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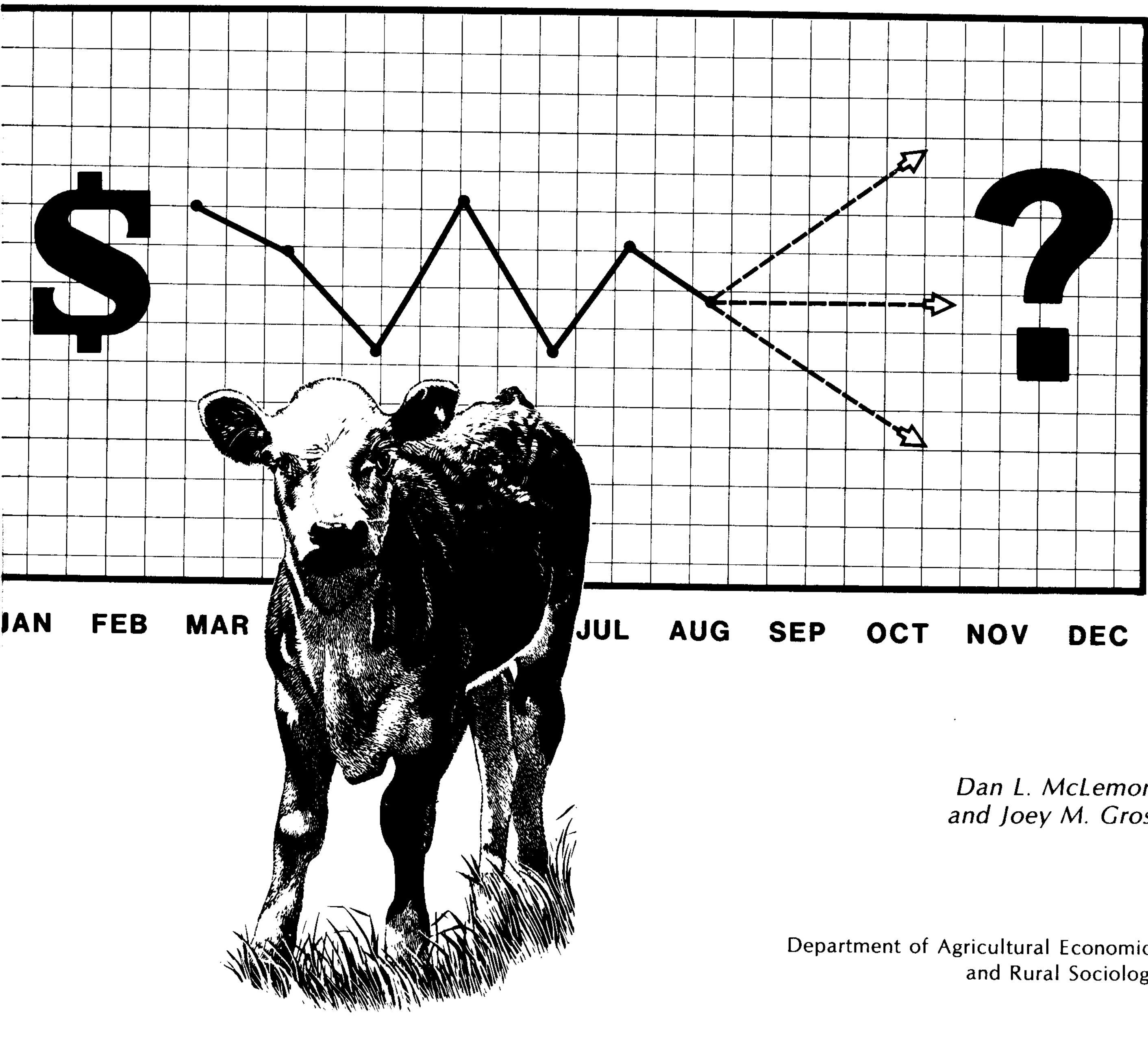

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Table of Contents

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Introduction

Feeder cattle prices in Tennessee and in the U.S. as a whole tend to be volatile. For example, during the six-month period from October 1978 to April 1979 monthly average prices for 500 to 600 lb. Medium Number 1 feeder steers in Tennessee increased from $65.28 to $95.88 per cwt. By October 1979 prices had fallen to $78.42 [Tennessee Crop Reporting Service]. While these are extreme examples, movements of $5 to $10 per cwt. during a six-month period are not uncommon.

These price changes occur for a variety of reasons. The demand for feeder cattle is derived from the market for slaughter cattle which tends to be subject to wide price swings. The demand for feeder cattle tends to increase as slaughter cattle prices increase and as the feeding margin (principally affected by feed grain prices) decreases. When feed grain prices rise or slaughter cattle prices decline, feeder prices tend to decline. These demand-induced price movements are complicated by changes in the supply of feeder cattle, which is determined primarily by the cattle inventory cycle and by seasonality related to calving seasons

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and seasonal grazing conditions. These factors combine to create a substantial degree of price uncertainty for calf producers in Tennessee and in other states and for those who purchase feeder cattle for feedlot or grazing purposes.

Short-run price uncertainty presents a serious problem for decision-makers who produce feeder cattle and for those who use them as inputs. Production and marketing management decisions based on erroneous price expectations may lead to less than optimal resource use and to reduced incomes for cattle producers. The purpose of the research reported here was to provide tools which could be used in forecasting monthly feeder cattle prices in Tennessee six months in the future. Specific objectives were to:

1) Develop a single-equation econometric model based upon fundamental supply and demand factors that will provide monthly feeder cattle price forecasts six months in the future,
2) Develop an alternative single-equation model based upon prices generated by the feeder cattle futures market that will provide monthly forecasts six months in the future, and
3) Provide an evaluation of the accuracy of each model in forecasting prices for an out-of-sample period.

Econometric models, as referred to in objective 1, are appealing because they incorporate variables that are considered to be the causal factors that actually determine the price to be forecasted. However, these models tend to become complex, and numerous problems may be encountered in obtaining values of explanatory variables that must be available before a forecast can be made. The alternative model referred to in objective 2 requires only that futures price quotations be available in order for a forecast to be made.

Since development of models to forecast prices for each individual combination of grades, weights, and sexes of feeder cattle was impractical, a representative category of animal was selected. Based upon the number of animals marketed in the category and its conformance with delivery specifications for futures contracts, the category chosen to represent feeder cattle prices was Medium Number 1 500-599 lb. steers. Since most Tennessee feeder cattle are marketed through auction markets, average price on representative auction markets was chosen as the appropriate price to be forecasted. Forecasts for animals of other characteristics (grades, weights, sex) could be logically estimated based on the forecasted price of this representative category.

Development and Estimation of Models

Econometric Model

The independent variables included in the econometric model may be classified into demand and supply groups. The demand variables that were hypothesized to affect Tennessee feeder cattle prices in the future consisted of measures of feedlot demand and demand for feeder cattle for "nonfed slaughter". Supply variables consisted of the U.S. calf crop, number of available feeder cattle outside feedlots, and an indicator of the number of feeder cattle moving out of stockering programs.

Feedlot Demand. The demand for feeder cattle for placement in feedlots is related primarily to the profitability of the animal in the feedlot. Feedlot profitability is determined by the level of revenue derived from the finished animal and the cost of weight gain during the feeding process. The implied value of the feeder animal may be viewed as a residual remaining after feedlot costs are deducted from the value of the finished animal. That is, feedlot managers can afford to pay no more for the feeder animal than the difference between expected revenue from the slaughter animal and the expected cost of transforming the feeder animal into the slaughter animal. Thus, this difference should strongly influence the price of feeder cattle.

The variable used to measure this difference and to represent feedlot demand six months in the future (month t+6) was the price of the live cattle futures contract which would mature eight months in the future (t+8)[1], less the calculated cost of feed and interest in the feedlot eight months in the future (t+8).[2] This variable was used on a per head basis. Cost of feed and interest was calculated as the weighted sum of the appropriate corn futures price, soybean meal futures

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[1]Since futures contracts are not traded for delivery in every month, prices for nondelivery months were calculated by interpolating between the prices for the contracts on either side of the nondelivery month. This method was used for <u>all</u> futures price series used in this study.

Throughout this report, t is used to designate the current month or the month <u>from</u> which the forecast is made. t+6 is used to designate the month <u>for</u> which the forecast is made. t+8 refers to the month occurring eight months in the future and two months after the month for which the forecast is made.

[2]The price and cost information used to calculate this variable applied to the month (t+8) which followed the month for which the forecast was made by two months. Month t+8 was chosen because it represented the most distant future month for which futures price data were consistently available throughout the sample period. Since a six-month feeding period was assumed, the most appropriate live cattle futures price would have applied to the month (t+12) six months beyond the month for which the forecast was made. However, those data were not available.

price, and short term interest rate.[3] While several cost items were omitted from the calculation in the interest of simplicity, the items included represent the major sources of variability in cost of feedlot gain. Increases in feedlot demand should have a positive effect on feeder cattle price. Thus, the estimated coefficient for the variable was hypothesized to have a positive sign.

Nonfed Slaughter Demand. Under certain market conditions a substantial number of feeder cattle may be purchased by packers for slaughter. This may occur when prices for finished cattle are extremely high relative to prices for feeder cattle due to high costs of feedlot weight gain. Thus, the difference between feeder cattle prices and finished cattle prices on a nationwide basis may be used as an indicator of the demand for feeder cattle for slaughter. This variable was calculated as the price of finished cattle less the price of feeder cattle. The variable was used in two ways in the econometric model. First, the variable was calculated for the month from which the forecast would be made (t) by subtracting current cash feeder cattle price (600-699 lb. Medium Number 1 steers) from current finished cattle cash price (900-1099 lb. Choice steers). This difference should indicate the number of feeder cattle currently demanded for slaughter. These cattle

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[3]Cost of feed and interest was equal to: (1 + interest rate/4) x ((45 x corn price) + (0.135 x SBOM price)) + ((interest rate/2) x (6 x feeder cattle price)). Interest rate was in terms of percent per year in decimal form; corn price was in dollars per bushel; soybean meal price was in dollars per ton; and cattle price was in dollars per cwt. A feeding period of six months was assumed during which the animal would grow from 600 to 1100 lbs. Consumption during the period included 45 bushels of corn and 0.135 ton of soybean meal [USDA, Livestock and Poultry Situation].

would not be available for sale as feeder cattle during later months. Second, the variable was also calculated for the month (6 months in the future) for which the forecast would be made (t+6) by subtracting the feeder cattle futures price for the contract maturing six months in the future from the live cattle futures price for the contract maturing six months in the future (t+6). This difference should indicate the demand for feeder cattle for slaughter during the period for which the forecast is made (t+6). Both variables were hypothesized to have a positive effect on feeder cattle price.

Calf Crop. The United States calf crop is estimated by USDA on an annual basis. The calf crop represents the basic quantity from which new breeding stock and feeder animals are drawn. Calves are normally sold for feeding purposes at ages ranging from six months to one year. Since monthly forecasts were desired from the econometric model, the annual calf crop numbers were centered on July 1 of the year to which they applied. Numbers for the other eleven months were developed by interpolating between adjacent Julys. Since calf crop is a measure of feeder cattle supply, the variable should carry a negative sign.

Available Feeder Cattle. Estimates of the number of steers and heifers weighing more than 500 lbs. that are not on feed on the first day of each quarter are provided by USDA. This number represents the potential U.S. supply of heavier feeder cattle during the immediate future and thus may be an important variable in determining prices six months in the future (in t+6). Estimates for individual months between quarterly estimates were obtained by interpolation. The expected sign on this variable was negative.

Current Stockering Margin. Lightweight (300 to 500 lb.) cattle sold by calf producers usually move into stockering programs to be grown on forage to heavier weights (600 to 800 lbs.). Therefore, a substantial part of the U.S. supply of feedlot-ready cattle come from stockering operations. One of the principal determinants of the number of cattle moving through stockering programs is the profitability of the stockering enterprise. Profitability is largely determined by the margin between the purchase price of the lightweight animal and the sale price of the heavier animal. Larger margins provide a stronger incentive to engage in stockering. When larger numbers of cattle are in stockering programs the current supply of cattle for purchase by feedlots is reduced, but the future supply is increased. Thus, larger current stockering margins (in t) lead to larger feeder cattle supplies in future months (in t+6).

The stockering margin variable was calculated by subtracting current (in t) monthly average prices for Medium Number 1 600 to 699 lb. feeder steers from current (in t) monthly average prices for Medium Number 1 400 to 499 lb. steers. This reverse calculation procedure yielded positive margins in most cases since lighter-weight calves usually sell at a premium over heavier calves. Thus, the expected sign for this variable in the econometric model was positive.

Seasonality. Previous studies have shown that feeder cattle prices in the South tend to contain a seasonal pattern [McManus and Daniel; Shurley and Williams; Leong and Fielder]. This pattern usually consists of higher prices in the spring caused by the availability of pasture and lower prices in the fall caused by the marketing of the large proportion of calves born in the early spring. Since these factors affecting prices are not accounted for by the other variables in the econometric model, the seasonal pattern was represented by a set of 0, 1, -1 dummy variables [Pindyck and Rubinfeld, pp. 135-137]. Based upon observation of seasonal patterns in 1972-81 data on Tennessee feeder cattle prices, the year was divided into three periods: March through May, June through September, and October through February. These periods were represented by a set of two dummy variables (June through September was the omitted class). The March through May variable was hypothesized to have a positive sign while the October through February coefficient was expected to be negative.

Statistical Model. The econometric model discussed above may be represented in symbolic form as follows:

$$P_{t+6} = \beta_0 + \beta_1 FD_{t+8} + \beta_2 NFS_t + \beta_3 NFS_{t+6} + \beta_4 CC_t + \beta_5 AFC_t + \beta_6 SM_t + \beta_7 D_1 + \beta_8 D_2 + e_{t+6}$$

where:

P_{t+6} = average cash price ($/cwt.) of 500 to 599 lb. medium number 1 feeder steers on Tennessee auction markets in month t+6.

FD_{t+8} = feedlot demand, represented by the value of the slaughter animal as reflected in live cattle futures prices for delivery in month t+8, less the cost of feed and interest in month t+8 ($/hd.).

NFS_t = current (month t) nonfed slaughter demand, represented by the monthly average cash price for choice 900-1099 lb. slaughter steers at Omaha, less monthly average cash price for medium number 1 600-699 lb. feeder steers at Oklahoma City ($/cwt.).

NFS_{t+6} = future (month t+6) nonfed slaughter demand, represented by the monthly average price of slaughter cattle futures for delivery in month t+6, less the monthly average price of feeder cattle futures for delivery in month t+6 ($/cwt).

CC_t = annual U.S. calf crop (thousands) centered on July with other months obtained by interpolation between Julys.

AFC_t = number (thousands) of steers and heifers weighing more than 500 lbs. not on feed on the first day of each quarter, with other months obtained by interpolation.

SM_t = current (month t) stockering margin ($/cwt.) calculated by subtracting the monthly average cash price for medium number 1 600-699 lb. feeder steers from the monthly average cash price for medium number 1 400-499 lb. feeder steers at Oklahoma City.

D_1 = 1 if month t+6 is October through February; 0 if month t+6 is March through May; -1 if month t+6 is June through September.

D_2 = 1 if month t+6 is March through May; 0 if month t+6 is October through February; -1 if month t+6 is June through September.

e_{t+6} = error term.

Futures Market Model

Development of the futures market model to forecast Tennessee feeder cattle prices six months in the future was based upon the premise that futures market prices provide a forecast that represents a consensus of knowledgeable traders about likely future conditions. This premise has been called into question [Just and Rausser], and the relationship between futures prices and local cash prices for feeder cattle is not always dependable [McLemore]. However, the futures market does play a central role in the formation of price expectations. The futures forecast is also readily available during every business day.

Variables. The futures market model consisted of two explanatory variables: (1) the current price (in t) for the feeder cattle futures contract that expires during the month for which the forecast is made (t+6), and (2) the difference between the current futures price (in t) and the price for the same futures contract one month ago (in t-1). The first of these variables was hypothesized to be highly and positively correlated with the actual price that will occur six months in the future because it represents the market's collective assessment of future price based upon currently available information.

The second variable was included in order to take account of the prevailing direction of movement (up or down) of the futures price. Rationale for including this variable is based upon the idea that futures markets tend to underestimate higher prices and overestimate lower prices. That is, when prices are moving down, the futures market may be biased upward in its forecast and when prices are moving up, the futures market forecast may be biased downward. These biases may result from the psychological influence of current spot price level on traders in the market.

The difference variable was calculated by subtracting last (t-1) month's price from the current (t) month's price. Thus, the sign on the estimated coefficient for this variable was hypothesized to be positive.

Statistical Model. The futures market model may be represented in symbolic form as follows:

$$P_{t+6} = \beta_0 + \beta_1 FCF_t + \beta_2 \Delta FCF_t + e_{t+6}$$

where:

P_{t+6} was defined above.

FCF_t = the monthly average (for month t) of Thursday settlement prices ($/cwt.) for the feeder cattle futures contract for delivery in month t+6 (see footnote 1).

$\Delta FCF_t = FCF_t - FCF_{t-1}$.

e_{t+6} = error term.

Data Sources

The data used in this study came from secondary sources. The time series used to estimate the parameters of the two models applied to the 1972 through 1981 period (the within-sample period). Comparable data for 1982 and 1983 (the out-of-sample period) were used to evaluate the forecasting accuracy of the two models.[4]

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[4]The within-sample period contained 120 monthly observations. However, since the model was designed to forecast six months in the future, only 114 observations could be used. The out-of-sample period consisted of 18 observations from January 1982 to June 1983.

Futures prices for slaughter cattle and for feeder cattle were monthly averages of Thursday settlement prices on the Chicago Mercantile Exchange. Corn and soybean meal futures prices were monthly averages of Thursday settlement prices on the Chicago Board of Trade.

Interest rates used in calculating the cost of gain in the feedlot were the most common interest rates charged on non-real estate farm loans [USDA, Agricultural Finance Databook]. Monthly figures were interpolated from quarterly data.

Cash prices used in measuring demand for feeder cattle for nonfed slaughter in the current period consisted of monthly average cash prices for Medium Number 1 600-699 lb. feeder steers from the Oklahoma City market and monthly average cash prices for Choice 900-1099 lb. slaughter steers from the Omaha market [USDA, Livestock and Meat Statistics]. These particular markets were chosen because they are very active markets in these two commodities and probably exhibit nationally representative prices.

Data on the U.S. calf crop and on the number of steers and heifers over 500 lbs. not on feed were taken from USDA, Livestock and Meat Statistics. The stockering margin variable utilized the Oklahoma City monthly cash price series described above for 600-699 lb. steers and for Medium Number 1 400-499 lb. steers.

Data for Tennessee feeder cattle prices (the dependent variable) were taken from the Annual Bulletins of the Tennessee Crop Reporting Service. These data represented monthly average prices for Medium Number 1 500-599 lb. feeder steers on 14 Tennessee auction markets.

Results

Application of ordinary least squares procedures to estimate the parameters of both the econometric and futures market models using 1972-81 data revealed that statistically significant positive first order autocorrelation of errors existed in both cases. Durbin-Watson d statistics were 0.64 for the econometric model and 0.58 for the futures market model. This problem was corrected for both models by use of the Statistical Analysis System AUTOREG procedure [SAS Institute].

Estimated Models

Econometric Model. The estimated econometric model and standard errors associated with individual parameter estimates are as follows:

$$\hat{P}_{t+6} = \underset{(32.56)}{203.26} + \underset{(0.0118)}{0.0247}FD_{t+8} + \underset{(0.1485)}{0.0335}NFS_t$$

$$- \underset{(0.2154)}{0.8485}NFS_{t+6} - \underset{(0.0006)}{0.0035}CC_t - \underset{(0.00019)}{0.00014}AFC_t$$

$$+ \underset{(0.1933)}{0.0903}SM_t - \underset{(0.6471)}{0.7019}D_1 + \underset{(0.6763)}{0.8901}D_2$$

$$R^2 = 0.76$$

An F test indicated that the overall regression model was statistically significant at the 1 percent level. The R^2 value of 0.76 suggests that the explanatory variables were reasonably effective in accounting for the variation in feeder cattle prices six months in the future.

The coefficient on feedlot demand (FD_{t+8}) was significantly different from zero at the 5 percent level and the sign on the coefficient was positive as expected. This result indicates that as the feedlot demand measurement increased by $1 per head, the price of feeder cattle increased by 2.47¢ per hundredweight.

The estimated coefficient for current nonfed slaughter demand (NFS_t) was not statistically significant, while the coefficient for future nonfed slaughter demand (NFS_{t+6}) was statistically significant at the 1 percent level. The positive sign on NFS_t was consistent with _a priori_ expectation, but the negative sign on NFS_{t+6} was not consistent with expectation. The unexpected negative sign may have occurred because of the method of measurement of nonfed slaughter demand. Since it is represented by slaughter cattle futures prices less feeder cattle futures prices, larger values of the variable are associated with lower feeder cattle prices, _ceteris paribus_. Thus, the unexpected sign could be due to an arithmetic rather than causal relationship, which suggests that it may be erroneous to use the price difference as a proxy for nonfed slaughter demand.

The estimated coefficient for calf crop (CC_t) was statistically significant at the 1 percent level and the negative sign was as hypothesized. This result indicates that the size of the calf crop has an important impact on feeder cattle prices. As calf crop increased by 1 million head the price of feeder cattle decreased by $3.50 per hundredweight.

The coefficient for the number of available feeder cattle weighing more than 500 lbs. (AFC_t) was not statistically significant. However, it did carry the expected negative sign.

The estimated coefficient on the stockering margin variable (SM_t) was also not statistically significant. However, its sign was consistent with the hypothesized relationship.

Neither of the coefficients on the seasonal dummy variables (D_1 and D_2) were statistically significant. The sign on the October through

February variable was negative as expected, while the sign on the March through May variable was positive as expected. Calculation of the coefficient for June through September by taking the negative sum of D_1 and D_2, results in -0.1882 which is closer to zero than the other two seasonal effects.

Futures Market Model. The estimated futures market model and standard errors associated with each parameter estimate are as follows:

$$\hat{P}_{t+6} = \underset{(6.06)}{17.60} + \underset{(0.0994)}{0.6751}FCF_t - \underset{(0.2022)}{0.2079}\Delta FCF_t$$

$$R^2 = 0.42$$

The overall regression model was statistically significant at the 1 percent level. The R^2 statistic indicates that the model was successful in predicting somewhat less than half of the variation in feeder cattle prices six months in the future during the 1972-81 period.

The estimated coefficient on feeder cattle futures price (FCF_t) was statistically significant at the 1 percent level. The sign on the coefficient was consistent with economic logic. The coefficient indicates that a change of $1 per hundredweight in the appropriate futures market price was associated with a 67¢ per hundredweight change in the cash feeder cattle price six months later.

The estimated coefficient on the month-to-month change in the feeder cattle futures market price (ΔFCF_t) was not statistically significant. In addition, the coefficient carried a negative sign, which is not consistent with the hypothesized sign.

Evaluation of the Estimated Models

Models developed to forecast prices should be finally judged on their ability to accurately forecast. A relatively weak test of each model involved a comparison of price-predicting performance during the time period which generated the data from which the models were estimated (within-sample period). A more rigorous test involved the comparison of forecasting performance during a time period outside the period which generated the data used for estimation (out-of-sample period).

Three methods of comparison were used to evaluate the models: the root-mean-square-error statistic, Theil's U_2 statistic, and a graphical comparison. The root-mean-square-error (RMSE) is the square root of the average of the squared difference between the forecasted prices and the actual prices over a number of periods (months).[5] A smaller value of the root-mean-square-error statistic indicates a more accurate forecast [Pindyck and Rubinfeld, p. 362]. Theil's U_2 statistic is the square root of the ratio of the sum of the squared differences between actual and predicted prices to the sum of the squared differences between

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[5]Root-mean-square-error is defined as:

$$\text{RMSE} = \sqrt{\frac{\Sigma(\hat{P}_{t+6} - P_{t+6})^2}{n}}$$

where: $\hat{P}_{t+6}$ is the forecasted price for time period t+6,

P_{t+6} is the actual price for time period t+6.

n is the number of time periods included.

actual prices and actual prices six months earlier.[6] Thus, the Theil's U_2 statistic compares the accuracy of the forecast from the model with the accuracy of assuming that the best forecast of future prices is the current price (a no-change forecast). The U_2 statistic will equal zero when the model's forecasts are perfect. A U_2 value of 1 indicates that the model forecast and the no-change forecast are equally accurate [Leuthold].

Within-Sample Period. Table 1 shows RMSE and Theil's U_2 statistics for monthly data from the 1972-81 period (within-sample). The RMSE statistic shows how well the estimated models represented the data which were used to estimate the models. The econometric model shows a smaller RMSE indicating that its fit is superior to that of the futures market model on the average.

The U_2 statistics also show that the econometric model is superior. In addition since both U_2 statistics were less than 1, the futures market and the econometric models provided predictions which on average were superior to the "no-price-change" predictions over the ten-year period.

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[6] Theil's U_2 statistic is defined as:

$$U_2 = \sqrt{\frac{\Sigma(\hat{P}_{t+6} - P_{t+6})^2}{\Sigma(P_t - P_{t+6})^2}}$$

where: P_t is the actual price for time period t,

Other variables are as defined above.

Table 1. Root-Mean-Square-Error and Theil's U_2 Statistics for Within- and Out-of-Sample Periods for the Estimated Models

Period/Model	Number of Observations	RMSE	Theil's U_2
Within-Sample (1972-81)			
Econometric	114	3.6969	0.3630
Futures Market	114	5.1840	0.5090
Out-of-Sample (1982-83)			
Econometric	18	3.0000	0.6810
Futures Market	18	3.3984	0.7713

Out-of-Sample Period. Table 1 also shows RMSE and U_2 statistics for the out-of-sample period (1982-83). RMSE and U_2 statistics indicate that on average the econometric model provided more accurate forecasts than the futures market model out-of-sample as well as within-sample. In addition both models showed smaller RMSE values out-of-sample than within-sample indicating better forecasting performances for 1982-83 than for 1972-81. However, U_2 statistics were larger out-of-sample than within-sample. U_2 statistics were both less than 1 showing that on average both model forecasts were superior to no-change forecasts for 1982-83.

Figure 1 presents a graphical comparison of actual prices and forecasted prices from both models for the out-of-sample period. While both models were reasonably accurate for some months (October 1982 and June 1983 for example), both models also were somewhat inaccurate for

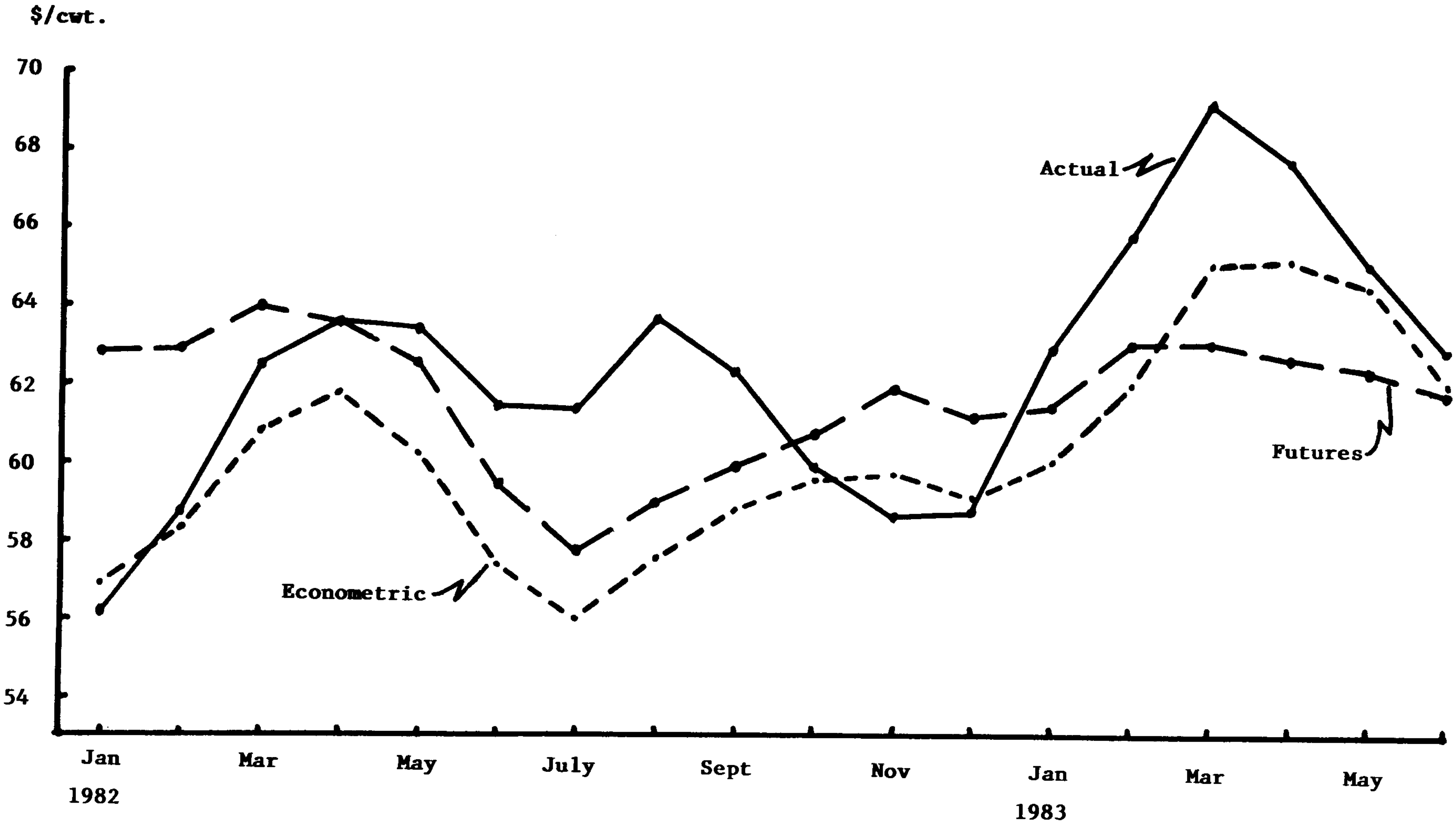

Figure 1. Actual Feeder Cattle Prices on Tennessee Auction Markets and Price Forecasts from Econometric and Futures Market Models, January 1982 through June 1983

other months (August 1982 and March 1983 for example). The actual price line showed five reversals or turning points during the period. Each model indicated two turning points correctly and missed two by one month. However, the actual turning point in August 1982 was not detected by either model. Both models indicated turning points three months later in November 1982 at the time when the actual price was beginning a movement back up. Over the 18-month period the econometric model seems to be in somewhat closer harmony with actual price than does the futures market model. In fact the econometric model forecast was within $1 per hundredweight of actual price during January, February, October, and December 1982 and May and June 1983. However, the econometric forecast was in error by more than $5 in July and August 1982. Overall, both models tended to underforecast more often than they overforecasted during the 1982-83 period.

Conclusions

These efforts to develop price forecasting models which could be used to predict monthly Tennessee feeder cattle prices six months in the future obtained mixed results. For the econometric model only two of the eight explanatory variables met the criterion for statistical significance and carried the hypothesized sign. These two explanatory variables were: an indicator of the future demand for feeder cattle for placement in feedlots and the USDA estimate of the U.S. calf crop. Explanatory variables which produced nonsignificant estimated coefficients but which carried the hypothesized sign were: an indicator of the current demand for feeder cattle for nonfed slaughter, the number of feeder cattle weighing more than 500 lbs. not in feedlots, the price margin for stockering cattle, and seasonal price dummy variables. The variable representing future demand for feeder cattle for nonfed slaughter produced a statistically significant coefficient, but the sign was not as expected.

The futures market model contained two explanatory variables. The feeder cattle futures price variable was statistically significant and carried the hypothesized sign. However, the monthly change in futures price variable was not significant and its sign was not as hypothesized.

When the models' forecasts were tested against actual prices during the within-sample (1972-81) and out-of-sample (1982-83) periods the econometric model showed results which were superior to the futures market model. Both models predicted better than a no-change forecast.

While shortcomings in the models are evident, the econometric model should be a useful tool in developing forecasts for producers and buyers of feeder cattle in Tennessee. Future research efforts should be directed toward improving forecasting techniques.

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