Cattle -- Marketing

1983

The Use of Forecasts in Decision Making: The Case of Stocker Cattle in Florida

By

Carlos A. Arnade

Thomas H. Spreen

Selected paper presented at the American Agricultural Economics Association meetings, West Layfayette, Indiana, July 31-August 3, 1983

The authors are former Graduate Research Assistant and Associate Professor in the Food and Resource Economics Department, Gainesville, Florida

ABSTRACT

The decision to overwinter feeder cattle hinges directly on the forecast of spring cattle prices. An analysis of forecasts from several alternative models is presented. The models are evaluated using both the traditional mean square criterion and their ability to lead to the correct decision.

The Use of Forecasts in Decision Making: The Case of Stocker Cattle in Florida

Cattle production is dispersed throughout the Southeast with a typical operation producing weaned calves in the fall. In Florida, weaned calves weigh approximately 400 pounds and generally are not placed in feedlots. The calves are grown out on high roughage diets to approximately 600 pounds. This intermediate phase is called stocker cattle production or "backgrounding" (Florida Dept. of Ag.). In the Southeast temporary winter pastures of rye, ryegrass, or cereal grains provide roughage supplemented by small amounts of corn. Nearly all winter pastures use annuals which cannot survive summer heat and must be replanted each fall.

The cattle producer faces a decision each fall. He can immediately sell weaned feeder calves or retain the calves and initiate stocker cattle production. If a cattle producer chooses to background feeder calves, a major proportion of the cost is incurred at the beginning of the production process. Estimates indicate nearly ninety percent of the cost of backgrounding is incurred in establishment of pasture and foregone revenues from retention of the calf (Arnade). These are sunk costs and can be distinguished from fixed costs by noting sunk costs are not incurred unless production is initiated.

The purpose of this paper is to analyze the stocker decision. An economic decision model is developed. Statistical loss functions are reviewed and alternative loss functions are proposed for evaluation of price forecasts used in making economic decisions. Statistical forecasting models are estimated for 600-700 pound feeder steer prices and evaluated under multiple criteria.

A Conceptual Framework

Consider a firm which produces a single output Y from a set of inputs $X' = (X_1, \ldots, X_n)$ according to the production relation

(1) $Y = f(X_1, \ldots, X_n)$.

Suppose the firm operates in competitive markets and thus takes input and output prices as exogenous data so that its profit function is

(2) $\pi = PY - RX$

where P is the price of Y and $R = (r_1, \ldots, r_n)$ is the vector of prices of X.

Assume that output is deterministic. This assumption can be phrased in several ways. From the view of producer decision making, if a producer commits a set of input levels $X^o = (X^o{}_1, \ldots, X^o{}_n)$, then he expects that output Y^o will result where

(3) $Y^o = f(X^o)$

Next, introduce time into the production process, i.e., suppose that if production is initiated in period t, that the output Y cannot be marketed until period t+1. Furthermore, assume that all inputs are committed in period t such that all costs are "sunk," then the expected profit function is

(4) $E_t(\pi_{t+1}) = E_t(P_{t+1})Y_{t+1} - R_t X_t$

where $E_t(\pi_{t+1})$ is the expectation of profit to be realized in period t+1 formed in period t and $E_t(P_{t+1})$ is the expected product price in period t+1 formed in period t.

Conventional economic theory suggests that the producer reacts to $E_t(\pi_{t+1})$ in making his production decision. Assuming all resources divisible, one could hypothesize that

(5) $$Y_{t+1} = G[E_t(\pi_{t+1})]$$

where Y_{t+1} is realized output in period t+1 and $\frac{dG}{dE_t(\pi_{t+1})} > 0$. Resources are not all divisible, however, since there are cases in which the producer's decision is discrete, i.e. to produce or not produce. In this case, the producer reacts to $E_t(\pi_{t+1})$ according to

(6a) $$Y_{t+1} = 0 \text{ if } E_t(\pi_{t+1}) < 0$$

(6b) $$Y_{t+1} = \bar{Y}_{t+1} \text{ if } E_t(\pi_{t+1}) \geq 0$$

where $\bar{Y}_{t+1}$ is the output level if production is initiated. If production is initiated, then actual profit is

(7) $$\pi_{t+1} = P_{t+1}\bar{Y}_{t+1} - R_tX_t.$$

The only stochastic variable on the right-hand-side of (7) is P_{t+1}. Let P^*_{t+1} be the value of P_{t+1} which makes π_{t+1} equal to 0. Then P^*_{t+1} represents a "trigger price" because from (6a-b), $E_t(P_{t+1}) \geq P^*_{t+1}$ will cause the producer to initiate production, while $E_t(P_{t+1}) < P^*_{t+1}$ will not. The term "breakeven price' is also used for P^*_{t+1}.

Loss Functions

A typical statistical model for price forecasting relates the variable of interest, in this case P_t, to some set of explanatory variables (Z_t). The functional relationship can be written as

(8) $$P_t = g(Z_t, \theta)$$

where θ is a set of parameters, which may be estimated using some statistical procedure.

Statistical estimation requires the specification of some criterion on which alternative estimates can be evaluated. Only in this way can a "best" or "optimal" estimate be determined. Nearly all techniques used in the estimation of forecasting models use mean square error as the criterion. Let $\hat{\theta}$ be the estimate of θ using the mean square error criterion, then

$$(9) \qquad \hat{\theta} = \min_{\theta}[\frac{1}{T} \sum_{t=1}^{T} [P_t - g(Z_t, \theta)]]^2.$$

The loss function is the sum of the squared "errors" (averaged over the sample). The error is the difference between observed P_t and predicted P_t, $\hat{P}_t$, where

$$(10) \qquad \hat{P}_t = g(Z_t, \hat{\theta})$$

Mean square error is intuitively appealing as a loss function as the general notion is to find that value of θ, $\hat{\theta}$, such that $\hat{P}_t = g(Z_t, \hat{\theta})$ is as close to P_t as possible. A small "error" results in a smaller penalty than a large "error."

Other loss functions are plausible such as mean absolute error or the minimax criterion which is to minimize the maximum error of any single observation over the sample. The production decision problem presented above suggests at least two other possible criteria on which a statistical model used to forecast P_{t+1} could be evaluated.

In a discrete decision framework (e.g. (6a-b)), an effective forecasting model is one that can correctly predict whether $P_{t+1} \geq P^*_{t+1}$ or $P_{t+1} < P^*_{t+1}$. Accuracy of the forecast in the MSE sense is not important except that a small MSE forecast should more correctly predict the relationship between P_{t+1} and P^*_{t+1}. It is plausible, however, that a model with a higher MSE will more accurately predict whether P_{t+1} is less than or greater than P^*_{t+1}. If P_{t+1} is slightly less than P^*_{t+1}, an inaccurate prediction far below P_{t+1} would be more useful than one close to but above P^*_{t+1}.

An alternative criterion is to define $\hat{D}_t$ to represent realized net returns when the decision implied by the forecast is implemented in period t. Define D^*_t to be the net returns from the correct decision, and $D_t = |D^*_t - \hat{D}_t|$. D_t is zero if the decision implemented is optimal in the sense that D^*_t is realized and D_t positive indicates that a "wrong" decision was made. Let

$$(11) \qquad D = \sum_{t=1}^{T} D_t$$

A larger D indicates a less useful model than a smaller D.

An alternative statistic is to let

$$I_t = 1 \quad \text{if } P_t > \overset{*}{P}_t \text{ and } \hat{P}_t > P^*_t$$
$$\text{or if } P_t < P^*_t \text{ and } \hat{P}_t < P^*_t,$$
$$= 0, \text{ otherwise,}$$

that is, $I_t = 1$ if the forecast, $\hat{P}_t$, is "right" in that a correct decision is made and $I_t = 0$ if the forecast is "wrong." Then

$$(12) \qquad I = \frac{1}{T} \sum_{t=1}^{T} I_t$$

measures the proportion of correct forecasts. I close to one indicates a valuable model while I close to zero indicates a poor model.

Use of Logit Models

Given a time series of observed prices P_t, and breakeven prices P^*_{t+1}, one could calculate a time series of the profitability of a particular enterprise. In the framework of equation (6a-b), an enterprise initiated in period t is profitable if P_{t+1} exceeds P^*_{t+1}. Define

$$R_{t+1} = 1 \text{ if } P_{t+1} > P^*_{t+1}$$
$$0, \text{ otherwise.}$$

Instead of focusing effort on forecasting the quantitative time series P_t, one could forecast the qualitative time series R_t. Thus the model

$$(13) \qquad R_t = h(Z_t, \Gamma)$$

is the forecasting equation, where Γ is a vector of parameters to be estimated. Since R_t is qualitative, an ordinary least squares procedure is not appropriate. The method of logit analysis is appropriate in this case. Using a maximum likelihood estimator, a value of Γ is determined, call it Γ_{MLE}, such that $h(Z_t, \Gamma_{MLE})$ is most likely to have generated the pattern of zeros and ones observed in R_t. This is equivalent to maximization of the statistic I (eg. 12). Given space limitations, the reader is referred to Judge, et al. (pp. 521-525) for the details of logit estimation.

Empirical Analysis

The stocker decision faced by North Florida cattle producers is analyzed in the context discussed above. Producers in this region face the decision of retaining (or purchasing) weaned calves weighing approximately 400 pounds each fall. If stocker production is undertaken, cool season pastures of rye, ryegrass, or some other small grain are cultivated. The animals are generally kept until late spring. In this analysis, assume stocker production is initiated in the fourth quarter and ends in the second quarter. Using cost studies by Gunter and Westberry, the feeding cost of backgrounding feeder calves on rye and ryegrass pasture supplemented with small amounts of corn (or an equivalent amount of hay in those years in which it was cheaper) is estimated over the 1960 to 1981 period). Fourth quarter Kansas City 400-500 pound medium frame No. 1 (MF1) steer prices are used to represent the cost of the 400 pound feeder calf. Second quarter 600-700 pound Kansas City MF1 steer prices are used for the output price.[1]

Estimation of Forecasting Models

Five different forecasting models are formulated. Four models forecast the quantitative series of Kansas City 600-700 pound feeder prices, while the other model employs the logit procedure to predict the profitability of overwintering feeder cattle in North Florida. All models are estimated over the 1960 to 1975 period, and analyzed *ex post* over the 1976 to 1981 period.

Two deterministic models, the no-change model and the trend (or extrapolative) model are anlyzed. Within sample (1960-1975) mean square error (MSE) and the I statistic are shown in Table 1.

A Box-Jenkins type model is estimated using standard Box-Jenkins procedures (See Nelson, pp. 69-142). The autoregressive-integrated-moving average (ARIMA) model estimated is a first-differenced, first order autoregressive model (using the (p, d, g) notation, the estimated model is (1,1,0)). The estimated autoregressive parameter, MSE, and I statistic are shown in Table 1.

A different philosophical approach is taken in the formulation of price forecasting models based upon the structure of the market for feeder cattle. For forecasting purposes, a structural econometric model is written in reduced form. In reduced form, however, it still may be difficult to use the model for forecasting if several of the explanatory variables are current exogenous variables. The use of lagged endogenous and exogenous variables can ameliorate this difficulty.

In the particular problem of this study, only second quarter feeder cattle prices are of interest. A reduced-form equation is

$$(14) \qquad P_s = \alpha_0 + \alpha_1 X_{1,s-1} + \alpha_2 X_{2,s} + \alpha_3 X_{3,s-1} + U_s$$

where

P_s = Second quarter 600–700 pound Kansas City MF1 steer prices in year s,

$X_{1,s-1}$ = Index of the ranch costs in year s-1 (calculated on a per head basis, see Arnade, p. 53),

$X_{2,s}$ = Marketings from feedlots in year s,

$X_{3,s-1}$ = Average fourth quarter U.S. corn prices in year s-1;

U_s is a random disturbance and α_i, i=0, ..., 3 are parameters to be estimated. $X_{1,s-1}$ is a supply shifter while $X_{2,s}$ and $X_{3,s-1}$ are demand shifters. $X_{1,s-1}$ and $X_{3,s-1}$ are known in the fourth quarter when predicting the second quarter price next year, while $X_{2,s}$, fed marketings, is not known and must be forecasted.

The logit model uses the same regressors as in (14).

$$(15) \qquad R_s = \beta_0 + \beta_1 X_{1,s-1} + \beta_2 X_{2s} + \beta_3 X_{3,s-1} + V_s$$

where

R_s = 1 if actual second quarter 600–700 pound Kansas City MF1 steer price exceeds the breakeven price in year s

= 0 otherwise.

β_i, i=0, ..., 3 are parameters to be estimated, V_s is a random disturbance, and all other variables are as defined above.

The estimated reduced form model (called Least Squares) and logit model are shown in Table 2.

Computation of Forecasts

To better assess the forecasting properties of the five models, post sample evaluation is performed over the six year period 1976 to 1981. The predicted prices from each model as well as the breakeven price and actual price are shown in Table 3.

The ARIMA, least squares, and logit models are all updated. For example, to generate the 1977 forecast, the model is re-estimated using data up through 1976. All updating is done by simply augmenting the sample. After each update, the residuals of the ARIMA model are checked via the Box-Pierce Q statistic for white noise. The tests show that the (1,1,0) model is adequate to reduce the series to white noise over the 1960 to 1981 period (although the estimate of the first order autoregressive coefficient varies slightly).

The least squares and logit models are updated in a similar fashion. The parameter estimates of these models are also stable as the sample is augmented.

To generate forecasts from both the least squares and logit models, fed marketings (X_2) must be forecasted. An ARIMA model is estimated for this series and used to provide forecasted values of fed marketings.

Forecast Evaluation

The performance of the six models in *ex post* forecasting is summarized in Table 4. Mean square error (MSE), percentage of correct forecasts (I), and profit deviation (D) are computed for each model.

On the basis of mean square error, the least squares model is the best model both within sample and *ex post*. The trend model, which has the highest within sample MSE, ranks second post sample, although its *ex post* MSE differs little from that of the no change and ARIMA.

On the basis of the statistic I, all models were correct 50% of the time except the trend model which had a two-thirds correct rate. The trend model also gave the best value of D, with the least squares model yielding the second lowest D.

The results suggest that the minimum MSE model is not the most useful model in terms of implementation of the correct decision. The statistics I and D measure approximately the same phenomenon and the same model yielded the best I and D values.

The poor performance of the ARIMA is somewhat disconcerting. On the basis of all three statistics, the ARIMA model is no better than the no change model. A curious aside is first to rewrite the ARIMA model to give

$$(16) \quad P_t = 1.312P_{t-1} - .312P_{t-2}$$

The trend model is $P_t = 2P_{t-1} - P_{t-2}$. The models are similar, but the parameters of the ARIMA were estimated using statistical criteria and thus should perform better as a forecasting tool.

Concluding Remarks

The thrust of this paper is that if forecasts are used as inputs into decision-making, then a criterion on which forecasts can be evaluated is the outcome of the decision implemented. In the context of stocker cattle production in North Florida, a relatively simple trend model, which exhibited a high within-sample mean square error, proved to be a better forecast tool than more statistically sophisticated models.

The evaluation period is characterized by wide price swings with high prices more than double low prices over the period. The performance of all models is marginal. The implications of this study are then necessarily limited by the peculiarities of feeder cattle markets over the past six years.

Footnotes

[1]Choice grade prices are used before the change in the feeder cattle grading system was made. Kansas City prices are used because prior to 1970 Florida feeder calf price time series are incomplete.

Table 1. Estimated Price Forecasting Models

Model		MSE[a]	I[b]
No change:	$P_t^* = P_{t-1}$	7.15	.625
Trend:	$P_t^* = P_{t-1} + (P_{t-1} - P_{t-2})$	9.80	.733
ARIMA:	$(1 - .312B)(1 - B)P_t = U_t{}^c$	6.65	.733

a/Mean square error.

b/Percentage of correct predictions relative to the estimated breakeven price.

c/Estimated Box-Pierce Q statistic with 22 degrees of freedom is 22.46. The 95th percentage point from a χ^2 statistic with 22 degrees of freedom is 33.9 (for details see Box and Pierce).

Table 2. Estimated Least Squares and Logit Models

Model	Intercept	X_1 a/	X_2 b/	X_3 c/	MSE	I
Least squares	-.182	1.024	-.569	-3.073	5.92	.625
	(3.32) d/	(.109)	(.22)	(1.35)		
Logit	8.36	.179	-.49	-4.55	e/	.75
	(5.64)	(.125)	(.03)	(4.22)		

a/Estimated cost of producing a feeder calf in the previous year. For details see Arnade (p. 53).

b/Annual fed marketings (thousand head) (Livestock and Meat Statistics).

c/Average fourth quarter U.S. corn price (Agricultural Statistics).

c/The figures in parentheses are the estimated standard errors of the estimated parameters.

e/Mean square error is not applicable for the logit model.

Table 3. Predicted, Actual, and Breakeven Prices, 1976-1981

Model	1976	1977	1978	1979	1980	1981
No change	38.05[a]	36.90	41.25	67.44	83.30	75.53
Trend	43.71	33.00	39.75	75.02	81.77	72.08
ARIMA	39.32	35.49	40.70	69.03	81.80	74.32
Least squares	40.20	45.84	63.13	84.93	80.97	77.86
Logit	.012[b]	.485	.825	.820	.920	.415
Breakeven	39.32	44.14	60.19	84.09	79.57	78.64
Actual	43.89	41.10	58.00	86.74	70.43	70.65

[a] Price per hundredweight.

[b] The probability that the actual price exceeds the breakeven price.

Table 4. Summary of Forecast Performance

Model	MSE	I	D
No change	12.21	.5	95.56
Trend	10.71	.67	69.42
ARIMA	11.60	.5	95.56
Least squares	6.17	.5	84.49
Logit	[a]	.5	92.74

[a] Not applicable

REFERENCES

Arnade, Carlos A. "An Evaluation of Alternative Price Forecasting Mechanisms in Relation to the Florida Stocker Decision." M.S. Thesis, University of Florida. 1982.

Box, G.E.P., and G.M. Jenkins. Time Series Analysis Forecasting and Control, 2nd ed. San Francisco: Holden-Day. 1976.

Box, G.E.P., and D.A. Pierce. "Distributions of Residual Autocorrelations in ARIMA Time Series Models." Journal of the American Statistical Association 64:1209. 1970.

Florida Department of Agriculture and Consumer Services. Beef Cattle in Florida. Bulletin No. 28. Gainesville, FL. 1977.

Gunter, D., and G. Westberry. "The Cost and Returns of Grazing Stocker Calves on Annual Pastures in North Florida." Food and Resource Economics Department, University of Florida, Gainesville. 1979.

Judge, G., R. Hill, W. Griffiths, H. Lutkepohl, and T.C. Lee. Introduction to the Theory and Practice of Econometrics. New York: John Wiley and Sons. 1982.

Nelson, C.R. Applied Time Series Analysis for Managerial Forecasting. San Francisco: Holden-Day. 1973.

U.S. Department of Agriculture. Agricultural Prices. Washington, D.C. 1960-1982.

U.S. Department of Agriculture. Cattle on Feed. Washington, D.C. 1960-1982.

U.S. Department of Agriculture. Livestock and Meat Statistics. Washington, D.C. 1960-1982.