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ABSTRACT

Econometric, univariate-time-series, and multivariate-time-series (transfer function) models were developed to make six-month forecasts of the futures market basis for feeder cattle on Tennessee markets using 1977-88 data. The estimated models were evaluated using out-of-sample data for 1989. The econometric model yielded the best forecasts, although the time-series models also provided forecasts that were superior to naive, no-change forecasts. Initiation of cash settlement reduced the basis. A seasonal pattern in the basis was confirmed by both the econometric and time-series models.

INTRODUCTION

The importance of reliable prediction of the basis[1] in achieving effective price risk reduction through futures market hedging is widely accepted (Chicago Board of Trade; Garcia et al.; Nelson). Once the hedge is placed, the only price risk borne by the hedger is the risk that the basis will not behave as expected. Thus, the more accurately the hedger is able to forecast the basis for the period when the hedge will be lifted, the less risk he/she will bear.

Accurate basis forecasting allows the hedger to consider the futures price at the time the hedge was placed, less the basis for the time when the hedge will be lifted, as a "locked in" price. However, most feeder cattle producers have only very crude tools for use in basis prediction. These tools may consist of no more than an assumption that the basis will behave as it did during the same period last year or the average for the same period over the last few years. These types of tools appear to be inadequate when the basis is highly volatile, as with feeder cattle in local markets long distances from major trading areas (Carter and Lyons; Ward and Schimkat). Thus, the effectiveness of hedging feeder cattle is limited.

The objectives of the research reported here were to provide a description of the basis for feeder cattle on Tennessee markets and to develop relatively simple models that may be used to forecast the basis for Tennessee feeder cattle markets six months in the future. Graphical and statistical descriptions of the basis were developed. Econometric, univariate, and multivariate time series (transfer function) models were estimated using historical data. These models were then evaluated using out-of-sample data. A binary (0 or 1) variable was used to account for effects of the change to cash settlement of the feeder cattle futures contract.

Theory

The theory of the basis for nonstorable commodities such as feeder cattle is not well developed (Naik and Leuthold). However, in markets that are located some distance from major trading areas, the basis is thought to be affected by transportation costs and by current local market supply and demand conditions relative to general expected supply and demand conditions during the settlement period for the particular futures contract (Garcia, et al.)

Transportation cost is thought to affect basis because potential price differences between spatially separated market areas in a free market economy are limited to the amount of transportation cost between the two market areas. That is, with potential for commerce between the two markets, transportation cost between the markets sets the upper limit on the difference in prices. Because Tennessee is not a major price-making area for feeder cattle in the U.S., Tennessee prices may differ from U.S. price averages, but not by more than the cost of moving feeder cattle between Tennessee and the major U.S. market areas. Higher transportation costs should allow a larger basis to exist.

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[1] The term *basis* refers to the price for a given futures contract, less the cash price for the commodity in a specific local market.

Factors that affect relative supply and demand conditions are much less clearly identifiable. The general potential supply of feeder cattle is reflected indirectly in the U.S. cattle inventory. The immediately available supply is measured directly in the quantity of feeder cattle available for placement in feeding or stocking programs.

Results from other research have shown that the phase of the cattle cycle also affects the relationship between U.S. average feeder cattle prices and Southeastern prices (Purcell and Holmes). The Purcell and Holmes study concluded that the Southeast is a "residual supplier" of feeder cattle and that, as a result, demand for Southeastern cattle declines relative to demand in the major market areas as the U.S. supply of feeder cattle rises. This relationship is reflected in the fact that Southeastern prices tend to be lower relative to U.S. average prices during the falling and low price phases of the cattle cycle. Thus, the Tennessee basis should tend to be larger during those periods.

In addition, previous research has identified a seasonal pattern in the basis for Tennessee feeder cattle (McLemore). The general pattern found in earlier analysis was that basis tended to be larger during the winter months than during other seasons.

METHOD

Basis was defined as the price of the nearby feeder cattle futures contract on the Chicago Mercantile Exchange (CME) minus average cash price in local Tennessee markets for cattle meeting the futures contract specification. Daily basis observations were divided into three 10-day periods in each month and averaged within each 10-day period, resulting in 36 observations per year.[2]

Thus, basis predictions from the models were for average basis during specific 10-day periods. In calculating basis, the nearby futures contract was used up through the 10th day of settlement months. Beginning with the 11th day of the settlement month, the next nearest contract was used.

The level and movement of the basis over the 1977-88 period were generally described using graphics and descriptive statistics. The latter included means and standard deviations (a) for the period as a whole and (b) for each 10-day period over years, to obtain a pattern of seasonal basis movement. These descriptions of basis patterns were developed preliminary to the development of the following forecasting models.

Econometric Model

The econometric model was intended to incorporate causal variables that are associated with basis. However, because the purpose of the model was for forecasting rather than for structural hypothesis testing, variables were not necessarily required to pass strict logical tests of causality. The inclusion of purely seasonal variables is a manifestation of this approach. Other variables represent transportation cost and supply and demand factors.

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[2] Days 1 through 10 made up the first 10-day period in each month. Days 11 through 20 made up the second, while the remaining days in a given month made up the third 10-day period.

The econometric model was as follows:

$$(1)\quad B_{t+18} = \alpha_1 + \alpha_2 F_t + \alpha_3 I_t + \alpha_4 R_t + \alpha_5 T_t + \alpha_6 C_t + \alpha_7 Q_t + \alpha_8 S_1 + \text{--} + \alpha_{42} S_{35} + e_t$$

where:

	B_{t+18}	=	10-day average of daily cash prices (\$/cwt) on 15 Tennessee auction markets, subtracted from the daily settlement price for the nearby futures contract, 18 time periods (six months) from the current time (t).
	F_t	=	current price (\$/cwt) of the CME feeder cattle contract that corresponds to the period for which basis is being forecast (t+18).
	I_t	=	U.S. cattle inventory on January 1 (1000s).
	R_t	=	ratio of total quarterly cow slaughter (1000s) to January U.S. cow inventory (1000s).
	T_t	=	current monthly transportation cost index (1967=100).
	C_t	=	a 0, 1 binary variable with a value of 0 through August 10, 1986 and a value of 1 afterward.
	Q_t	=	quarterly number of steers and heifers weighing 500 lbs (225 kg) or more on U.S. farms (1000s).
	S_1--S_{35}	=	0, 1, -1 time-period dummy variables representing the 36 10-day periods each year.
	e_t	=	the error term.

The feeder cattle futures contract price (F_t) was included to serve as a measure of the general level of feeder cattle futures prices. It was expected to be positively related to the basis. U.S. cattle inventory (I_t) was included to represent general supply conditions in the beef industry. The expected sign on I_t was positive. The ratio of cow slaughter to cow inventory (R_t) was intended as an indicator of the stage of the cattle cycle. Higher ratios are indicative of liquidation phases of the cattle cycle and should be associated with a larger basis.

The index of transportation cost (T_t) was included to represent the economic separation between Tennessee markets and markets in major price-making locations. Higher values of the index should be associated with a larger basis. The binary variable C_t accounted for the change in the feeder cattle futures contract to cash settlement that occurred beginning with the September 1986 contract.[3]

The initiation of cash settlement was expected by many observers to cause a reduction in the size and variability of the basis, because cash settlement would be less expensive and simpler than physical delivery and because the cash-settled futures contract applies to heavier (600-800 lb) cattle of somewhat lower grade than the earlier contract (Cohen and Gorham).

The *feeder cattle available* variable (Q_t) was included to represent the available quantity of feeder animals outside feedlots. The expected sign on Q_t was positive. S_1 through S_{35} allowed intercept shifts to account for systematic seasonal differences among 10-day periods.

The econometric model was examined for multicollinearity by regressing each explanatory variable on all the other explanatory variables. R^2 values from this set of regressions were 0.75 for F_t, 0.86 for I_t, 0.67 for R_t, 0.51 for T_t, 0.85 for C_t, and 0.66 for Q_t. These levels of collinearity were not considered serious enough to warrant corrective action.[4]

Initial runs using OLS regression to fit the model indicated significant first-order autocorrelation of residuals. The Durbin-Watson statistic was 0.881, with a first-order autocorrelation coefficient of 0.558. This problem was alleviated using the general differencing scheme available in the SAS AUTOREG procedure (SAS Institute). Higher order autocorrelation coefficients for the residuals were less than 0.3.

Univariate Time Series Model

Autoregressive integrated moving average (ARIMA) models are used primarily for forecasting a time series using only the series itself. These models are based upon the idea that there may be an autoregressive pattern in the data and that random errors or shocks in the series may influence subsequent values of the series (Makridakis and Wheelwright). ARIMA models may be written in the following general form:

$$(2)\quad B_t = \delta + \Phi_1 B_{t-L1} + \Phi_2 B_{t-L2} + \cdots + \Phi_p B_{t-Lp} + \Theta_1 e_{t-m1} + \Theta_2 e_{t-m2} + \cdots + \Theta_q e_{t-mq} + e_t.$$

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3 Prior to the September 1986 contract, feeder cattle futures contracts on the Chicago Mercantile Exchange could be settled by physical delivery. Beginning with the September contract, settlement is by cash, based upon the U.S. Feeder Steer Price reported by Cattle-Fax.

4 Other explanatory variables were considered in the initial stages of the research. These were omitted from the model because of high levels of correlation ($R^2 > 0.86$) with the explanatory variables that were maintained in the model. Variables that were omitted included a grazing condition index for Tennessee, U.S. calf crop, number of cows and heifers that have calved, producer price index, cash price of feeder calves, and placements in feedlots.

In this model, B_t represents the basis or a difference[5] of the basis in time period t, e_t represents the random error term, and Φ_i and Θ_j represent autoregressive and moving average parameters, respectively. The specific autoregressive and moving average parameters to be estimated are selected based upon examination of the data and the particular needs of the analysis. Several different specifications of ARIMA models of the basis were developed in this study, based upon autocorrelation functions from the data and for the residuals, and upon preconceived notions concerning seasonality in the basis and the inherent need for the model to forecast six months (18 time periods) into the future. A seasonal pattern in the basis should imply an autoregressive parameter at a lag equivalent to one year (t-36). Because the objective in this study was to provide methods for forecasting basis six months in the future, parameters at lags smaller than 18 time periods were not considered. Models were identified and estimated using the ARIMA procedure in SAS (SAS Institute).

Multivariate Time Series Models

The multivariate time series model, or transfer function, is a logical combination of univariate time series (ARIMA) models and econometric models containing causal explanatory variables. It is capable of incorporating information from the autoregressive and moving average structure of the series to be forecasted with additional information contained in one or more other time series that are causally related to the series of interest (Makridakis and Wheelwright; Pindyck and Rubinfeld, pp. 593-605). Transfer function models may be represented as:

$$(3)\quad B_t = \delta + \Phi_1 B_{t-L1} + \Phi_2 B_{t-L2} +\text{--}+ \Phi_p B_{t-Lp} + \Theta_1 e_{t-m1} + \Theta_2 e_{t-m2} +\text{--}+ \Theta_q e_{t-mq} + e_t + \psi_1 X_{t-n1} +\text{--}+ \psi_k Z_{t-r1}.$$

where X_t through Z_t represent explanatory variables or input series and ψ_i are regression parameters.

The transfer function models estimated in this study involved the binary variable representing the change in the futures contract to cash settlement (C_t) and the transportation cost index variable (T_t) from the econometric model, along with the univariate ARIMA specifications that provided the best fit.

The variable C_t was chosen for inclusion in the transfer function models because all actual forecasts from the models would be for basis derived from a cash-settled futures contract. The variable T_t was chosen because it showed the largest t value and the largest standardized regression coefficient in the econometric model. The input variables were entered with a lag of 18 periods, as in the econometric model discussed previously.

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[5] Used in this context, *difference* refers to one basis observation minus another (usually the immediately preceding) observation. Thus, the first difference of the basis series is also a series constructed as $\Delta B_t = B_t - B_{t-1}$. The differences are the changes from one period to the next.

Data

The data used in this study were from the 1977-89 period. Data for 1977-88 were used to fit the models, while data for January 1 to June 30, 1989 were used for an out-of-sample evaluation and comparison of the fitted models. A total of 432 observations were available for the estimation process, while 18 were available for out-of-sample evaluation of the estimated models.

Daily futures settlement price data were obtained from CME sources. The cash feeder cattle prices were daily averages from 15 Tennessee auction markets for 600 to 700 lb, medium, Number One feeder steers. The daily averages were composed of the mid-points of the price ranges quoted for that class of animals on each individual market. These prices were obtained from the Tennessee Agricultural Extension Service. U.S. cattle inventory (January 1), quarterly cow slaughter, and quarterly feeder cattle supply data were taken from U.S. Department of Agriculture (USDA) sources.

The transportation cost index was developed as a monthly weighted sum of three other indexes: the wholesale price index for refined petroleum products, the motor vehicle and equipment cost index, and an index of hourly wages received by transportation and public utilities workers. The indexes for petroleum products price and equipment cost were taken from the U.S. Statistical Abstract (U.S. Bureau of the Census), while hourly wages were available from the U.S. Bureau of Labor Statistics Employment and Earnings.

In calculating the transportation cost index, the petroleum products price index and the wage index were each weighted by 0.4, while the equipment cost index was weighted by 0.2. These weights were based upon rough judgements regarding the relative importance of these costs in the total cost of transporting livestock.

RESULTS

The pattern of movement of the 10-day average basis for Tennessee feeder cattle during the 1977-88 period is shown in **Figure 1**. Substantial variation is apparent both within and among years. **Table 1** shows the mean and standard deviation of the basis over the entire period and separately for the period prior to and following the initiation of cash settlement.

Table 1.
Mean and Standard Deviation of the Basis for 600 to 700 lb Medium Number 1 Feeder Steers, by Contract Settlement Method, Tennessee, 1977-88.

Period	N	Mean($)	Standard Deviation($)
Overall (1977-88)	431	5.7045	2.9804
Prior to cash[a] Settlement	345	6.6141	2.3385
During Cash Settlement	86	2.0557	2.4444

[a] Cash settlement was initiated with the September 1986 futures contract.

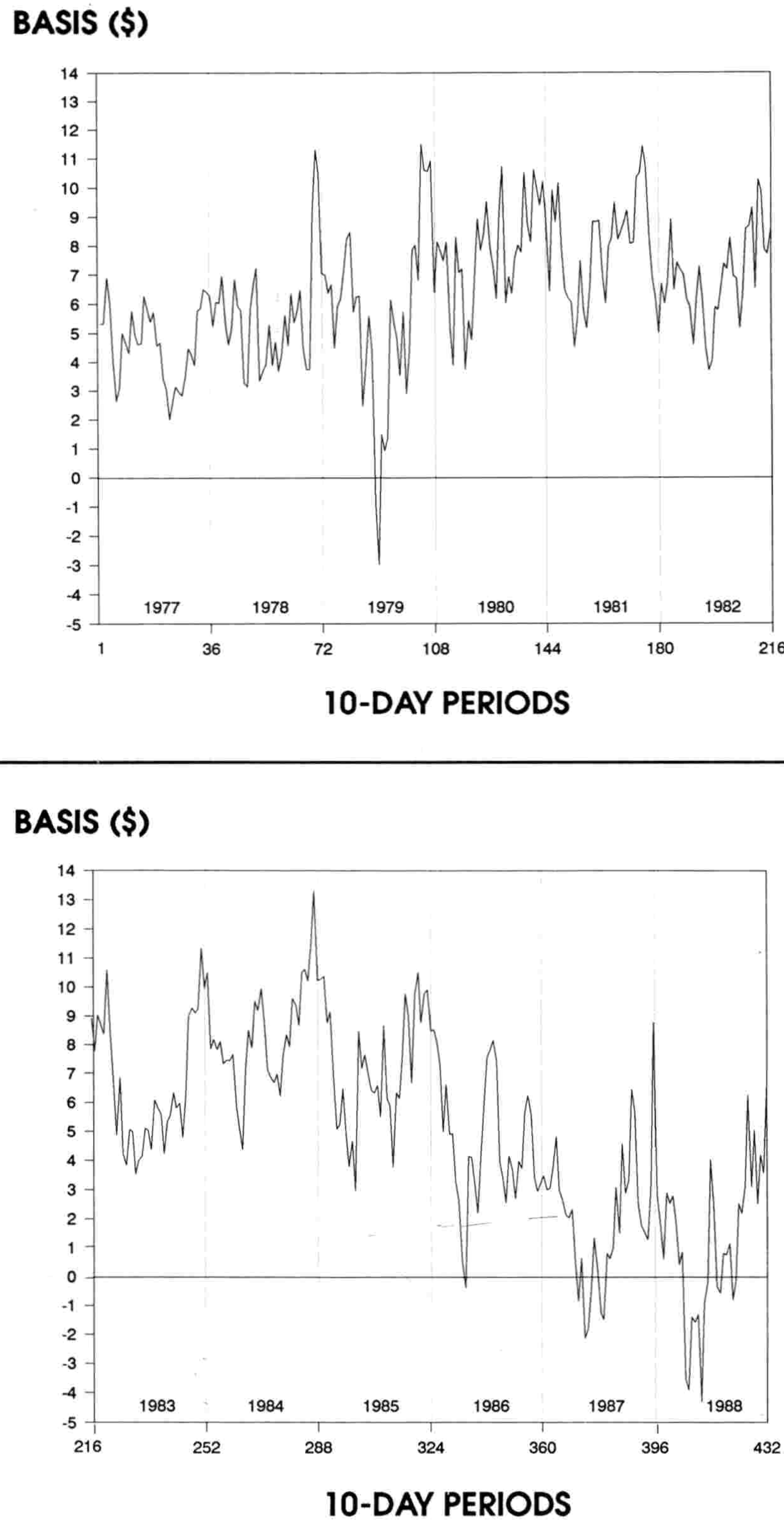

Figure 1. ***(shown in two parts)*** **Average futures market basis ($/cwt) for 600 to 700 lb medium Number 1 feeder steers on Tennessee auctions, by 10-day period, 1977-88.**

The mean basis declined from \$6.61 per cwt prior to cash settlement to \$2.06 per cwt with cash settlement. However, the variability of the basis was slightly higher with cash settlement. Conditions other than the change to cash settlement may have influenced the change in both the level and variability of the basis between the two periods.

The mean basis for each 10-day period over the 12 years is shown in **Figure 2**, along with the standard deviation for each period. **Table 2** contains the numbers used in **Figure 2** and presents a seasonal index for the basis. **Figure 2** and **Table 2** confirm that the basis tends to be larger during October through February and smaller during April through September. The variability of the basis, as indicated by the standard deviation, shows a less pronounced seasonal pattern.

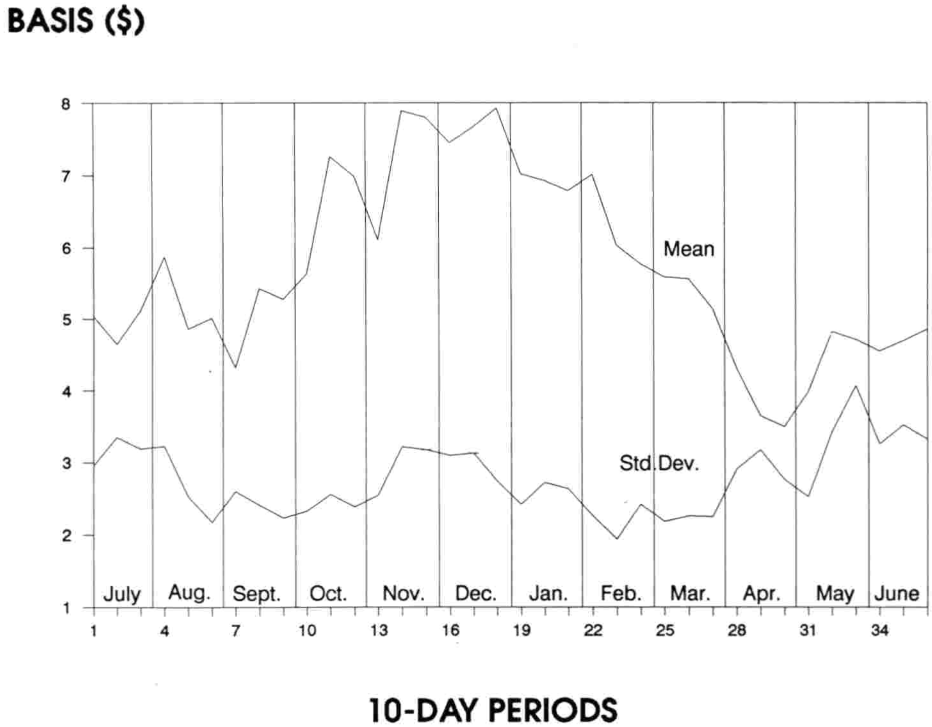

Figure 2. **Seasonal average basis (\$/cwt) and standard deviation for 600 to 700 lb medium Number 1 feeder steers on Tennessee auctions, by 10-day period, 1977-88.**

Estimation of the Econometric Model

The results from fitting the econometric model are shown in **Table 3**. The R^2 for the model was 0.46 and the root mean squared error (RMSE) was \$1.42. Akaike's information criterion (AIC) and Schwarz's Baysian criterion (SBC) were 1450.49 and 1625.89, respectively (Judge, et al.). Excluding the set of seasonal dummy variables (S_1 -- S_{36}), all explanatory variables were statistically significant at the $\alpha = 0.05$ level, except for the cattle inventory variable (I_t). An F-test of the contribution of the group of 36 seasonal dummy variables ($F_{35, 355} = 3.019$) indicated a significant contribution to explained variation ($\alpha = 0.01$). Twenty of the 36 individual seasonal dummies were significantly different from zero

Table 2.
Basis Mean and Standard Deviation and Seasonal Index of the Mean Basis for 600 to 700 lb Medium Number 1 Feeder Steers, by 10-Day Period, Tennessee, 1977-88.

10-Day Period		Futures Contract Used	Basis: Mean	Basis: Standard Deviation	Seasonal Index of the Basis[a]
			($/cwt)	($/cwt)	
July	1-10	August	5.04	2.97	88.4
	11-20	August	4.66	3.35	81.8
	21-31	August	5.12	3.20	89.8
Aug.	1-10	August	5.87	3.23	103.0
	11-20	September	4.86	2.54	85.3
	21-31	September	5.01	2.17	87.9
Sept.	1-10	September	4.32	2.60	75.8
	11-20	October	5.43	2.42	95.3
	21-30	October	5.28	2.23	92.6
Oct.	1-10	October	5.64	2.34	98.9
	11-20	November	7.27	2.57	127.5
	21-31	November	7.00	2.39	122.8
Nov.	1-10	November	6.11	2.56	107.2
	11-20	January	7.90	3.22	138.6
	21-30	January	7.80	3.18	136.8
Dec.	1-10	January	7.45	3.10	130.7
	11-20	January	7.67	3.14	134.6
	21-31	January	7.94	2.76	139.3
Jan.	1-10	January	7.03	2.43	123.3
	11-20	March	6.94	2.73	121.8
	21-31	March	6.80	2.65	119.3
Feb.	1-10	March	7.02	2.26	123.2
	11-20	March	6.03	1.95	105.8
	21-28	March	5.77	2.43	101.2
Mar.	1-10	March	5.60	2.18	98.2
	11-20	April	5.57	2.27	97.7
	21-31	April	5.16	2.25	90.5
Apr.	1-10	April	4.33	2.92	76.0
	11-20	May	3.65	3.18	64.0
	21-30	May	3.50	2.77	61.4
May	1-10	May	3.99	2.53	70.4
	11-20	August	4.84	3.44	84.9
	21-31	August	4.72	4.07	82.8
June	1-10	August	4.57	3.27	80.2
	11-20	August	4.71	3.53	82.6
	21-30	August	4.87	3.34	85.4

[a] The seasonal index is based on the overall mean basis from **Table 1** ($5.7045 per cwt).

Table 3.
Econometric Model Parameter Estimates with Standard Errors, t Values, and Standardized Regression Coefficients, for the Feeder Cattle Basis, Tennessee, 1977-88.

Variable[a]	Parameter Estimate	Standard Error	t Value	Standardized Regression Coefficient[b]
Intercept	- 35.186549	11.627196	- 3.026	——
F_t (Futures Price)	0.092754	0.029406	3.154	0.3264
I_t (Cattle Inventory)	0.000117	0.000067	1.749	0.2253
R_t (Ratio of Cow Slaughter)	99.143765	49.106330	2.019	0.2050
T_t (Transportation Cost)	0.015479	0.003236	4.783	0.3712
C_t (Cash Settlement)	- 2.541440	0.882946	- 2.878	——
Q_t (Available Feeder Cattle)	0.000524	0.000240	2.180	0.1947
S1 (July 1-10)	- 0.469600	0.488659	- 0.961	
S2 (July 11-20)	- 0.895689	0.488562	- 1.833	
S3 (July 21-31)	- 0.484296	0.488928	- 0.991	
S4 (Aug. 1-10)	0.369016	0.483479	0.763	
S5 (Aug. 11-20)	- 0.389767	0.480138	- 0.812	
S6 (Aug. 21-31)	- 0.245291	0.480113	- 0.511	
S7 (Sept. 1-10)	- 0.816510	0.483233	- 1.690	
S8 (Sept. 11-20)	0.378382	0.486314	0.778	
S9 (Sept. 21-30)	0.253930	0.487363	0.521	
S10 (Oct. 1-10)	0.697811	0.496351	1.406	
S11 (Oct. 11-20)	2.239608	0.490578	4.565	
S12 (Oct. 21-31)	1.970913	0.490574	4.018	
S13 (Nov. 1-10)	1.080535	0.496022	2.178	
S14 (Nov. 11-20)	2.746247	0.515550	5.327	
S15 (Nov. 21-30)	2.666274	0.523018	5.098	
S16 (Dec. 1-10)	2.245224	0.524234	4.283	
S17 (Dec. 11-20)	2.531135	0.523350	4.836	
S18 (Dec. 21-31)	2.621048	0.516079	5.079	
S19 (Jan. 1-10)	1.171029	0.516726	2.266	
S20 (Jan. 11-20)	1.203884	0.503984	2.389	
S21 (Jan. 21-31)	0.880363	0.504180	1.746	
S22 (Feb. 1-10)	1.102229	0.499939	2.205	
S23 (Feb. 11-20)	0.146004	0.498998	0.293	
S24 (Feb. 21-28)	- 0.016432	0.498884	- 0.033	
S25 (Mar. 1-10)	- 0.454068	0.499657	- 0.909	
S26 (Mar. 11-20)	- 0.683787	0.500555	- 1.366	
S27 (Mar. 21-31)	- 1.121403	0.501549	- 2.236	
S28 (Apr. 1-10)	- 2.157875	0.516845	- 4.175	
S29 (Apr. 11-20)	- 2.969490	0.512740	- 5.791	
S30 (Apr. 21-30)	- 2.993763	0.508916	- 5.883	
S31 (May 1-10)	- 2.667882	0.545125	- 4.894	
S32 (May 11-20)	- 1.739913	0.563667	- 3.087	
S33 (May 21-31)	- 2.208250	0.569968	- 3.874	
S34 (June 1-10)	- 1.918126	0.529244	- 3.624	
S35 (June 11-20)	- 1.183317	0.526098	- 2.249	
S36 (June 21-30)	- 0.888174	0.517666	- 1.716	

[a] Variables are as previously defined.
[b] Not shown for the dummy variables.

at the $\alpha = 0.05$ level. This result further confirms the existence of a seasonal basis pattern. The pattern evident in the presence of the other explanatory variables (**Table 3**) appears to be consistent with the pattern for the raw data revealed in **Table 2**.

Excluding the seasonal dummies, all of the explanatory variables were positively related to the basis except for the change to cash settlement (C_t) which was associated with a reduction in the basis of $2.54. Standardized regression coefficients (Pindyck and Rubinfeld, pp. 90-91) shown for each of the continuous explanatory variables in **Table 3**, indicated the effect of a one standard deviation change in each explanatory variable on the basis. For example, a one standard deviation change in futures price (F_t) was associated with a 0.3264 standard deviation change in the basis. Based upon this measure, transportation cost (T_t) and futures price (F_t) were likely to have had the most important influences on basis during the 1977-88 period.

Estimation of the ARIMA Models

The results of fitting six univariate ARIMA models are shown in **Table 4**. In general, autoregressive (AR) coefficients were found to be statistically significant at lags of 18 and 36 periods ($\alpha = 0.05$). The 36-period lag (one year) is indicative of a strong seasonal pattern. Because the models were intended to forecast six months ahead (18 periods), the 18-period lag represents utilization of the latest available basis data for each forecast. Lags of less than 18 periods would not be usable. Moving average (MA) components were also significant for 18-period lags.

Several model specifications using other lags were also estimated but were eliminated from consideration because they provided fits that were inferior to the models presented in **Table 4**. The criteria for comparison among models were primarily RMSE and statistical significance of individual coefficients.

Table 4 includes models for undifferenced data and data first-differenced at one period, at 36 periods, and at one and 36 periods[6]. These different models are presented because the autocorrelation functions from the data did not provide clear signals as to whether differencing of the data was necessary to achieve a stationary time series.

Based upon RMSE, the ARIMA models using data first-differenced at one period provided superior fits. Addition of the MA(18) component to the AR(18,36) model improved RMSE slightly. The AIC and SBC values indicated that the models that were first-differenced at one lag and at one and 36 lags were superior. The AR(18,36) model using data differenced at one lag yielded a χ^2 statistic that led to failure to reject the null hypothesis of white noise residuals ($\alpha = 0.10$). The other models in **Table 4** were judged inadequate according to the χ^2 test, in that the null hypotheses of white noise residuals were rejected ($\alpha = 0.10$)[7].

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[6] Differencing at 36 periods represented an attempt to remove the seasonal pattern from the data.

[7] Examination of autocorrelation functions of the residuals from these models and subsequent trials with other AR and MA components failed to produce improved models.

Table 4.
ARIMA Models with Measures of Fit and Estimated Parameters, for the Feeder Cattle Basis, Tennessee, 1977-88.

Model	Differencing	RMSE($)	AIC	SBC	N	Ljung Box χ^2 @ Lag 36	Parameter Estimates & Standard Errors[a]			
							Constant	AR(18)	AR(36)	MA(18)[b]
AR(18,36) MA(18)	1	1.634	1581	1598	413	48.99	0.0012	-0.7595	0.240	0.9359
								(0.0872)	(0.0534)	(0.0787)
AR(18,36)	1	1.645	1586	1598	413	44.24	0.0042	0.1461	0.1471	
								(0.0501)	(0.0529)	
AR(18,36) MA(18)	0	2.379	1897	1913	414	861.16	3.0495	-0.3000	0.7000	0.7610
								(0.0494)	(0.0433)	(0.0496)
AR(18,36)	0	2.456	1922	1934	414	1031.23	1.0416	0.2066	0.5752	
								(0.0429)	(0.0466)	
AR(18,36)	36	2.619	1804	1816	378	688.17	-0.2888	0.2999	-0.2513	
								(0.0509)	(0.0517)	
AR(18,36)	1, 36	1.956	1579	1590	377	70.63	0.0020	0.1217	-0.4608	
								(0.0479)	(0.0501)	

[a] Reported coefficients are based upon the forecasting model:

$B_t = \delta + \Phi_1 B_{t-18} + \Phi_2 B_{t-36} + \Theta_1 e_{t-18} + e_t$ where B represents the basis or a difference of the basis, e represents the error term, t represents time period, and Φ_i and Θ_i represent AR and MA coefficients, respectively.

[b] Signs on the MA coefficients assume that residuals or errors are calculated as $e_t = y_t - \hat{y}_t$.

When comparing undifferenced models with differenced models, an important distinction between the two types of models must be kept in mind. The undifferenced models directly predict the basis *level* for a period six months in the future. The first differenced models, on the other hand, predict the *difference* between the basis level for a period six months in the future and the immediately preceding period. Thus, to obtain a forecast of the *level* of the basis from a first-differenced model, the entire series of differences occurring between the last known basis and the basis to be forecasted must be predicted. In the case of the models presented in this study, a total of 18 differences must be predicted by the first-differenced models to obtain a single forecast of the basis six months in the future.

Each basis forecast is the sum of the last known basis and the 18 predicted differences. Therefore, the differenced models are substantially more difficult to use in actual practice. Also, the basis forecast from the first-differenced models is subject to error in each of the 18 forecasted differences. Each of these potential errors is summed into the basis forecast. In contrast, the forecasted basis from the undifferenced models is subject only to a single forecast error.

The implication is that comparison of RMSEs between undifferenced and differenced models may be very misleading because the RMSE reported for the differenced models measures only the error in predicting the last difference. Thus, reported RMSE probably substantially overstates the accuracy of the differenced models compared to the undifferenced models. This caution also applies to the transfer function models presented next.

Estimation of the Transfer Functions

Table 5 includes the results of estimating the multivariate time series or transfer function models that consisted of the first-differenced and undifferenced ARIMA models from **Table 4**, augmented with input variables representing the initiation of cash settlement (C_{t-18}) and the transportation cost index (T_{t-18}) from the econometric model. Only the first-differenced and undifferenced models from **Table 4** were used in the transfer functions because they were somewhat simpler and provided better fits.

RMSE, AIC, and SBC values indicated that the first-differenced models fit better than the undifferenced models in **Table 5**, although these comparisons may be seriously flawed, as explained above. Generally, the AR coefficients at 18 and 36 lags and the MA coefficients at 18 lags were statistically significant ($\alpha = 0.05$).

Regression coefficients on the change to cash settlement (C_{t-18}) were statistically significant ($\alpha = 0.05$) in five of the seven reported models. The regression coefficient on transportation cost (T_{t-18}) was significant in only one of three models containing that variable. Inclusion of the T_{t-18} variable actually increased RMSE, compared to the identical model without T_{t-18}. The χ^2 statistics for the first-differenced models AR(18,36) C_{t-18} T_{t-18} and AR(18,36)C_{t-18} indicated failure to reject the null hypothesis of white noise residuals at the $\alpha = 0.10$ level.

The other transfer function models were judged inadequate by the χ^2 criterion ($\alpha = 0.10$) although all of the first-differenced models in **Table 5** showed similar χ^2 statistics.

Table 5.
Transfer Function Models with Measures of Fit and Estimated Parameters, for the Feeder Cattle Basis, Tennessee, 1977-88.

Model	Differencing	RMSE($)	AIC	SBC	N	Ljung Box χ^2 @ Lag 36	Parameter Estimates & Standard Errors[a] Constant	AR(18)	AR(36)	MA(18)[b]	C_{t-18}	T_{t-18}
AR(18,36) MA(18) C_{t-18}	1	1.628	1579	1599	413	50.34	0.0123	-0.7633	0.2367	0.9385	-3.220	
									(0.0536)	(0.0804)	(1.599)	
AR(18,36) MA(18) $C_{t-18}T_{t-18}$	1	1.629	1581	1605	413	49.55	0.0091	-0.7628	0.2372	0.9374	-3.213	0.0071
									(0.0537)	(0.0800)	(1.600)	(0.0134)
AR(18,36) $C_{t-18}T_{t-18}$	1	1.642	1587	1607	413	46.28	0.0094	0.1451	0.1433		-3.046	-0.0011
								(0.0504)	(0.0532)		(1.617)	(0.0139)
AR(18,36) C_{t-18}	1	1.640	1585	1601	413	46.22	0.0092	0.1451	0.1429		-3.046	
								(0.0503)	(0.0531)		(1.615)	
AR(18,36) MA(18) C_{t-18}	0	2.069	1782	1802	414	510.66	9.0470	-0.6909	0.3091	0.7844	-4.656	
								(0.0667)	(0.0556)	(0.0584)	(0.296)	
AR(18,36) MA(18) $C_{t-18}T_{t-18}$	0	2.108	1798	1823	414	636.63	5.7128	-0.8718	0.1282	0.8425	-4.528	0.0115
								(0.0798)	(0.0648)	(0.0674)	(0.269)	(0.0015)
AR(18,36) C_{t-18}	0	2.161	1817	1833	414	519.65	4.6718	-0.0652	0.4408		-4.450	
								(0.0460)	(0.0478)		(0.313)	

a Reported coefficients are based upon the forecasting model:

$B_t = \delta + \Phi_1 B_{t-18} + \Phi_2 B_{t-36} + \Theta_1 e_{t-18} + \Psi_1 C_{t-18} + \Psi_2 T_{t-18} + e_t$ where B represents the basis or a difference of the basis, e represents the error term, t represents time period, C and T are as defined earlier, Φ_i and Θ_i represent AR and MA coefficients, respectively, and Ψ_i are regression coefficients.

b Signs on the MA coefficients assume that residuals or errors are calculated as $e_t = y_t - \hat{y}_t$.

Trials with other AR and MA components based on examination of the residual autocorrelation functions did not provide better fitting models.

The coefficients on C_{t-18} in **Table 5** indicate that the initiation of cash settlement was associated with a basis decline of between \$3.05 and \$3.22 for the first-differenced data and between \$4.95 and \$4.66 for the undifferenced data. The coefficients for the undifferenced data are consistent with the difference in means between the period prior to cash settlement and during cash settlement from **Table 1** (\$4.56).

All of the coefficients on C_{t-18} from the transfer functions were larger than that from the econometric model (\$2.54). This lower coefficient from the econometric model implies that a part of the apparent difference in basis, due to the initiation of cash settlement, may actually be attributable to the influence of other variables included in the econometric model but not included in the transfer functions.

Within-Sample Comparisons of Models

Comparisons among all estimated models indicated that the econometric model provided the best fit within-sample (1977-88), based upon RMSE and AIC criteria. The RMSE for the econometric model was \$1.42, while the best ARIMA and transfer function models gave RMSEs of \$1.634 and \$1.628, respectively. The econometric model yielded an SBC value that was larger than that of several of the time series models, due to the larger number of estimated parameters in the econometric model.

Among the time series models, first-differencing the data seemed to improve fit, although, as noted earlier, this apparent superiority may well be very misleading. The transfer function models gave slightly better fits than the univariate ARIMAs. The inclusion of MA(18) components yielded significant MA coefficients and marginally improved RMSEs.

Out-of-Sample Evaluation

Each of the estimated models shown in **Tables 3**, **4**, and **5** were used to forecast the basis for the 18 out-of-sample 10-day time periods from January 1 through June 30, 1989. RMSE and two Theil's U_2 coefficients were calculated for each model using forecasted and actual basis for the 18 periods. These are shown in **Table 6**. The actual basis values, the forecasted values for the econometric model, and the most accurate of the ARIMA and transfer function model values are graphed in **Figure 3**.

In the out-of-sample evaluation, RMSE was calculated based on the actual "miss" in forecasting the basis. Thus, the RMSEs in **Table 6** are valid measures of accuracy for both differenced and undifferenced models.

Theil's coefficients were computed with the naive, no-change forecast, included in the Theil's formula, based first upon the 10-day period *from* which the forecast was made and, second, upon the 10-day period one year prior to the period for which the forecast was made. The second computation of the Theil's coefficient provided a comparison of the forecasting ability of the estimated models with the simple approach that assumes that basis this year will be the same as basis last year.

The first approach to the Theil's coefficient is referred to as *six-month* in **Table 6**

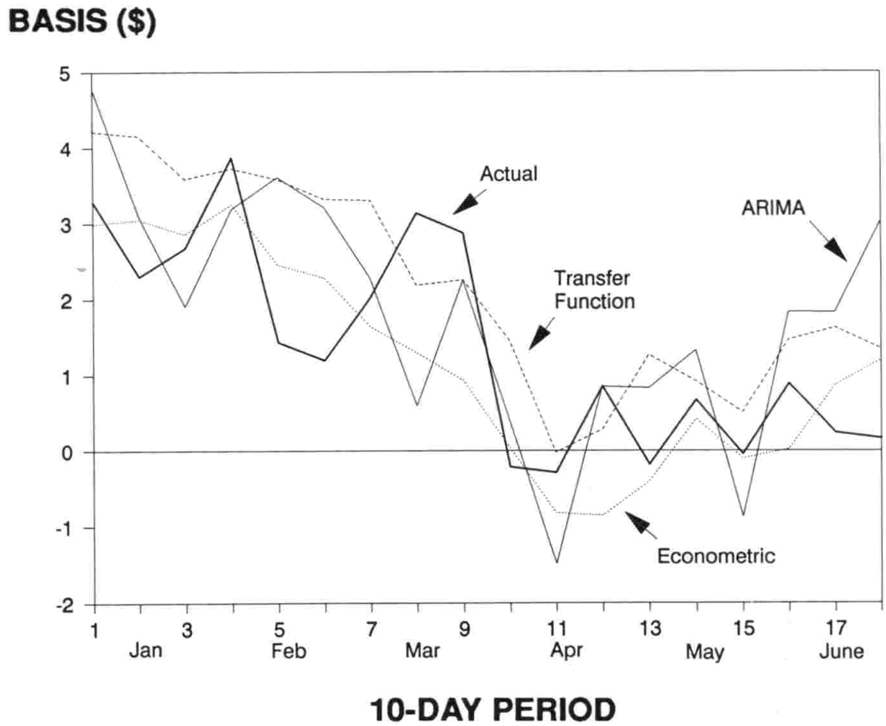

Figure 3. **Actual and forecasted feeder cattle basis ($/cwt) for the out-of-sample period January through June 1989, Tennessee.**

while the second approach is referred to as *one-year.* In view of the seasonal pattern evident in the basis, the one-year approach provided a more realistic test of the forecasting accuracy of the estimated models than did the traditional Theil's U_2 formula.

Based upon RMSE and Theil's coefficients, the econometric model provided more accurate forecasts than any of the other models. The average "miss" in forecasting the 18 time periods with the econometric model was $0.95. The largest miss was $1.95. Since both Theil's coefficients were less than unity, the forecasts from the econometric model were more accurate than either the naive forecast of no change in the basis, or the practice of assuming that the best forecast is the basis that existed during the same period last year.

Among the ARIMA time series models, the best forecasts were provided by the specification containing AR(18,36) MA(18) components applied to undifferenced data. The RMSE was $1.40. The one-year Theil's coefficient was 0.6153, indicating that the model gave forecasts that were superior to the naive forecast of no change from last year's basis. The two undifferenced ARIMA models performed better than any of the differenced ARIMA models.

The transfer functions including both C_{t-18} and T_{t-18} were superior to the corresponding univariate ARIMA specifications. This finding is consistent with the within-sample comparisons. The transfer function that gave the best forecasts (RMSE=$1.21 and one-year Theil's=0.5342) was the AR(18, 36) MA(18) C_{t-18} T_{t-18} specification applied to undifferenced data. The undifferenced transfer function models performed better than differenced transfer function models in the out-of-sample evaluation.

Table 6.
Root Mean Squared Error ($/cwt) and Theil's Inequality Coefficients for Out-of-Sample Forecasts of the Feeder Cattle Basis, from Estimated Econometric, ARIMA, and Transfer Function Models for January through June, 1989, Tennessee.

Model	Input Series	Degree of Differencing	N	RMSE($)	Theil's U_2 Six -Month	Theil's U_2 One-Year
Econometric	—	—	18	0.9511	0.2899	0.4188
ARIMA'S						
AR(18,36) MA(18)	—	1	18	2.8817	0.8785	1.2689
AR(18,36)	—	1	18	4.0632	1.2388	1.7892
AR(18,36) MA(18)	—	0	18	1.3973	0.4260	0.6153
AR(18,36)	—	0	18	1.4438	0.4402	0.6358
AR(18,36)	—	36	18	2.0431	0.6229	0.8997
AR(18,36)	—	1,36	18	1.5223	0.4641	0.6703
Transfer Functions						
AR(18,36)	C_{t-18}	1	18	3.2512	0.9912	1.4317
AR(18,36)	C_{t-18} T_{t-18}	1	18	4.0246	1.2270	1.7722
AR(18,36) MA(18)	C_{t-18}	1	18	2.0849	0.6357	0.9181
AR(18,36) MA(18)	C_{t-18} T_{t-18}	1	18	1.9662	0.5995	0.8658
AR(18,36) MA(18)	C_{t-18}	0	18	1.5686	0.4783	0.6907
AR(18,36) MA(18)	C_{t-18} T_{t-18}	0	18	1.2131	0.3698	0.5342
AR(18,36)	C_{t-18}	0	18	2.1252	0.6479	0.9358

CONCLUSIONS

The results of this study show that the basis (futures minus cash price) for feeder cattle on Tennessee markets can be predicted reasonably well for six months using econometric and/or time series models. Most of the models reported in this study provided forecasts that were more accurate than simply assuming that basis this year will be the same as basis last year. The econometric model gave a better fit within-sample (RMSE=$1.42) and provided more accurate forecasts out-of-sample (RMSE=$0.95) than either the univariate or multivariate time series (transfer function) models. The accuracy of the econometric model confirmed that key explanatory variables that are readily available to hedgers are useful in basis forecasting. These include transportation cost, futures price level, the ratio of cow slaughter to cow inventory, and the quantity of feeder cattle available outside feedlots. All of these variables were positively related to basis.

The transfer function models were superior to the univariate ARIMAs in all within-sample cases and in most out-of-sample cases. This superiority may be attributed to the presence of the variables representing transportation cost and the initiation of cash settlement. Both econometric and time series models confirmed the existence of a seasonal pattern in the basis. This pattern showed a larger basis from mid-October through early February and a smaller basis from late March through mid-June. The estimated models showed that the basis for Tennessee markets was reduced by the initiation of cash settlement of the futures contract in September 1986. The econometric model estimate of this reduction was $2.54 per cwt.

Users of this information should note that the basis for individual lots of cattle may be substantially different from the mean basis for a given 10-day period. Differences may result from variations in futures prices within or among days or from differences in cash prices among days and market locations. Differences in cash prices may occur because of factors such as lot size, cattle quality, and local competition among buyers.

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