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Forecasting Cash Feeder Steer Prices: A Comparison of the Econometric, VAR, ARIMA, Feeder Cattle Futures and Composite Approaches

Christine Cole, James Mintert and Ted Schroeder*

Many researchers have examined the accuracy of alternative forecasting methods for commodity prices. Techniques evaluated include econometric models and futures markets (Just and Rausser), autoregressive-integrated-moving average (ARIMA) models (Brandt and Bessler; Leuthold et al.), multivariate, univariate, and composite models (Harris and Leuthold), and combinations of individual forecasting approaches (Brandt; Harris and Leuthold). Forecast evaluation results have been mixed. Just and Rausser found insufficient evidence to determine whether futures markets or econometric models are more accurate forecasting tools. They did find, however, that econometric models performed more accurately than futures markets for livestock commodities. Harris and Leuthold found few efficiencies were gained by combining time series and econometric techniques to forecast live cattle prices whereas Brandt concluded that composite forecasts may be preferred to using a single forecast approach. Additionally, Brandt and Bessler found that ARIMA models provided the most accurate individual quarterly hog price forecasts, although composite forecasts performed better than ARIMA forecasts.

Recent research leaves unanswered the question of which forecasting technique is preferred when forecasting agricultural commodity prices. In particular, little attention has been paid to the accuracy of various forecasting techniques applied to prices for livestock that are actually the input in a single production process, such as feeder cattle. An exception was Skaggs and Snyder's investigation of the predictive accuracy of several feeder cattle price forecasting techniques. They forecast a composite feeder cattle price instead of a single weight and sex of feeder cattle, which likely masked variability in the cash price and limited the usefulness of their results. Additionally, their structural models did not focus on the role of feeder cattle as an input in the fed cattle production process. In general, forecasting feeder cattle prices poses a particularly difficult problem because of the uncertainty regarding future output and input prices.

The typical production process for finishing feeder cattle is to place them on a high grain content ration for approximately four to five months after which they are suitable for slaughter (Langemeier et al., Langemeier). Consequently, expected prices for slaughter cattle and expected prices for feed and other inputs required to finish the feeder cattle are expected to have a major impact on feeder cattle prices. The feeder cattle market is of particular interest because futures markets exist for slaughter cattle and for corn, the principal feedstuff used to finish feeder cattle to slaughter weight. Thus, it is possible to construct econometric feeder cattle price forecasting models which use deferred live cattle futures and corn futures contracts as proxies for expected slaughter cattle prices and feed costs. Econometric models constructed in this manner use information readily available at the time the forecast is made to generate feeder cattle price forecasts.

Commodity market outlook is an important component of many state university

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extension programs (Irwin et al.). Livestock outlook programs often require that forecasts be made shortly after the USDA releases livestock inventory reports, such as the quarterly **Cattle on Feed** reports. In particular, extension audiences are interested in obtaining price forecasts one quarter beyond the quarter when the USDA reports are released. For example, at the time of the release of the January **Cattle on Feed** report, forecasts for the second quarter of the year are needed. Given the short length of time available to generate the forecast, price forecasting models that do not require forecasts of the independent variables are particularly desirable.

The purpose of this paper is to compare the forecasting performance of a two-quarter ahead econometric feeder steer price forecasting model for 700-800 pound steers at Dodge City, Kansas which utilizes input and output price expectations with a multivariate vector autoregressive (VAR) model utilizing the same information, an ARIMA model, a naive model, and a model that uses Chicago Mercantile Exchange (CME) feeder cattle futures prices to forecast cash prices. All models are constructed so they rely on information that is available either before or shortly after the release of the quarterly **Cattle on Feed** reports to make forecasting relatively quick.

ECONOMETRIC MODEL

One approach to forecasting the price of a production input is to incorporate market expectations regarding output and other input prices into the model. The econometric model used to forecast feeder cattle prices in this study takes this approach. Cash feeder steer prices are estimated as a function of deferred CME live cattle futures prices, deferred Chicago Board of Trade (CBT) corn futures prices, expected interest rates on feeder cattle loans, and binary variables for seasonality. Live cattle futures, corn future prices and interest rates on feeder cattle loans are all lagged two quarters thereby making it possible to use the model to forecast two quarters ahead. The deferred live cattle futures contract serves as a proxy for expected output price and the deferred corn futures price as a proxy for the expected cost of feed required to finish feeder steers to slaughter weight. Lagged interest rates for feeder cattle loans serve as a proxy for expected loan rates. To select live cattle and corn futures contracts, it was assumed feeder steers sold in a particular quarter would be placed on feed during that quarter, fed four to five months, and sold for slaughter at the end of the feeding period. Deferred live cattle and corn futures prices were chosen such that the futures contract's expiration date was after the end of the expected feeding period for live cattle futures and near the middle of the feeding period for corn futures. The use of live cattle and corn futures prices and lagged loan rates eliminates the need to forecast the independent variables in the econometric model.

The actual econometric model estimated was as follows:

$$1) P_t = F(\text{CATFUT}_{t-2}, \text{CORNFUT}_{t-2}, \text{CATLOAN}_{t-2}, D2, D3, D4)$$

where P_t is the quarterly average price of 700-800 pound feeder steers at Dodge City, Kansas; CATFUT is the CME live cattle futures contract price; CORNFUT is the CBT corn futures contract price; CATLOAN is the interest rate on feeder cattle loans; and D2, D3, and D4 are binary variables for the second, third, and fourth quarters of the year, respectively.

The econometric model in this study was designed to generate forecasts shortly after the release of the quarterly **Cattle On Feed** report. The USDA normally releases the quarterly **Cattle On Feed** reports near the end of January, April, July and October. Consequently, equation 1 was estimated using live cattle and corn futures price data available on the last trading day of January, April, July and October. This means, for example, cash feeder steer prices in the first quarter were estimated as a function of August live cattle and May corn futures closing prices on the last trading day of October. Similarly, second quarter cash feeder steer prices were estimated as a function of October live cattle and July corn futures closing prices on the last trading day of January, third quarter cash feeder steer prices were estimated as a function of February live cattle and September corn futures closing prices on the last trading day of April, and fourth quarter cash feeder steer prices were estimated as a function of April live cattle and December corn futures closing prices on the last trading day of July.

The econometric model was estimated using ordinary least squares (OLS) regression. Out-of-sample quarterly price forecasts were calculated for 1986-1993. Data for 1976-1985 were used to specify the initial econometric model. The 1976-1985 regression model was used to calculate out-of-sample feeder cattle price forecasts for 1986. To predict 1987 prices, the model was re-estimated to include data from 1976-1986. This iterative procedure was repeated for each forecast year, through 1993. Parameter estimates for the final model estimated over the 1976 through 1992 period were as follows:

$$2) P_t = 11.96 + 1.501 \text{ CATFUT}_{t-2} - 9.532 \text{ CORNFUT}_{t-2} - 0.772 \text{ CATLOAN}_{t-2} - 1.613 D2 - 3.466 D3 - 5.112 D4 + e_t$$

(2.75) (-6.48) (23.62) (-2.54) (-1.02) (-2.18) (-3.19)

Asymptotic t-ratio's are reported in parentheses beneath the respective parameter estimate. The model explained 90.2 percent of the variation in feeder cattle futures prices and had a root mean square error (RMSE) of 4.613.

FUTURES MODEL

Cash feeder cattle prices were estimated as a function of the deferred CME feeder cattle futures prices, lagged two quarters. The feeder cattle futures contracts were chosen such that the futures contracts expired during the forecast period, t . Since there was more than one feeder cattle futures contract trading in each quarter, a decision rule was employed to select the appropriate futures price. The average of all closing prices for all feeder cattle futures contracts expiring during the forecast quarter, t , on the last trading day of the month in which the quarterly **Cattle On Feed** report was released was used to estimate the model. For example, cash feeder steer prices in the first quarter were estimated as a function of an average of the January and March feeder cattle futures prices on the last trading day of October. Second quarter cash prices were estimated as a function of an average of the April and May feeder cattle futures prices on the last trading day of January, third quarter cash prices were estimated as a function of an average of the August and September feeder cattle futures prices on the last trading day of April and fourth quarter cash prices were estimated as a function of the October and November feeder cattle futures prices on the last trading day of July. A binary variable was included in the model

to account for any shift that might have occurred when the CME's feeder cattle futures contract changed from a physical delivery to a cash settlement contract, beginning with the January 1986 contract. The actual futures model estimated was in the following form:

$$3) P_t = F(FDRFUT_{t-2}, CMECASHD)$$

where P_t is the price of 700-800 pound feeder steers at Dodge City, Kansas; FDRFUT is the appropriate feeder cattle futures contract as outlined previously and CMECASHD is a binary variable equal to 0 prior to the fourth quarter of 1985 and 1 thereafter.

OLS regression and model updating techniques identical to those used with the econometric model were applied to equation 3 and the model was then used to generate out-of-sample price forecasts. The parameter estimates for the model estimated over the 1976 through 1992 time frame were as follows:

$$4) P_t = 6.952 + 0.857 FDRFUT_{t-2} + 6.669 CMECASHD + e_t$$

(2.05) (16.34) (4.57)

Asymptotic t-ratio's are reported in parentheses beneath the respective parameter estimate. The model explained 87.5 percent of the variation in feeder cattle futures prices and had an RMSE of 5.209.

NAIVE MODEL

The naive model in this analysis uses the most recent feeder cattle cash price lagged two quarters (P_{t-2}) as a forecast for the cash feeder cattle price in the forecast time period (P_t). Cash price was lagged two quarters (instead of one) because at the time the forecast is made, P_{t-1} is not available. For example, the first quarter price is not known at the end of January when the second quarter forecast is made. Consequently, the naive model is defined as:

$$5) P_t = P_{t-2} + e_t$$

ARIMA MODEL

The ARIMA model was initially estimated using quarterly feeder cattle cash price data from 1977 through the third quarter of 1985. The estimated ARIMA was an AR(4). The model had desirable properties with no residual autocorrelation detected using the Ljung-Box Q statistic. The model was then used to forecast prices out-of-sample two quarters ahead. After each quarter the ARIMA model was re-estimated adding the latest quarter of data to the model. The structure of the ARIMA was left as an AR(4) throughout this updating and re-estimation period. The final model, estimated using data from 1977 through 1992 was as follows:

$$6) P_t = 1.093P_{t-1} - 0.154P_{t-2} + 0.344P_{t-3} - 0.279P_{t-4} + e_t$$

(9.00) (-0.87) (1.97) (-2.33)

Asymptotic t-statistics are in parentheses. In the final update of the model, autocorrelation of the residuals was present with the Ljung-Box Q statistic (24 lags) being significant at the 0.01 level. This occurred somewhere during the updating and re-estimation procedure. The next step in this research will be to determine at what point in the updating process the estimated ARIMA began to exhibit autocorrelation and re-identify the model (changing its structure) at that point.

VAR MODEL

Multivariate vector autoregressive models are often used to examine dynamic relationships among a set of interrelated economic variables. Such VAR models most often utilize a set of distributed lag equations to model each variable as a function of other variables in the system. This approach reduces spurious a priori restrictions on the dynamic relationships (Sims). The VAR model included three equations with endogenous variables of the cash feeder cattle price, the fed cattle futures price for delivery during the anticipated slaughter date of the feeder cattle, and the corn futures price.

The VAR system can be defined in general as:

$$7) P_t = \sum_{k=1}^K \begin{bmatrix} b_{11}(k) & \dots & b_{1n}(k) \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ b_{n1}(k) & \dots & b_{nn}(k) \end{bmatrix} P_{t-k} + E_t$$

where t refers to time ($t = 1, \dots, T$), P_t is a 3×1 vector of economic variables, K is the lag order of the system, the $b_{ij}(k)$'s are the parameters to be estimated, and E_t is a vector of random errors. To implement the VAR system, a technique for choosing the appropriate lag order (K) of the system is required. The appropriate order of the VAR system was determined using the likelihood ratio test statistic for alternative lag orders. The final lag order chosen was the largest for which the null hypothesis was rejected. The number of lags selected was two quarters. To verify the final choice of lag length, the Ljung-Box Q statistic was used to test for significant residual autocorrelation in the residuals. In the initial estimation period for each equation, the Q statistic added support for the final specification in that no significant autocorrelation was detected.

The VAR model was modified to use information only available on the forecast date. Therefore, the model was estimated using only information available up to the end of the first month of the quarter prior to the quarter being forecasted. As such, the VAR essentially represents a two-quarter ahead forecast. A trend variable, interest rates, and quarterly dummy variables were added to the VAR as exogenous variables in each equation. Also, in the feeder cattle price equation the most recently available fed cattle futures and corn prices were added as

additional explanatory variables (these could not be added to the fed cattle and corn price equations since these would be the same as the dependent variables).

The VAR model was initially estimated using data from 1977 through 1985. The model was then updated each quarter using the Kalman filter process in RATS (Doane and Litterman) and out-of-sample forecasts were estimated each quarter. Similar to the ARIMA modeling process, the same VAR structure was maintained throughout the estimation period. The Ljung-Box Q statistic showed no signs of autocorrelation among the residuals, in the early updates. However, in the final model estimated using data from 1977 through 1992, residual autocorrelation was detected in the feeder cattle price equation with a Q(24) significant at the 0.05 level. As with the ARIMA model, the next step in this research is to determine at what point this autocorrelation surfaced during the updates and change the model structure accordingly.

COMPOSITE MODEL

A composite forecasting model was constructed from forecasts generated by the econometric, futures, naive, VAR, and ARIMA models. Each model was given an equal weight in the composite as the composite forecasts were simply the average of the forecasts from all of the other models for each time period.

DATA

Cash 700-800 pound feeder steer price data used in this study were monthly prices reported by the USDA's Agricultural Marketing Service for the Winter Livestock Auction in Dodge City, Kansas. Monthly prices were averaged to obtain the quarterly average, expressed in dollars per hundredweight. Chicago Mercantile Exchange live cattle futures, feeder cattle futures, and CBT corn futures settlement prices were obtained from the Knight-Ridder Commodity Research Bureau DataBase. CME and CBT prices were the closing futures price quotes, expressed in dollars per bushel, for the last trading day of the calendar month in which the USDA releases a quarterly **Cattle On Feed** report, (i.e., January, April, July and October). Estimates of the quarterly average interest rate on feeder cattle loans, expressed in percent, were obtained from the **Quarterly Agricultural Credit Survey**, Federal Reserve Bank of Kansas City.

RESULTS

Table 1 presents out-of-sample forecast root mean square errors (FMSE), mean absolute deviations (MAD), mean absolute percentage errors (MAPE), and the percentage of turning points forecast for all of the models calculated for the out-of-sample forecast period of 1986 through 1993. The econometric model had the lowest MAD (3.43) and MAPE (4.456) whereas the composite model had the lowest FMSE (4.262) of all the models. In comparison, the standard deviation of the Dodge City quarterly cash price series for 700-800 pound feeder steers was 9.262 for the entire 1986-1993 period. Standard deviations calculated for each calendar year within the 1986-1993 period were much lower, however, ranging from a low of 1.949 in 1993 to a

high of 3.896 in 1987.

An evaluation of the various models' turning points was also conducted. A turning point was defined as being correctly identified if one of the following conditions occurred $P_{t-2} < P_t$ and $P_{t-2} < \hat{P}_{t/t-2}$ or $P_{t-2} > P_t$ and $P_{t-2} > \hat{P}_{t/t-2}$. The econometric and composite models both correctly forecast over 70 percent of the turning points in the cash feeder steer price series. In contrast, the futures, VAR and ARIMA models all forecast approximately one-half of the turning points in the cash price series.

Table 2 presents the results of the Ashley-Granger-Schmalensee (AGS) test of forecast root mean squared errors (FMSE) conducted on all models. The results of the AGS test indicates that the FMSE of the composite model is statistically smaller than that of all other models except the regression model at the 0.05 level or less. This is consistent with Brandt's results indicating that simple average composite models forecast live hog prices better than individual models. The regression model had a significantly lower FMSE at the 0.10 level than the futures, naive, and VAR models.

Overall, forecast evaluation results suggest that feeder cattle price forecasts from an econometric model based on deferred live cattle futures, deferred corn futures and lagged interest rates on feeder cattle loans produce better forecasts of feeder steer cash prices at Dodge City than do models based on feeder cattle futures. This result is somewhat surprising and warrants further investigation. Additionally, forecasts from the composite model were slightly better than from the econometric model, but the gain was a small reduction in the FMSE. Consequently, the additional cost of developing forecasts for all the individual models required to produce the composite forecast might exceed the gain in forecast accuracy. In addition, the AGS test indicated that the improvement in the FMSE in the composite model relative to the regression was not statistically significant.

CONCLUSIONS

A new technique for forecasting the price of an input in a production process was developed for use in an econometric forecasting model. This approach to forecasting uses market derived expectations of future output and other input prices as a means of forecasting the future price of an input. This technique was applied to forecasting quarterly average cash feeder cattle prices at Dodge City, Kansas using data from 1976 through 1992. Out-of-sample forecasts were generated for the 1986 through 1993 period. Forecasts from this model were compared to those from a VAR model using the same information, a model that estimated cash feeder cattle prices as a function of lagged feeder cattle futures prices, an ARIMA model, a naive model where the cash price in period t was forecast to be equal to the cash price in period $t-2$ and a composite model which was an average of all the other models' forecasts.

Out-of-sample forecasting performance suggests that using deferred live cattle and corn futures prices as proxies for expected slaughter cattle and feed prices in an econometric forecasting model provides good forecasts for cash feeder steer prices. The simple econometric model based on these variables and the composite model provided the best forecasting performance. The econometric model is intuitively appealing because it includes variables expected to affect the demand for feeder cattle and because it is relatively simple to use.

Economic theory implies that increases in expected slaughter cattle prices, decreases in expected feed costs and decreases in interest rates, all other factors held constant, are all expected to have a positive impact on feeder cattle prices. The simple econometric model examined in this paper provides results that are consistent with theory and quantifies the impact of expected slaughter cattle and corn prices on feeder cattle price forecasts which is useful both for adjusting forecasts after the original forecast date and in responding to questions from extension audiences. For example, the model indicates that a \$1 per hundredweight increase in deferred live cattle futures will, on average, lead to an increase in the two-quarter-ahead estimate of 700-800 pound feeder steer prices of approximately \$1.50 per hundredweight. Similarly, a \$0.10 decrease in deferred corn futures prices will, on average, lead to an increase in the two-quarter-ahead estimate of 700-800 pound feeder steer prices of approximately \$0.95 per hundredweight. This information can then be used to adjust feeder steer price forecasts if a substantial change takes place in either corn or live cattle futures prices after the original forecast date. The other models evaluated in this paper, including the composite model, do not offer the advantage of quantifying the expected impact on cash feeder steer prices of changes in expected slaughter cattle or feed prices.

Finally, it is interesting to note that this simple econometric model provided forecasts that were superior to those provided by a model based on deferred feeder cattle futures prices. Additional research on this point is warranted to determine if this was merely a function of the model specification chosen or whether feeder cattle futures forecasting performance is generally inferior to a combination of corn futures, live cattle futures and lagged interest rates.

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Table 1. Out-Of-Sample Forecast Evaluations, 1986-1993.

Criteria	Model					
	Econometric	Futures	Naive	VAR	ARIMA	Composite
FMSE ^a	4.335	5.815	5.003	5.519	4.922	4.262
MAD ^b	3.430	4.799	4.306	4.791	4.170	3.693
MAPE ^c	4.546	6.250	5.563	6.165	5.376	4.778
Turning Point ^d	71.875	50.000	----	53.125	53.125	71.875

^aForecast root mean square error.^bMean absolute deviation.^cMean absolute percentage error.^dPercentage of turning points forecast correctly.

Table 2. Ashley-Granger-Schmalensee Test of Forecast Mean Squared Errors (FMSE)^a

Alternative Forecast	Lower FMSE Forecast					
	Regression	Futures	Naive	VAR	ARIMA	Composite
Regression	—	—	—	—	—	0.172
Futures	0.001	—	0.074	0.035	0.020	0.001
Naive	0.066	—	—	—	0.022	0.003
VAR	0.097	—	0.069	—	0.128	0.004
ARIMA	0.190	—	—	—	—	0.032

^aSignificance levels indicate significance of lower FMSE forecast model relative to alternative forecast. Smaller significance levels indicate stronger FMSE performance of lower FMSE forecast method.