EGG PRICES REVISITED

Lee F. Schrader, David A. Bessler, and Warren Preston

Abstract

Recent egg price quotes are evaluated in a vector autoregression. The results indicate that empirical relationships observed over the period 1975-1976 differ from those observed over the period 1979-1982.

Key words: egg prices, multiple time series analysis, moving average representation, nonstructural model.

This paper reexamines relationships among alternative price quotes for eggs. In an earlier paper, Bessler and Schrader analyzed quotes issued by the Egg Market Evaluation Committee (EMEC) for Class 1 gradable nest run eggs and those for "spot" Grade A large eggs published in *Producers' Price Current* (now called *Urner Barry's Price Current*), a private subscription service.

The accuracy and sensitivity of price quotations developed by alternative means are important questions in a market dominated by formula pricing. The EMEC price quotes were based almost exclusively on open trading activity on Egg Clearinghouse, Inc. (ECI), a relatively new institution employing electronic trading. The Urner Barry (UB) quote was based on a more traditional canvass of egg marketing and retailing firms to assess the price adjustment necessary to clear the market. During the periods studied, Urner Barry price reporters had access to the details of trading on ECI as well.

Where formula pricing predominates, the reference price quote determines transactions prices in the short run. Eventually the market must clear. If the quote does not reflect needed change, the formula differentials must change. Thus, it is argued that, if a quote produced by one means leads one produced by another means, the one which leads would be the more efficient reference price for pricing formulas. Bessler and Schrader found evidence of both instantaneous (Granger-type) causality and causality running from EMEC price quotes to the Urner Barry (UB) quotes one, two, and three quote periods into the future. Bessler and Schrader interpreted this as indication that information and judgment used by UB reporters did not serve to make the UB quote a better indicator of the unobserved equilibrium price than that indicated by trading on ECI which was the primary basis for the EMEC quote.

Several factors have changed since 1977-78, the period analyzed in the original study. In addition, new econometric methods which are applicable to this problem have been developed. Urner Barry's practice of changing their quote level only twice weekly was modified to changing the quote on any day for which change was indicated by events. EMEC continued the earlier policy of twice weekly (Tuesday and Thursday) quotes. In addition, a number of nonobservable changes may have taken place. The practice of daily review may have resulted in UB quotes which are more responsive to changes in conditions affecting price. The Bessler and Schrader study, results of which were made available to UB, may have had some effect on the weight given to ECI trading in the UB quote. The volume of trading on ECI has decreased from 969 thousand cases during 1977 to 680 thousand in 1981. However, trading increased again to 771 thousand in 1983. There has been some shift in location of ECI trade with a larger proportion of ECI trading by firms located in the Midwest in the more recent period. Midwest firms represented the origin of 63 percent in 1982 and 56 percent of those in 1983.

There may also have been some shift in practice by ECI participants toward trading

Lee F. Schrader is a Professor of Agricultural Economics, Purdue University; David A. Bessler is an Associate Professor of Agricultural Economics, Texas A & M University; and Warren Preston is a Graduate Research Assistant, Purdue University.

Purdue University Agricultural Experiment Station Journal Paper No. 10374.

to influence price rather than only to acquire or dispose of eggs. Reluctance to trade at lower prices because of probable impact on market quotes led ECI management to limit access to trading information to members and to end their support of EMEC in late 1984. A subsequent increase in ECI trading seems to confirm that trading was affected by recognition of its impact on the reference quote for pricing formulas. Trading or not trading to influence price would impair ECI's effectiveness as an indicator of market clearing price.

Given the recent changes in the characteristics of the Urner Barry quote and changes in ECI trade, a reevaluation of the relationships among the alternative egg quotes is in order. This paper is presented as follows: first, the original statistical methods (used by Bessler and Schrader) are applied to more recent data. These data are then analyzed using the new innovation (residual) accounting techniques of Sims. The paper ends with a few observations on the current relationships among alternative price quotes for eggs and directions for further study.

ORIGINAL TESTS ON RECENT DATA

The original analysis by Bessler and Schrader of 1977-78 data used both the Pierce and Haugh test and Sims' test. Both methods indicated a substantial degree of instantaneous Granger-type causality. Tests using both three and nine period lags indicated causality running from EMEC to UB quotes.

Data for 1979-82 were analyzed by similar methods. Only Tuesday and Thursday UB quotes were used, effectively ignoring information for the intervening days. In the first test, both series were prefiltered using the following autoregressive processes:

$$(1)\ X_t - 1.23\ X_{t-1} + .19\ X_{t-2} + .14\ X_{t-3} = 5.26 + U_t$$

and

$$(2)\ Y_t - 1.48\ Y_{t-1} + .53\ Y_{t-2} = 3.85 + V_t$$

where U_t and V_t are the innovations (residuals) of the EMEC (X_t) and UB (Y_t) series, respectively. Cross-correlations of the two innovation series (UB at t and EMEC ranging from t−27 to t+27) exceed the two standard deviation intervals at lags of 25, 12, 1, and 0. Thus, there is evidence of both instantaneous causality and of UB leading EMEC, the opposite of that found for 1977-78.

A direct Granger test was also applied. To test for UB leading EMEC, ordinary least squares estimates were computed for the following models:

$$(3)\ x_t = a_{10} + \sum_{j=1}^{q} a_{1j} X_{t-j} + e_{1t_1}$$

and

$$(4)\ x_t = a_{20} + \sum_{j=1}^{q} a_{2j} X_{t-j} + \sum_{r=1}^{q} b_{2k} Y_{t-r} + e_{2t},$$

where q was set at three and nine for separate tests. If F-tests reject the hypothesis that all coefficients of model (4) are zero and the hypothesis that all the b_{2k} coefficients are zero, causality from UB to EMEC may be inferred. Such was the case for both three and nine period values for q. An analogous test for causality running from EMEC to UB was conducted. These tests resulted in a failure to reject the hypothesis of no effect of EMEC on UB, a result consistent with those from the cross-correlation analysis.

The apparent change in direction of causality revealed by these methods led to extension of the analysis to include the EMEC quotation for the Midwest (EMECW) as well as the Eastern quote (EMECE) used in the prior analysis. The perceived shift in ECI trading toward the Midwest and indications that actions to influence price were concentrated in Eastern trades, suggested that EMECW might have become a more sensitive price indicator than EMECE. The need to deal with more than two series simultaneously and the need to deal with the impact of contemporaneous relationships suggest the use of vector autoregressions. The periods of analysis were also extended to include 1975-78 and 1979-82.

INNOVATION ACCOUNTING FOR 1975-1978 AND 1979-1982 DATA

The innovation (residual error) accounting technique provides a general method for analysis of dynamic interrelationships among time series data. The Granger-type causality tests presented here do not allow the researcher to make "strength-of-relationship-type" statements at alternative lags. That is, the Granger-type causality tests allow the researcher to say whether a predictive relationship exists in the data or not. The innovations accounting techniques allow the researcher to partition the uncertainty in each series to past shocks in itself (its history) or to other series being studied. Under the heading of error decomposition, egg quotes are modeled as a vector time series—one result of this study will be a more complete dynamic analysis of egg-quote interrelationships. First, however, a few "technical thickets" on multiple time series will be reviewed. The reader who finds this section to be unclear should refer to Sims (or Bessler) for more details.

A multivariate time-series model generates a representation of each variable as a linear combination of current and past innovations (residuals) in the variables of the system. This model, given by equation (5), is sometimes labeled a Wold representation (Bessler):

$$(5)\ Z_t = \theta(L)\ \varepsilon_t,$$

where Z_t is a stationary, linear regular random vector of order c; ε_t is a white noise innovation vector of order c; and $\theta(L)$ is a square matrix of order c, whose elements are polynomials in the lag operator, L; i.e.,

$$(6)\ \theta(L) = \begin{matrix} (1-\theta_{11}(L^1)-...) & (-\theta_{12}(L^1)-...) & ... (-\theta_{1c}(L^1)-...) \\ (-\theta_{21}(L^1)-...) & (1-\theta_{22}(L^1)-...) & ... (-\theta_{2c}(L^1)-...) \\ \vdots & \vdots & \vdots \\ (-\theta_{c1}(L^1)-...) & (-\theta_{c2}(L^1)-...) & ... (1-\theta_{cc}(L^1)-...) \end{matrix}$$

Under fairly general conditions, equation (5) can be well-approximated by a finite order vector autoregression (a regression of each variable on past values of all variables in the system). That is, the current position of the vector Z_t can be represented as either a linear function of past shocks in the vector of variables (a Wold representation) or as a linear function of past levels of the vector of variables (as an autoregression), that is, as equation (7):

$$(7)\ (\theta(L))^{-1}\ Z_t = \varepsilon_t,$$

where Z_t, ε_t and $\theta(L)$ are defined as stated.

In applications, the order of the autoregression is usually not known and must be determined statistically. Here, the order of the autoregression is selected using a likelihood ratio test — as modified by Sims (p. 17). That is, the statistic $(T-c)\ (\log|\Sigma_{t-1}| - \log|\Sigma_t|)$ is studied, where T is the number of observations used to estimate the vector autoregression, c is the number of equations (the number of series studied in the VAR), and Σ_t is the error-product and cross-product matrix for a t^{th} order autoregression. Under the null hypothesis (that the elements of the autoregressive matrix at period t are equal to zero), the statistic is distributed chi-squared with c-squared degrees of freedom. Data from two periods (1975-78 and 1979-82) on EMECE, EMECW, and UB are fit equation-by-equation by ordinary least squares regression (see Doan and Litterman). Approximate minimum significance levels, at which the null hypothesis can be rejected, are given in Table 1. Both periods suggest an eighth-order autoregression. All subsequent analysis will be with respect to these eighth-order autoregressions.

A standard test of the structural stability of the coefficients from the two-time periods is rejected quite easily (chi-squared statistic, Table 2, with 75 degrees of freedom is 139.74, for a marginal significance of less than $10.^{-6}$). The test is on shift (dummy) variables associated with coefficients in each equation in the 1979-1982 period. Information on the differences between the two periods can be obtained by studying the behavior of the coefficients equation-by-equation. In Table 2,

TABLE 1. APPROXIMATE SIGNIFICANCE LEVELS ON LIKELIHOOD RATIO STATISTICS ON LAGS 1-10 FOR THREE VARIABLE VAR'S ESTIMATED OVER 1975-1978 AND 1979-1982[a]

Lag	1975-1978	1979-1982
1	.00	.00
2	.00	.00
3	.00	.01
4	.00	.09
5	.00	.08
6	.89	.10
7	.48	.38
8	.00	.03
9	.11	.46
10	.81	.40

[a] The null hypothesis associated with each test is that the coefficient matrix at the particular lag length is zero. Because the hypotheses are tested sequentially starting at one and going through ten, control on exact significance levels is not possible; see Bessler for a discussion of this point.

TABLE 2. TESTS FOR MODEL HOMOGENEITY ON EGG PRICE RELATIONSHIPS: 1975-1978 VS. 1979-1982

Overall test[a]	Chi-squared (75) = 139.74
Individual equation[b]	F(25,775)
EMECE	1.76*
EMECW	1.48
UB	1.24

[a] The overall test is computed according to footnote 18 in Sims (p. 17).

[b] Individual equation F statistics are calculated under the restriction that the coefficients of all lagged variables do not differ between time periods. An asterisk indicates rejection of the null hypothesis at the 5 percent level of significance.

F-tests on the equality of coefficients between the two time periods are listed. The F-test is a test on the set of twenty-four slope shift variables—eight for each variable—and one-time period level shifter. Note that the F-statistic on the EMECE equation is the largest—indicating that this equation is where the most serious difference exists between the two periods. In fact, using a usual critical value of the F-distribution ($\alpha = .05$), the hypothesis that the coefficients associated with the two other regressions (EMECW and UB) are equal is not rejected (critical value $F(25,778) = 1.53$), while the hypothesis for the EMECE regression is rejected. These initial tests support the hypothesis that relationships have changed between the two time periods.

Some further evidence on the relationships among the egg quotes over time is given in the changes in error decompositions, Table 3. The estimated vector autoregression is written in its moving average form (or its Wold representation as in equation (5), Bessler). Following Granger and Newbold, the h-period-ahead forecast error variance of a moving average process can be expressed as an h−1 order moving average process. For a diagonal variance-covariance matrix, the h^{th} period-ahead forecast error variance can be partitioned into its component parts (that due to each series). That is, the h-period-ahead forecast error can be written as:

$$(8)\ \varepsilon(t,h) = Z(t+h) - f(t,h),$$

where $Z(t+h)$ is the actual vector of Z variables in period $(t+h)$ and $f(t,h)$ is the optimal forecast of the Z vector in period $t+h$ using information available in period t. Writing $Z(t+h)$ and $f(t,h)$ in their Wold-form gives the following expression for the h-period-ahead forecast error:

$$\begin{aligned}(9)\ e(t,h) &= \varepsilon_{t+h} + \theta_1\varepsilon_{t+h-1} + \theta_2\varepsilon_{t+h-2} + \cdots \\ &\quad + \theta_{h-1}\varepsilon_{t+1} + \theta_h\varepsilon_t + \theta_{h+1}\varepsilon_{t-1} + \cdots \\ &\quad - \theta_h\varepsilon_t - \theta_{h+1}\varepsilon_{t-1} - \cdots \\ &= \sum_{j=0}^{h-1} \theta_j\varepsilon_{t+h-j},\end{aligned}$$

where $\theta_0 = 1$. The covariance matrix of the h-step-ahead forecast error will be given as $V(h)$:

$$(10)\ V(h) = E\{\varepsilon(t,h)\varepsilon(t,h)'\}.$$

Generally $V(h)$ will not be diagonal, in which case there is not an obvious partition. However, if a diagonalization of V can be found, which amounts to finding a transformation on the Wold representation, such that

$$(11)\ \tilde{\theta}_j = \theta_j H,$$

then the desired partition can be attained. One matrix H which accomplishes this diagonalization is the Choleski decomposition (details are given in Bessler). That is, following Sims, one can attribute contemporaneous covariance among the components of a multiple time series as arising from one series or another (innovations in series i cause innovations in series j in the current time period). It is frequently not clear on the ordering of the Choleski decomposition and results do change when different orderings are used. However, the present study is interested in changes in the error decompositions over time. These changes are much less a function of the Choleski ordering (alternative changes were studied and are available from the authors).

TABLE 3. CHANGES IN ERROR DECOMPOSITIONS FOR THE THREE VARIABLE VAR OVER PERIODS 1975-78 AND 1979-1982[a]

Dependent variable and lag (listed vertically)	Price quote		
	EMECE	EMECW	UB
EMECE			
1	−.02	−.03	+.05
2	.00	−.03	+.03
9	+.13	−.35	+.21
18	+.13	−.38	+.25
EMECW			
1	−.00	−.02	+.02
2	−.01	−.01	+.02
9	−.04	−.09	+.13
18	−.03	−.09	+.12
UB			
1	−.00	−.07	+.07
2	−.01	−.17	+.18
9	−.05	−.50	+.55
18	−.05	−.57	+.62

[a]The uncertainty in the dependent variable at various lags can be accounted for by variability in lagged values of variables in the VAR. These partitions have been calculated over both the early (1975-78) and the late (1979-82) periods. The numbers in the table represent the changes in the proportions attributed to each series between the two periods. For example, EMECW accounted for (explained) 38 percent less of the EMECE quote in 1979-82, at an 18-period lag. (The numbers in the table will sum to zero in any row.)

Changes in error decompositions for each series are given in Table 3. The influence of EMECW on itself, EMECE, and UB has diminished in the latter period. Note especially the rather drastic reduction in its influence on EMECE and UB at the longer lags. On the other hand, the influence of UB on both EMEC quotes has increased in the latter period, especially at the long lags. These results again generally support the Granger-type causality tests discussed earlier.

OBSERVATIONS

The reduction in the influence of EMECW on the EMECE and UB quotes at long lags perhaps reflects both a shift in the pattern of trading on ECI and a fairly continuous increase in transport costs which allows for more independent price movement in the Midwest and Northeast. The increased importance of the UB quote perhaps is a result of the more frequent reporting of that quote. The statistical analysis presented in this study identifies that a significant change has occurred in the structure of egg price quotes over the period 1977-1982. Other researchers may wish to go further and attempt to model the structure of the egg industry and test hypotheses on explicit causal variables. Any such model will most likely need to include a qualitative variable (a (0,1) variable) to account for the earlier study by Bessler and Schrader and its potential feedback on the Urner Barry quote.

These results do not necessarily imply a diminished role for Egg Clearinghouse in the 1979-82 period. They may indicate that ECI trading information was being exploited more fully than before by the Urner Barry reporters. The results may also indicate that public trading of a small volume is not an efficient price indicator once it is recognized as a major influence on reference prices for pricing formulas. Unfortunately, the present analyses cannot distinguish between these hypotheses having much different implications for commodity pricing institutions. It is clear that changes in the performance of institutions do occur and that periodic reexamination of previously established relationships is necessary.

REFERENCES

Bessler, D. A. "Relative Prices and Money: A Vector Autoregression on Brazilian Data." *Amer. J. Agr. Econ.*, 66(1984): 27-34.

Bessler, D. A. and L. F. Schrader. "Relationships Between Two Quotes for Eggs." *Amer. J. Agr. Econ.*, 62(1980): 767-71.

Doan, T. and R. Litterman. "User's Manual: RATS." Minneapolis: VAR Econometrics, 1981.

Granger, C. W. J. and P. Newbold. *Forecasting Economic Time Series*, New York: Academic Press, 1976.

Sims, C. "Macroeconomics and Reality." *Econometrica*, 48(1980): 1-48.