of the model in use. It has been discouraging to discover time after time how poorly the model has behaved outside the period used for estimation.

At present, many in the industry believe that forced molting has suddenly become much more common. In effect, they argue that the old relationships between chick hatch and egg production no longer hold. If true, the model presented here is useless in the next few years. To date, current flock-to-hatch and production-to-hatch ratios are not outside historic ranges. But, only time will tell.

The incidence of Marek's Disease control is a case in point. At the time (1971-72) the impact was believed to be very great. The egg price depression of that period was widely believed to have been exacerbated by the disease control success. Yet, the most recently estimated versions of the model do not indicate a significant impact from disease control. There is no easy way for the forecaster to know when to second guess a model.

References

Brandt, Jon A. and David A. Bessler. "Composite Forecasting: An Application with U.S. Hog Prices." American Journal of Agricultural Economics, February 1981:135-140.

Nerlove, M., D. M. Grether, and J. L. Carvalho. Analysis of Economic Time Series: A Synthesis. New York: Academic Press, 1979.

Appendix

A Univariate Model of U.S. Egg Price

An ARIMA model of monthly New York egg prices was formulated following the general procedure outlined in Nerlove et al. (p. 108). The estimated autocorrelations necessary for building the model are given in Table Al. The autocorrelations on price levels tail off slowly, suggesting a possible nonstationarity in levels. The autocorrelations on the first regular differenced price series show a possible seasonal nonstationarity (note lags 12, 24, and 36). Finally, the first regular and first seasonal differenced series indicate stationary behavior. As the estimated autocorrelations on this final differenced series do not tail off, a moving average representation ought to provide an adequate model.

From the autocovariance generating function, the order of the moving average process can be determined as follows:

$$H = q + Q(\rho),$$

where H = largest significant autocorrelation, q = the largest order regular moving average term, Q = the order of seasonal moving average, and ρ is the length of the season. From Table Al, column 3, note H = 12, following Nerlove et al., p. 206, we set q = 0, Q = 1, for a seasonal lag of ρ = 12.

Column 4 gives the estimated autocorrelations from the residuals from the following estimated model:

Table A1. Estimated Autocorrelations on (1) Levels, (2) First Differences, (3) First and Seasonal Differences and (4) Residuals on Modeled Monthly Egg Prices (1966-1971)

lag	(1) P_t [a]	(2) $(1-B)P_t$ [b]	(3) $(1-B)(1-B^{12})P_t$ [c]	(4) $\hat{\varepsilon}_2$ [d]
1	.75[e]	-.08	.04	.06
2	.57[e]	.00	.07	.03
3	.40[e]	-.11	-.16	-.20
4	.28[e]	.07	.06	.00
5	.14	-.23	-.24	-.16
6	.10	.10	.06	.13
7	.03	-.23	.21	.11
8	.06	.02	-.09	-.06
9	.08	-.03	.07	-.04
10	.10	-.00	.05	.00
11	.14	-.07	.07	.06
12	.21	.50[e]	-.47[e]	-.06
24	-.11	.50[e]	.02	.01
36	.24	.41[e]	.08	.12

[a]Estimated autocorrelations on egg prices (P_t).

[b]Estimated autocorrelations on the first regular differences of egg prices ($(1-B)P_t$).

[c]Estimated autocorrelations on the first regular differences and first seasonal difference of egg prices ($(1-B)(1-B^{12})P_t$).

[d]Estimated autocorrelations on the residuals from the estimated model ($(1-B)(1-B^{12})P_t = (1-\theta_1 B^{12})\varepsilon_t$).

[e]Indicates autocorrelation significantly different from zero at 5 percent level.

$$(1-B)(1-B^{12})P_t = \underset{[6.29]}{(1-.65\ B^{12})}\varepsilon_t,$$

where B is the lag operator and the figure written in brackets is a t-statistic associated with the hypothesis that the seasonal coefficient is equal to zero. Clearly, the estimated coefficient is significantly different from zero and from Table A1, column 4, the model adequately removed autocorrelation.

A model of the form given above was reestimated each calendar year from 1971-1979. The residuals from each of these subsequent fits were not detectably autocorrelated. *Ex ante* forecasts were generated for both seven-month and 13-month lead times from the appropriate model. These are the "straw man" forecasts which are labeled "ARIMA forecasts" in the body of this paper.