8-1987

Econometric and time series models for predicting the futures market basis for Tennessee feeder cattle

Andrew James Dodd

Recommended Citation

Dodd, Andrew James, "Econometric and time series models for predicting the futures market basis for Tennessee feeder cattle. " Master's Thesis, University of Tennessee, 1987.
https://trace.tennessee.edu/utk_gradthes/7355

To the Graduate Council:

I am submitting herewith a thesis written by Andrew James Dodd entitled "Econometric and time series models for predicting the futures market basis for Tennessee feeder cattle." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Dan L. McLemore, Major Professor

We have read this thesis and recommend its acceptance:

Charles B. Sappington, Emmit L. Rawls

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Andrew James Dodd entitled "Econometric and Time Series Models for Predicting the Futures Market Basis for Tennessee Feeder Cattle." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Dan L. McLemore

Dan L. McLemore, Major Professor

We have read this thesis
and recommend its acceptance:

Charles Sappington

Emmit L. Rawls

Accepted for the Council:

CW Minkel

Vice Provost
and Dean of The Graduate School

ECONOMETRIC AND TIME SERIES MODELS FOR PREDICTING THE FUTURES MARKET BASIS FOR TENNESSEE FEEDER CATTLE

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Andrew James Dodd
August 1987

DEDICATION

This work is gratefully dedicated to my wife who in spite of having her own research to complete, gave me help, support and patience. To my parents this work is also dedicated for instilling in me the importance to always keep learning.

ACKNOWLEDGEMENTS

The writer would like to express his sincere appreciation to Dr. Dan L. McLemore for his time, knowledge and guidance. Dr. Charles B. Sappington and Dr. Emmit L. Rawls gave their time, interest and professional knowledge and for this the writer is grateful. The writer also wishes to thank Dr. Joe A. Martin for giving him the opportunity to further his education and to Morgan Gray for assisting him with computers. The writer would like to thank his wife, Sherry, for her help and his friends and family for their support.

ABSTRACT

The purpose of this study was to develop forecasting models capable of predicting basis for Tennessee feeder cattle six months in advance. Both econometric and time series models were developed, estimated and tested out-of-sample.

The econometric model was estimated using five continuous independent variables. These were: transfer cost, futures price level, feeder cattle supply, stage of the cattle cycle and local grazing conditions. Dummy variables were used to represent the futures contract change to a cash settlement system and to represent the seasonality of feeder cattle production and marketing.

The first type of time series model used was a univariate ARIMA model. Two ARIMA model specifications were used in the study, both of which accounted for seasonal components in the autoregressive scheme.

Transfer function models were the second type of time series models used. Two forms of transfer function models were used with each including the futures contract change dummy variable in addition to seasonal autoregressive components. The second transfer function also used a transportation cost index as an exogenous variable.

The five models were used to predict values for 12 10-day marketing periods out-of-sample. These forecasts were compared to actual values using Theil's U_2 coefficient, root mean square error and graphics. Four models were able to predict better than a naive no-price-change model as indicated by U_2 coefficients less than one.

Values for the U_2 coefficients ranged from 0.28 to 1.12 and the corresponding RMSE ranged from \$0.87 to \$3.49.

The transfer function model with the dummy variable to represent the futures contract change to cash settlement and the transportation cost index was the superior model based on the above criteria. The econometric model was second best and the transfer function model with only the cash settlement dummy variable ranked third. The pure time series models ranked fourth and fifth, consistently overestimating the Tennessee feeder cattle basis.

TABLE OF CONTENTS

CHAPTER PAGE

I. INTRODUCTION. 1

Statement of the Problem. 4

Review of Literature. 4

Economic Factors. 4

Basis Studies 6

Feeder Cattle Pricing 8

Objectives. 9

II. METHODOLOGY AND MODELS. 11

Overview. 11

Econometric Model 12

Transfer Costs. 12

Futures Price 12

Available Quantity of Feeder Cattle 13

Local Market Conditions 13

Cash Settlement 14

Seasonal Dummy Variables. 14

Model Specification 16

Autoregressive Integrated Moving Average Model. 17

Transfer Function Model 20

CHAPTER PAGE

Data. 21
  Transfer Costs. 21
  Cash Feeder Cattle Price. 22
  Futures Price and Basis 22
  Local Market Conditions 23
  Quantity of Feeder Cattle Available 23
  Cattle Cycle Variable 23

III. ESTIMATED MODELS. 25
Econometric Model 25
Time Series Models. 29
  ARIMA Models. 29
    AR Model 1: (1)(35,36) 30
    AR Model 2: (18)(35,36). 31
  Transfer Function Models. 36
    Transfer Function Model 1: Cash Settlement Dummy Variable. 36
    Transfer Function Model 2: Transportation Cost Index and Cash Settlement Dummy Variable. 37
  Forecast Results. 40
    Introduction. 40
    Econometric Model 42
      AR Model 1: (1)(35,36) 42
      AR Model 2: (18)(35,36). 46

CHAPTER PAGE

Transfer Function Model 1: Cash Settlement Dummy Variable. 46

Transfer Function Model 2: Transportation Cost Index and Cash Settlement Dummy Variable. 51

IV. SUMMARY, CONCLUSIONS AND IMPLICATIONS 57

Summary 57

Models. 57

Data. 58

Estimation and Results. 59

Conclusions 61

Implications. 62

LIST OF REFERENCES. 64

APPENDIX. 67

VITA. 69

LIST OF TABLES

TABLE PAGE

II- 1. Ten-Day Marketing Periods and Corresponding Futures Contract Months. 15

III- 1. Correlation Coefficients for the Econometric Model Variables. 26

III- 2. Parameter Estimates for the Econometric Model with the Associated t-Values and Standard Errors. 28

III- 3. Chi-Square and Autocorrelation Coefficients from the AR(1)(35,36) Model of the Tennessee Feeder Cattle Basis, 1977-1986. 32

III- 4. Chi-Square and Autocorrelation Coefficients from the AR(18)(35,36) Model of the Tennessee Feeder Cattle Basis, 1977-1986. 34

III- 5. Models Fitted Using the ARIMA Method with Standard Errors and t-Values of Parameters 35

III- 6. Chi-Square and Autocorrelation Coefficients from the Transfer Function Model with CS for the Tennessee Feeder Cattle Basis, 1977-1986. 38

III- 7. Chi-Square and Autocorrelation Coefficients from the Transfer Function Model Using CS and TR for the Tennessee Feeder Cattle Basis, 1977-1986 41

III- 8. 1987 Tennessee Feeder Cattle Basis Forecasts from the Econometric Model by 10-Day Period 43

TABLE PAGE

III- 9. 1987 Tennessee Feeder Cattle Basis Forecasts from the AR(1)(35,36) Model by 10-Day Period. 45

III-10. 1987 Tennessee Feeder Cattle Basis Forecasts from the AR(18)(35,36) Model by 10-Day Period 48

III-11. 1987 Tennessee Feeder Cattle Basis Forecasts from the Transfer Function Model Using CS by 10-Day Period. 50

III-12. 1987 Tennessee Feeder Cattle Basis Forecasts from the Transfer Function Model Using CS and TR by 10-Day Period . 53

III-13. RMSE and Theil's Inequality Coefficients for Out-of-Sample Forecasts from Estimated Models for January Through April,1987 55

LIST OF FIGURES

FIGURE PAGE

III-1. 1987 Actual and Forecast Basis from the Econometric Model . 44

III-2. 1987 Actual and Forecast Basis from the AR(1)(35,36) Model. 47

III-3. 1987 Actual and Forecast Basis from the AR(18)(35,36) Model 49

III-4. 1987 Actual and Forecast Basis from the Transfer Function Model Using the Cash Settlement Dummy Variable. 52

III-5. 1987 Actual and Forecast Basis from the Transfer Function Model Using the Transportation Cost Index and the Cash Settlement Dummy Variable 54

CHAPTER I

INTRODUCTION

The beef cattle industry is an important part of agriculture in Tennessee. In 1986 it was estimated that beef cattle were raised on 74,000 farms in Tennessee [20]. Feeder calf production and backgrounding involves a large number of beef cattle producers in Tennessee. Knowledge of the cash price level is important when making decisions dealing with production and marketing of feeder cattle.

Prices of feeder cattle sold on Tennessee auction markets are volatile. Between 1977 and 1986, daily cash prices of 600-700 pound medium number one feeder steers for 15 Tennessee auction markets ranged from $31.88 to $89.50 per 100 pounds [17]. This price fluctuation can lead to uncertainty when feeder cattle producers are making production and marketing decisions.

As a way to deal with price uncertainty when marketing, producers can hedge using the Chicago Mercantile Exchange's feeder cattle futures contract. Hedging is a way of shifting risk to speculators by taking a position in futures opposite but equal to an existing cash position. This has been done in grain markets since the mid 1800's when commodity futures began trading in this country [6, p. 107].

If a producer of feeder animals currently owns feeder cattle, he is said to be long cash feeder cattle. The producer can offset the risk of a price decline by selling a futures contract. A producer has executed a perfect hedge when cash and futures prices increase or decrease by the same dollar amount during the period of the hedge. A perfect hedge requires that profits or losses on cash commodities will be precisely offset by losses or profits on futures positions [6, p. 149].

While hedging does shift price risk, it does not remove the risk associated with basis. Basis, as it was used in this study, is the difference between the nearby futures contract price and the Tennessee cash price for 600-700 pound medium number one feeder steers on 15 Tennessee auction markets. Basis is equal to the futures price minus the cash price. Cash and futures markets do not always move together as described with the perfect hedge. A more realistic example would involve the basis decreasing (narrowing) or increasing (widening) during the hedged period causing a profit or a loss on the hedging transaction.

The daily basis in Tennessee has ranged from -$8.33 to $16.75 per 100 pounds during the 1977 through 1986 period. Knowledge of basis is essential for the hedger who is forced to assume a risk in basis by using futures contracts to hedge against a larger risk in price level. The successful use of hedging by a producer depends on the ability to understand and predict basis for the time period when the producer simultaneously offsets his futures position and markets his feeders in the local cash market.

Futures prices and cash prices in the delivery period will tend to converge. Arbitrage insures this tendency through simultaneous purchase in the lower priced market and sale in the higher priced market. Prior to September, 1986, delivery was possible on feeder cattle futures contracts. This enabled arbitragers to deliver when the differences between cash and futures markets were greater than the transportation and transaction costs associated with delivery.

Beginning with the September, 1986, feeder cattle futures contract, the Chicago Mercantile Exchange (CME) implemented a cash settlement system to replace the delivery system previously used. The United States Feeder Steer Price (USFSP) as compiled by Cattle Fax is now used for cash settlement of positions held until expiration of the contract. The USFSP and futures price now tend to converge at contract expiration due to cash settlement potential rather than through the delivery system. With cash settlement, a different form of arbitrage will help the markets to converge by selling or buying the feeder cattle futures contract when its price is premium or discount to the USFSP.

The relationship between cash and futures prices differ between storable and nonstorable commodities. Hieronymus describes these differences as they relate to futures trading. Price relationships in storage markets are the functional interrelationships that are forced by the need to store until a later time (storage charge) and to ration the quantity available over time [6, p. 166]. The difference in futures and spot prices is payment for storage and the basis results from demand for and supply of storage [6, p. 154].

The essential characteristic of price relationships in nonstorable commodities is that there is no functional relationship. In theory, the price of each delivery period is a true forecast of price. Since it is not possible to carry the product forward to a time in the future, it must move through market channels and into consumption when it is ready for market [6, p. 166]. Marketing can be advanced or delayed with some change of form, provided it is not unreasonably costly for the producer. Because feeder cattle are nonstorable, basis is harder to predict than with storable commodities where historical basis and storage charges may provide fairly accurate estimates of future basis.

Statement of the Problem

Two major concerns of a Tennessee livestock producer considering hedging using futures are an understanding of futures markets and an understanding of the basis. The latter is addressed in this study. The need for an understanding of basis is essential for a successful hedge.

The problem dealt with in this study was forecasting the basis for the time period when feeder cattle will be marketed. In this study that time period was considered to be six months from the day hedges are placed. With an accurate prediction of basis the producer will be able to combine the forecasted basis level with the hedge price level to know with more certainty what his net market price will be for feeder cattle.

Review of Literature

According to Leuthold and Tomek, cash and futures price relationships in nonstorable commodities have not received the attention that storable commodities have received. Since nonstorables change form over time, there is no inventory demand, thus making basis more difficult to predict.

Economic factors. Knowledge of the economic factors which affect basis is fundamental to understanding futures market price behavior [9,

p. 49]. Some of these economic factors relate to the regional location of markets [2, 12, 14].

Bobst in 1973 compared hedging revenue variances to measure locational basis variability. Hedging results using 21 successive live cattle futures contracts were observed from January, 1969, to June, 1972. Three lengths of hedges were postulated for the study with Omaha as the delivery point. The study concluded that location basis variability was a significant factor in three Southern and Southern Plains markets. The hedgers in the three distant markets did not operate with the same degree of risk-shifting effectiveness compared with the Omaha area but hedging was effective. The hedging revenue means were lower than cash means showing that during the time period studied, hedging was a money-losing alternative [2, p. 77]. From this it can be postulated that basis is dependent on location.

Another study dealing with locational effects and hedging was the study done by O'Bryan, Bobst and Davis in 1977. Hedging feeder cattle in Kentucky markets from March, 1973, to April, 1976, was the subject of research. In this early study using feeder cattle futures, hedging revenues in Kentucky markets showed no difference in variability compared to delivery markets. Spatial differences did cause mean revenues to be lower in Kentucky markets. The study showed that a reduction in the variance of revenue was a result of increasing the length of hedges. This reduction in variance came at the cost of a reduction in expected revenue. The study also showed that spatial differences can help explain the price relationships between markets.

Research reported by Purcell and Holmes in 1978 attempted to explain the spatial price differentials between Southern and Central markets for live cattle and feeders. Weekly data from January, 1969, to December, 1976, were used in the study which compared Georgia and Kentucky feeder prices to Kansas City feeder prices. The cattle cycle was used to explain the differences in market prices between regions. They found that the feedlots reached further into the Southeast for calves when placements on feed were high and fed cattle were a large percent of total slaughter. This increased demand and bid prices up as was characteristic of the rising and favorable price phases of the cattle cycle. Demand for Southeastern calves declined when placements were low causing prices to be lower relative to Kansas City. This was exhibited during falling and low price phases of the cattle cycle. Prices for feeders in the Southeast were lower relative to the major cattle feeding states during the falling and low price time periods of the cattle cycle than they were during the stable and rising price phases. The Southeast appears to be a residual supplier and is more vulnerable to cattle inventory and slaughter cycles [14, p. 15]. This study suggests that basis is economically related to the relative quantity of feeder cattle and the cattle cycle.

Basis studies. Past research has provided basis studies using various empirical techniques to explain and forecast basis [1, 7, 10, 23, 24]. Ward and Schimkat said, "The literature on basis theory for nonstorable commodities such as feeder cattle is at best in the early stages of development. Storage theory offers little in explaining basis for nonstorables" [24, p. 193]. In their 1980 study, Ward and Schimkat also discussed the use of a time series model using spectral analysis and regression. Their time series model worked best for lighter-weight feeders. It explained nearly 71 percent of the variability in basis for the 300-400 pound weight category between January, 1973 and 1978. This study concluded that success in hedging depends on the characteristics of the cattle hedged as well as on the application of the empirical tools for forecasting, but there is potential hedging application for Southern producers [24, p. 196].

An econometric model developed by Leuthold in 1979 explained live cattle basis using monthly data from 1969 through 1976. This paper explained basis using an econometric model which reflected two independent sets of demand and supply functions for cash and futures market prices. Leuthold used four models for hedging two to seven months prior to contract delivery. The study concludes that basis for live cattle can be explained by the factors which affect shifts in supply and that basis was less variable than the futures or cash prices [7, pp. 15-16].

A study by Vollink and Raikes in 1977 examined the relationship between the price at par delivery points and the futures price during the delivery period for live cattle. The study was done using daily data from February, 1974, to February, 1976. Results showed that during the delivery period, par delivery point basis values for live cattle differed from zero by more than transactions costs associated with arbitrage. Reasons they provided for this difference could be associated with trader expectations and risks associated with returns to arbitrage. The model developed to explain the difference found that price expectations of speculators explained about 40 percent of the par delivery point basis variation for live cattle [23, p. 183]. Risk was assumed to account for some of the remaining variation.

McLemore's 1978 study examined local basis and geographic and weighing practice price differentials for feeder cattle and hogs in Tennessee [10, p. 33]. Tennessee feeder cattle basis was analyzed using a trend and seasonal effects model for 1972 to 1976. The methodology used in McLemore's 1978 study was useful to the current study of Tennessee basis. The techniques involved calculation of the basis, averaging of the basis and seasonal dummy variable specification.

An M.S. thesis by Bishop in 1983 attempted to identify the explanatory variables for Tennessee feeder cattle basis using data from 1972 through 1980. An econometric model, simple trend seasonal model and an ARIMA model were used to analyze and predict the Tennessee basis. Results indicated that transportation costs and cash feeder cattle prices were significant in explaining basis levels for Tennessee. The study also showed that a significant seasonal pattern existed for Tennessee basis. The econometric model used was superior to the simple trend seasonal model and ARIMA model in forecasting and in explaining the Tennessee basis.

Feeder cattle pricing. Research has been done concerning feeder cattle pricing which is helpful in understanding the basis between futures and cash prices. The study by Ehrich in 1969 showed a relationship between feeder cattle cash prices and futures prices for live cattle. This spread was the market value for feeding services. It was asserted that feeder cattle placements do not adjust to the price spread in the short run but that feeder cattle prices will adjust to fed cattle prices. The futures data used was monthly from January, 1965, to November, 1967.

Research by McLemore and Gross compared the forecasting ability of two models. An econometric and a futures market model were developed to predict feeder cattle price six months into the future. The period studied was 1972 to 1983 using monthly data. The econometric model explained 76 percent of the variation in feeder cattle prices. The futures model explained only 42 percent of the variation in prices. Comparison techniques to evaluate the predictive ability of the models were: root mean square error, Theil's U_2 statistic and a graphical comparison. The results of the comparison of forecasts indicated that the econometric model was superior to the futures model in forecasting accuracy. The methodology of this study was useful in developing and testing models to predict Tennessee basis.

Objectives

As was mentioned previously, the key for the successful hedging of feeder cattle is an understanding of the basis. The purpose of this study was to develop an accurate forecasting model for the Tennessee feeder cattle basis. This model could then be used by persons marketing feeder cattle to help remove basis uncertainty and by feeder cattle backgrounders for making production decisions based on the expected price of feeder cattle six months in the future.

The first objective was to develop an econometric model capable of forecasting Tennessee feeder cattle basis using economic variables which affect basis. The second objective was to develop a time series model which would forecast Tennessee basis from past levels. The development of a transfer function model to forecast basis from economic and time series data was the third objective. The fourth objective was to compare forecasts generated by each model using an out-of-sample testing period. The results of the tests provided an indication of the most accurate forecasting model for Tennessee basis.

CHAPTER II

METHODOLOGY AND MODELS

Overview

The need to know what economic factors affect the basis and what price relationships direct traders' actions is fundamental to understanding futures market price behavior [9, p. 49]. Economic theory provides concepts for the development of relationships between causal variables and the Tennessee basis. Tennessee basis can be estimated with the econometric model developed.

Assuming that a time series has been generated by a random or stochastic process, univariate time series analysis is appropriate for the purposes of forecasting. With time series analysis the description is not given in terms of a cause-and-effect relationship (as with regression) but in terms of how randomness is embodied in the process [13, p. 493].

Two types of time series analysis were used to develop models to forecast the Tennessee basis. The autoregressive integrated moving average (ARIMA) model is a univariate time series analysis procedure which relates past values and past disturbances of basis to current basis. Transfer function models were also developed for predicting basis. The transfer function involves the use of one or more economic causal variables in combination with the ARIMA process.

Producers need to estimate the Tennessee basis for the day when they will market their feeder cattle locally and offset their futures contract position. It is difficult to know the exact day when this will occur making it difficult to estimate basis. To address this problem the values for Tennessee basis were averaged into 10-day periods which required that the producer know only the approximate day he intends to market feeder cattle. The marketing periods were established by dividing each month into three 10-day periods yielding 36 marketing periods per year.

Econometric Model

The econometric model was developed for prediction, and the variables used were chosen to reflect this. Since perfect measurements are not possible for variables, best representatives were used based on simplicity. Variables were identified so that the model would have application for use by producer/hedgers of feeder cattle.

Transfer costs.

Transfer costs are related to basis because of the spatial distribution of markets. Cash prices in separated markets are related by the cost of transfer between the markets. The economic representation of the difference in location of markets is transfer cost. Basis is the difference between futures market price and the Tennessee cash market price which are spatially separated markets and are expected to be related by transfer costs.

A transportation cost index was used to represent transfer costs. It is expected that as transfer costs increase, the basis between futures and Tennessee cash prices will increase.

Futures price.

Futures prices represent the expected equilibrium price for delivery during a time period in the future [6, p. 166]. The level of feeder cattle contract prices for a time period in the future is expected to influence the level of the Tennessee basis in that time period. Tennessee basis is equal to the feeder cattle futures price minus the Tennessee cash price. This relationship between basis and futures prices was expected to be positive.

Available quantity of feeder cattle. Purcell and Holmes found that the quantity of feeder cattle and basis were related. As the national available supply of feeder cattle increases relative to feedlot placements, the bidding is not as aggressive for feeder cattle from the Southeast which causes the Tennessee basis to widen. This would be representative of the low price and falling price phases of the cattle cycle. To measure the economic relationship between the available quantity of feeders and Tennessee basis, annual calf crop numbers were used.

The cattle cycle was represented by the ratio of cow slaughter to the January 1 inventory of all cows. The measure would indicate phases of the cattle cycle associated with liquidation and expansion of cow numbers. As fewer cows were being slaughtered as a percentage of cow inventory, the quantity of feeder cattle would be expected to increase which would cause the price to decrease. The basis would be expected to become wider using the same rationale given in the preceding paragraph.

Local market conditions. Basis is not only influenced by nationwide market conditions but by local market conditions. The local price for feeder cattle is dependent on the local supply and demand for feeders. The local market is expected to be influenced by pasture conditions in Tennessee. With poor pasture conditions due to adverse weather, producers who traditionally buy feeder cattle to background may postpone their purchases causing a decline in demand. Local feeder cattle supply may increase since producers lacking forage may decrease their cattle holdings rather than purchase additional forage. The local market conditions were represented by the grazing condition index for Tennessee.

Cash settlement. Starting with the September, 1986, feeder cattle contract, the Chicago Mercantile Exchange changed from a delivery settlement system to a cash settlement system. The United States Feeder Steer Price (USFSP) as compiled by Cattle Fax is currently used for cash settlement of feeder cattle futures contracts held until expiration and is now the price with which the futures price tends to converge during the expiration period. Previously, futures prices tended to converge with cash prices in par delivery markets during the delivery period. The USFSP is a national average price and is lower relative to the prices associated with the former delivery markets [4, p. 8]. A dummy variable was included in the models to account for this structural shift in the makeup of the Tennessee basis.

Seasonal dummy variables. Feeder cattle basis in Tennessee has been shown to be seasonal [1, 10]. The traditional production and marketing of feeder cattle in the spring and fall of the year along with the Tennessee basis shifts due to futures contract month changes justify inclusion of time period dummy variables. As shown in Table II-1, futures contracts which correspond most closely to the actual marketing

Table II-1. Ten-Day Marketing Periods and Corresponding Futures Contract Months

Marketing Period		Futures Contract Used
January	1-10	January
	11-20	March
	21-EOM[a]	March
February	1-10	March
	11-20	March
	21-EOM	March
March	1-10	March
	11-20	April
	21-EOM	April
April	1-10	April
	11-20	May
	21-EOM	May
May	1-10	May
	11-20	August
	21-EOM	August
June	1-10	August
	11-20	August
	21-EOM	August
July	1-10	August
	11-20	August
	21-EOM	August
August	1-10	August
	11-20	September
	21-EOM	September
September	1-10	September
	11-20	October
	21-EOM	October
October	1-10	October
	11-20	November
	21-EOM	November
November	1-10	November
	11-20	January
	21-EOM	January
December	1-10	January
	11-20	January
	21-EOM	January

[a] End of the month.

period for the feeder cattle were used for the estimation of basis and placement of hedges. Because CME feeder cattle contracts are not traded for every month that actual marketings will occur, basis may change substantially when there are changes in contract months. An example would occur during the second marketing period in May when the futures contract used for hedging changes from a contract with May expiration to a contract with August expiration. Since these changes will occur during the same marketing periods each year, dummy variables were included.

Model specification. The econometric model was specified given the economic logic in the foregoing sections. The econometric model was designed for the prediction of the Tennessee basis six months (18 time periods) into the future. Each month was divided into three 10-day time periods so that the time period six months after time period t was denoted by t+18. The model used was:

$$B_{t+18} = f(TR_t, FP_t, CC_t, PCS_t, GC_{t+18}, CS_{t+18}\ Sd_1 \text{---} Sd_{36})$$

where:

B_{t+18} = 10-day average of daily cash price ($/cwt) on 15 Tennessee auction markets subtracted from the daily settlement price for the nearby futures contract 18 time periods or six months from the current time period (t).

TR_t = current transportation cost index (1967=100).

FP_t = current price ($/cwt) of the CME feeder cattle futures contract which corresponds to the marketing period for which Tennessee basis is being forecast.

CC_t = current feeder cattle supply variable (calf crop in 1,000's).

PCS_t = variable which represents the current phase of the cattle cycle (quarterly cow slaughter as a percent of cow inventory).

GC_{t+18} = Tennessee grazing conditions index associated with the marketing period 18 time periods beyond the current period.

CS_{t+18} = 0,1 dummy variable representing the contract structure change to the cash settlement system.

Sd_1---Sd_{36} = 0,1,-1 time period dummy variables representing the 36 10-day marketing periods each year.

Autoregressive Integrated Moving Average Model

A univariate time series model using the autoregressive integrated moving average (ARIMA) method was developed to predict basis. The objective of a model using the ARIMA process is to explain the movement of the time series z_t, by relating it to its own past values and to lagged and current disturbances [13, p. 514].

Using notation from Bowerman and O'Connell, the ARIMA model is denoted by:

$$z_t = \lambda + \varphi_1 z_{t-1} + \ldots + \varphi_p z_{t-p} - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q} + e_t$$

where:

z_t = original or differenced time series data.

$\varphi_1 \ldots \varphi_p$ = autoregressive parameters.

$\theta_1 \ldots \theta_q$ = moving average parameters.

λ = constant term.

e_t = random error.

p = order of autoregressive parameter.

q = order of moving average parameter.

t = time period.

Past values of the time series are represented by z_{t-i} and past values of the residuals are represented by e_{t-i}. The above formula can be rewritten as:

$$z_t - \varphi_1 z_{t-1} - \dots - \varphi_p z_{t-p} = \lambda + e_t - \theta_1 e_{t-1} - \dots - \theta_q e_{t-q}.$$

The seasonality of feeder cattle production and marketing, as discussed earlier, suggests that a seasonal model be used. The backshift operator (B) is introduced for simplification of seasonal models.

$$B\ y_t = y_{t-1}$$

$$B^k\ y_t = y_{t-k}$$

Using the backshift operator notation the model is changed to:

$$z_t - \varphi_1 B z_t - \dots - \varphi_p B^p z_t = \lambda + e_t - \theta_1 B e_t - \dots - \theta_q B^q e_t$$

or

$$(1 - \varphi_1 B - \varphi_2 B^2 - \dots - \varphi_p B^p) z_t = \lambda + (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q) e_t$$

It can be further simplified by defining:

$$\varphi_p(B) = (1 - \varphi_1 B - \dots - \varphi_p B^p)$$

as the nonseasonal autoregressive operator of order p and

$$\theta_q(B) = (1 - \theta_1 B - \dots - \theta_q B^q)$$

as the nonseasonal moving average operator of order q.

In order to model a time series possessing seasonal variation it is useful to use L to represent individual time periods in a year with seasonal effects so that:

$$\varphi_p(B^L) = (1 - \varphi_{1,L}B^L - \dots - \varphi_{P,L}B^{PL})$$

is the seasonal autoregressive operator of order P and

$$\theta_q(B^L) = (1 - \theta_{1,L}B^L - \dots - \theta_{Q,L}B^{QL})$$

is the seasonal moving average operator of order Q.

By combining the above four operators, the general multiplicative seasonal model is obtained.

$$\varphi_p(B)\ \varphi_p(B^L)\ y_t = \lambda + \theta_q(B)\ \theta_q(B^L)e_t$$

Expanding the above notation, the anticipated form of the model for the Tennessee feeder cattle basis was:

$$(1 - \varphi_1 B - \dots - \varphi_p B^p)(1 - \varphi_{1,L}B^L - \dots - \varphi_{P,L}B^{PL})y_t = \lambda$$
$$+ (1 - \theta_1 B - \dots - \theta_q B^q)(1 - \theta_{1,L}B^L - \dots - \theta_{Q,L}B^{QL})e_t$$

Identification of the specific form which best describes a particular time series is done by determining which parameters should be included in the model. Preliminary identification is accomplished through examination of the autocorrelation and partial autocorrelation functions for the data series.

Before proceeding, the time series must be stationary with values fluctuating around a constant mean. If a nonstationary series exists, it can often be made stationary by differencing the data one or more times. Whether a time series is stationary can be determined through the analysis of autocorrelation and partial autocorrelation functions.

The autocorrelations measure the relationships between any two time series observations separated by a lag of k time periods. The partial autocorrelations are also autocorrelations between any two lagged observations but with the effects of intervening observations eliminated [3, p. 345].

A time series is stationary if the autocorrelation function dies down with increasing lags or cuts off after a particular lag k. With a nonstationary time series the autocorrelation function dies down slowly. The partial autocorrelation function is used in the same manner.

Once the stationarity of the time series is established, estimation of parameters is undertaken. An iterative process is used to determine the values for the autoregressive and moving average parameters (φ,Θ) based upon the criterion of minimizing squared residuals [15, p. 139].

Transfer Function Model

Transfer functions are a combination of regression and univariate time series models. With transfer function models one or more independent variables are used to explain a dependent series. The residuals of the estimation are then used as the input series in an ARIMA model. This combination of time series analysis and regression analysis may provide a better forecast than would be possible through the use of either of these techniques alone [13, p. 593]. The transfer function notation used here is taken from Pindyck and Rubinfeld pages 593-594.

The regression model is of the form:

$$Y_t = a_o + a_1X_{1t} + a_2X_{2t} + E_t$$

where:

Y_t = value of the dependent variable.

a_o = intercept term.

a_1, a_2 = regression coefficients.

X_{1t}, X_{2t} = values of independent variables.

E_t = error term.

By subtracting the estimated values of Y_t from the actual values a residual series can be calculated. The residual series of E_t is then used in an ARIMA model with the same general form as previously discussed. The seasonal model was previously defined as:

$$\varphi_p(B)\ \varphi_p(B^L)\ y_t = \lambda + \Theta_q(B)\ \Theta_q(B^L)e_t$$

With $y_t = E_t$ the model can be defined as:

$$E_t = \frac{\Theta_q B \Theta_q B^L}{\varphi_p B \varphi_p B^L} e_t$$

which can be rewritten as:

$$Et = \varphi^{-1}(B^L)\Theta(B^L)e_t$$

with e_t being the normally distributed error term whose variance is different from E_t which is the time series being modeled. The regression and ARIMA model are combined by substituting the above formula for E_t to form the expected transfer function model which is:

$$Y_t = a_o + a_1X_{1t} + a_2X_{2t} + \varphi^{-1}(B)\Theta(B)e_t$$

Data

Data used in the study came from the years 1977 through 1986. January through April data for 1987 were reserved for testing forecasts out-of-sample.

Transfer costs. Transfer costs were represented by a transportation cost index. This index was a weighted sum of three indexes with 1967 as the base year. To represent fuel costs, the wholesale price index for refined petroleum products was included with a weight of 0.4. To represent the cost of equipment used in transportation the motor vehicle and equipment cost index was included and given a weight of 0.2. Labor costs were represented by an index calculated using the hourly wage received by transportation and public utilities workers. The wage index was weighted by 0.4. Weights for the indexes were based on estimated expenses of transporting feeder cattle by truck. Fuel and oil costs, tractor and trailer costs and driver and support personnel labor costs were considered.

The petroleum products and the motor vehicle and equipment indexes were taken from the *United States Statistical Abstract* for the years 1977 through 1987. Hourly wages were taken from the United States Bureau of Labor Statistics *Employment and Earnings* for January, 1987. The transportation cost index was calculated monthly for use in the models.

Cash feeder cattle price. Cash feeder cattle prices were daily averages from 15 Tennessee auction markets for 600-700 pound medium number one, feeder steers. Prices were obtained from the *Tennessee Market Highlights* published weekly by the Agricultural Extension Service of the University of Tennessee.

Futures price and basis. Futures prices were for the Chicago Mercantile Exchange (CME) feeder cattle futures contract. CME daily price sheets along with the Dunn and Hargitt Commodity Data Bank were used to obtain these data for 1977 through 1986.

The basis was computed for each trading day by subtracting the daily cash price from the daily futures price. Basis was then averaged into 10-day marketing periods yielding 36 marketing periods per year.

Days 1-10 were averaged together as were days 11-20. The third marketing period of each month was an average of basis for days 21 through the end of the month.

Local market conditions. The monthly grazing condition index was obtained through communication with the Tennessee Agricultural Statistics Service. This index was used to represent local market conditions. The index was available for months April through October. To arrive at an index for months without applicable data, interpolation between the October and April was used. Higher index numbers represented better pasture conditions.

Quantity of feeder cattle available. Calf crop numbers were obtained from the USDA Meat and Poultry Situation and Outlook. The annual calf crop number was centered on July of the corresponding year with straight-line interpolation between Julys used to arrive at numbers for the remaining months.

Cattle cycle variable. To represent the cattle cycle a variable was used that measures the ratio of cow slaughter to cow inventory. This variable was a variation of a measurable indicator of the cattle cycle taken from Cattle Cycles: How to Profit from Them and represented cow herd liquidation and expansion [21, p. 11]. The annual cow inventory was used for January and straight-line interpolation was used to obtain numbers for the remaining months. Quarterly cow slaughter was centered on the first day of the second month of each quarter. Values for the variable were then interpolated for each month. Data were obtained from the USDA Meat and Poultry Situation and Outlook.

CHAPTER III

ESTIMATED MODELS

Econometric Model

Results of the econometric model estimation are contained in this section. Initially the SAS GLM procedure was used which fits a general linear model using the method of ordinary least squares. Correlation between independent variables was measured to determine whether multicollinearity was a problem. First order autocorrelation of residuals was measured using the Durbin Watson(d) statistic.

The original econometric model explained 51.2 percent of the variation of the Tennessee basis six months in the future but showed positive autocorrelation of residuals with the Durbin Watson statistic equal to 0.77. This level of the Durbin Watson statistic was in the range indicating positive autocorrelation of residuals. Autocorrelation was corrected by using the SAS AUTOREG procedure discussed in the SAS User's Guide.

Correlation coefficients among the independent variables were used to measure multicollinearity and are reported in Table III-1. Coefficients near 1.00 indicate near perfect correlation between variables and would not be desirable. Multicollinearity did not appear to be a serious problem in the model with the largest correlation coefficient at 0.71805. This largest value occurred as the correlation between futures price and cow slaughter as a percent of cow inventory. Correlations among linear combinations of the variables were not examined.

Table III-1. Correlation Coefficients for the Econometric Model Variables

	Futures Price	Calf Crop	Percent Cow Slaughter	Transportation Index	Grazing Index
Futures price	1.00000				
Calf crop	-0.33698	1.00000			
Percent cow slaughter	-0.71805	-0.03710	1.00000		
Transportation index	0.34176	-0.27391	-0.31676	1.00000	
Grazing index	0.08562	-0.04288	0.01327	-0.06401	1.00000

The statistical form of the econometric model using the SAS AUTOREG procedure to address positive autocorrelation was:

$$B_{(t+18)} = \beta_1 + \beta_2 TR_t + \beta_3 FP_t + \beta_4 CC_t + \beta_5 PCS_t + \beta_6 GC_{(t+18)} + \beta_7 CS + \beta_8 Sd_1 --- \beta_{43} Sd_{36}$$

The variables were previously defined in Chapter II. The overall f-value for the econometric model was 3.237 which was significant at the 1 percent level. The estimated coefficients, t-values and standard errors for the econometric model are shown in Table III-2. The value of R^2 was 0.319, indicating that the model explained almost 32 percent of the variation in feeder cattle basis six months in the future for 1977 through 1986.

The transfer cost represented by the transportation cost index was statistically significant at the 1 percent level and had the expected positive relationship with basis. This is consistent with previous research which indicated that the transportation cost index was significant [1, p. 26]. An increase in the transportation cost index from 100 to 110 would increase the basis by $0.08 per hundred weight (cwt).

Futures price was significant at the 5 percent level and had the anticipated positive relationship with Tennessee basis. A $10 cwt increase in the futures price would increase the basis by $0.70 cwt.

The grazing condition index and calf crop variables were not significant but had the anticipated negative sign. The ratio of cow slaughter to cow inventory was not significant and did not have the anticipated negative relationship with basis.

Table III-2. Parameter Estimates for the Econometric Model with the Associated t-Values and Standard Errors

Variable	Parameter Estimate	t-Value	Standard Error
Intercept	-12.84201	-1.11	11.55179
TR (1967 base)	0.00827	3.38	0.00245
FP ($/cwt)	0.07071	2.23	0.03165
CC (1,000 head)	0.00024	1.27	0.00019
PCS (percent)	60.21533	1.08	55.74011
GC (0-100)	-0.01460	-0.93	0.01571
CS (0,1)	-2.58855	-2.79	0.92632
Sd1	1.10254	1.96	0.56221
Sd2	1.40918	2.57	0.54774
Sd3	1.16922	2.13	0.55009
Sd4	1.19652	2.20	0.54440
Sd5	0.10059	0.19	0.54262
Sd6	-0.03757	-0.07	0.54347
Sd7	-0.25029	-0.46	0.54202
Sd8	-0.37476	-0.69	0.54436
Sd9	-0.93307	-1.71	0.54533
Sd10	-1.70208	-2.99	0.56872
Sd11	-2.40012	-4.26	0.56336
Sd12	-2.68889	-4.79	0.56172
Sd13	-2.11110	-3.32	0.63610
Sd14	-0.64730	-0.99	0.65578
Sd15	-0.98620	-1.49	0.66337
Sd16	-1.29474	-2.06	0.62718
Sd17	-0.70698	-1.14	0.62122
Sd18	-0.70201	-1.15	0.61105
Sd19	-0.64886	-1.24	0.52537
Sd20	-0.80343	-1.53	0.52591
Sd21	-0.47941	-0.91	0.52720
Sd22	0.25777	0.50	0.51319
Sd23	-0.67938	-1.32	0.51520
Sd24	-0.77614	-1.51	0.51502
Sd25	-1.14078	-2.20	0.51892
Sd26	-0.20451	-0.39	0.52399
Sd27	-0.39987	-0.76	0.52637
Sd28	0.03503	0.06	0.54602
Sd29	1.52138	2.83	0.53791
Sd30	0.95760	1.78	0.53933
Sd31	0.58406	1.05	0.55535
Sd32	2.60824	4.54	0.57476
Sd33	2.84075	4.85	0.58542
Sd34	2.22047	3.75	0.59165
Sd35	2.43663	4.13	0.59044
Sd36	1.52751	2.63	0.58164

Ten of the 36 individual 10-day time period dummy variables were statistically significant at the 1 percent level. These were for the periods Sd10, 11, 12, 13, 29, 32, 33, 34, 35 and 36. In addition, six of the time period dummy variables were significant at the 5 percent level. These were for the periods Sd1, 2, 3, 4, 16 and 25. Except for the first 10 days in August (Sd22), all time period dummy variables from the third 10-day marketing period in February (Sd6) through the end of September (Sd27) were negative indicating that basis during the late winter through early fall was lower than the average basis. The seasonal dummy variables for October (Sd28) through the second marketing period in February (Sd5) were positive which indicates that basis for late fall and winter was above the average basis. This seasonal pattern was consistent with the research done by Bishop in 1983 [1, pp. 26-7].

The dummy variable representing the structural shift to a cash settlement delivery system was significant at the 1 percent level and was negative. This was expected since the United States Feeder Steer Price which is now used for cash settlement is usually lower than the traditional par delivery market prices [4, p. 8]. The estimated effect of the contract change causes the basis to decrease by $2.58 cwt.

Time Series Models

Estimates from time series models are reported in this section. The SAS ARIMA package was used to estimate the ARIMA and transfer function models.

ARIMA models.

Stationarity of the time series is a requirement before an ARIMA model can be estimated. If a time series is stationary, its values fluctuate around a constant mean. Nonstationary series can be made stationary by differencing the series one or more times [13, p. 502]. Through examination of the autocorrelation function for the Tennessee feeder cattle basis, it could be seen that the autocorrelations at successively longer lags died down. This suggested that the time series for Tennessee basis was stationary and no differencing was necessary. Thus, the value for d (the number of differences) in the ARIMA (p, d, q) specification was zero.

The autocorrelation function for the Tennessee basis died down through lag 15 and the partial autocorrelation function cut off after lag 4 which suggested that an autoregressive model was applicable. The opposite pattern would have indicated a moving average process where the autocorrelation function cut off after lag q and the partial autocorrelation function died down [3, p. 384].

A mixed autoregressive moving average model is not indicated since neither the autocorrelation function nor the partial autocorrelation function died down in a dampened exponential decay fashion. This suggested that the ARIMA model for Tennessee basis should not contain a moving average component and the value for q was zero.

The Tennessee basis was analyzed using ARIMA models which contained only autoregressive components. The degree of differencing (d) was zero as was the order of the moving average process (q). This effectively made the ARIMA model an AR or autoregressive model exclusively.

AR Model 1: (1)(35,36). Study of the autocorrelation function and partial autocorrelation function suggested a first order autoregressive model with seasonal effects at lagged periods of 35 and 36 (one year). This model was represented by AR(1)(35,36) and was fitted to the Tennessee basis for 1977 through 1986. The estimated model was:

$$\underset{(0.03541)}{(1 - 0.753707B^{1})}\ (1 - \underset{(0.05450)}{0.138948B^{35}} - \underset{(0.05447)}{0.199857B^{36}})Y_t = 1.00807 + e_t$$

The standard error estimate for the model was 1.457. The first order autoregressive parameter, AR(1), was estimated at 0.753707 with a t-ratio of 21.29. The estimate for the AR(35) autoregressive parameter was 0.138948 with a t-ratio of 2.55. The AR(36) autoregressive parameter estimate was 0.199857 with a t-ratio of 3.67.

The Q statistic through lag 36 was 31.46 which is lower than the 46.204 critical value using 32 degrees of freedom at the 5 percent level. Based on this statistic, the model adequately fit the data since the residual autocorrelations were not significantly different from zero as a set. The estimated autocorrelations of residuals are shown in Table III-3.

AR Model 2: (18)(35,36). Because the purpose of the study was to develop models to predict Tennessee basis levels six months into the future, a second ARIMA model was estimated using an autoregressive component of order 18 with seasonal effects at lagged periods of 35 and 36. This model is represented by AR(18)(35,36). By eliminating AR components of orders less than 18 the model was able to forecast the eighteenth time period into the future using actual data. To compare forecasts made by the two AR models, AR(1)(35,36) would need to generate 18 successive one-step-ahead forecasts with the forecasted value for t+1

Table III-3. Chi-Square and Autocorrelation Coefficients from the AR(1)(35,36) Model of the Tennessee Feeder Cattle Basis, 1977-1986

To Lag	Chi-Square	Degrees of Freedom	Autocorrelations					
6	4.22	2	-0.040	-0.046	0.024	0.055	0.047	0.046
12	8.33	8	0.027	0.004	-0.013	0.075	0.019	-0.064
18	18.24	14	0.016	0.069	-0.002	-0.097	0.021	0.106
24	23.10	20	-0.015	0.000	0.072	-0.048	0.005	0.070
30	28.30	26	0.030	-0.007	-0.039	0.004	0.083	-0.062
36	31.46	32	0.043	-0.019	0.058	0.048	0.005	-0.007

being used when forecasting t+2 and so on. In contrast, the AR(18)(35,36) model needs only one forecast to reach t+18.

The AR(18)(35,36) model was estimated as:

$$\underset{(0.05548)}{(1 - 0.161293B^{18})}\ (1 - \underset{(0.08152)}{0.246085B^{35}} - \underset{(0.08160)}{0.247066B^{36}})Y_t = 2.55067 + e_t$$

The standard error estimate for the model was 2.1638. The AR(18) parameter estimate was 0.161293 with a t-ratio of 2.91. The AR(35) autoregressive parameter estimate was 0.246085 with a t-ratio of 3.02. The AR(36) parameter estimate was 0.247066 with a t-ratio value of 3.03.

The Q statistic through lag 36 was 576.69 for AR(18)(35,36) which is higher than the 46.204 critical value using 32 degrees of freedom at the 5 percent level. The chi-square Q statistics and autocorrelation of residuals are reported in Table III-4. Based on the Q statistic, the model is inadequate in explaining basis, but comparisons of standard errors of forecasts generated by each model at t+18 showed that AR(18)(35,36) had a lower standard error than AR(1)(35,36). The standard error at the eighteenth time period in the future for AR(18)(35,36) was 2.1638 compared to 2.2170 for AR(1)(35,36). This results from the fact that 18 one-step-ahead forecasts had to be made with the AR(1)(35,36) model in order to arrive at a forecast for t+18.

Other specifications of ARIMA models were fitted to the Tennessee basis for the years 1977 through 1986. The models used with corresponding standard errors and parameter t-values are reported in Table III-5. Consideration of seasonal lags appropriate for forecasting and the size of standard errors were used to determine which ARIMA models would be

Table III-4. Chi-Square and Autocorrelation Coefficients from the AR(18)(35,36) Model of the Tennessee Feeder Cattle Basis, 1977-1986

To Lag	Chi-Square	Degrees of Freedom	Autocorrelations					
6	511.77	2	0.734	0.555	0.455	0.394	0.340	0.287
12	563.07	8	0.232	0.185	0.150	0.135	0.087	0.049
18	564.87	14	0.049	0.043	0.005	-0.023	0.001	-0.001
24	569.73	20	0.021	0.041	0.053	0.031	0.049	0.066
30	572.17	26	0.044	0.017	0.004	0.019	0.050	0.034
36	576.69	32	0.045	0.042	0.064	0.058	0.010	0.009

Table III-5. Models Fitted Using the ARIMA Method with Standard Errors and t-Values of Parameters

	Standard	t-Values of Parameters					
	Error	AR(1)	AR(2)	AR(18)	AR(35)	AR(36)	AR(37)
AR(1)(35,36)	1.45709	21.29**			2.55*	3.67**	
AR(1)(18)(36)	1.46597	21.65**		1.44*		3.47**	
AR(1,2)(36)	1.46772	13.43**	1.08			3.48**	
AR(1)(36)	1.46808	21.79**				3.44**	
AR(1)(36,37)	1.47003	21.55**				3.44**	0.24
AR(1)(35)	1.48183	22.15**			2.25*		
AR(1)(35)(37)	1.48388	21.76**			2.25*		0.13
AR(18)(35,36)	2.16376			2.91**	3.02**	3.03**	
AR(18)(36)	2.18736			2.52*		8.06**	

*Significant at the 5 percent level.

**Significant at the 1 percent level.

selected for comparison with the econometric model and transfer function models.

Transfer function models. Two transfer function models were estimated. Transfer function models differ from ARIMA models since one or more exogenous input variables are used. The residuals from the regression using these exogenous variables become the input series for the time series model.

Transfer function Model 1: cash settlement dummy variable. The dummy variable which represents the contract structural change to cash settlement was used in the first transfer function model. The variable was used as an explanatory variable for Tennessee basis, the dependent variable. The residuals from the regression were modeled using the AR(18)(35,36) seasonal model previously discussed. The cash settlement dummy variable was chosen because of its importance with regards to the current Tennessee basis structure. This dummy variable was significant at the 1 percent level in the econometric model. The transfer function model using the contract change dummy variable was estimated as:

$$B_t = 6.13842 - \underset{(0.67415)}{3.23242}\ CS + E_t$$

$$(1 - \underset{(0.055576)}{0.094417}B^{18})(1 - \underset{(0.07923)}{0.26627}B^{35} - \underset{(0.07921)}{0.26442}B^{36})\ E_t = 2.60882 + e^t$$

where CS is the contract change dummy variable. E_t is the OLS regression residual which is the input series for the ARIMA portion of the model. The variable e_t is the residual from the ARIMA portion of the model.

The standard error estimate for the model was 2.09874. The parameter estimate for CS was -3.23242 with a t-ratio of -4.79. These findings are consistent with the coefficient and t value for the CS dummy variable in the econometric model. The AR(18) autoregressive parameter estimate was 0.0944168 with a t-ratio of 1.70. The AR(35) autoregressive parameter estimate was 0.26627 with a t-ratio of 3.36. The AR(36) autoregressive parameter estimate was 0.26442 with a t-ratio of 3.34.

The chi-square Q statistics and autocorrelation of residuals are reported in Table III-6. The Q statistic through lag 36 was 529.00 which is much larger than the critical value of 46.204 for 32 degrees of freedom indicating a large remaining autocorrelation of residuals. This was consistent with the AR(18)(35,36) model which, based on the Q statistic, was not adequate in fitting the Tennessee basis.

Transfer function Model 2: transportation cost index and cash settlement dummy variable. The second transfer function model used both the transportation cost index and the cash settlement dummy variable as explanatory variables for Tennessee basis. The transportation index is the same as was used in the econometric model and was used in this model because it showed the highest t-ratio in the econometric model. The cash settlement dummy variable was used because of its importance in quantifying the structural change of the feeder cattle futures contract. The residuals from the regression were fitted using an AR(18)(35,36) model.

Table III-6. Chi-Square and Autocorrelation Coefficients from the Transfer Function Model with CS for the Tennessee Feeder Cattle Basis, 1977-1986

To Lag	Chi-Square	Degrees of Freedom	Autocorrelations					
6	472.05	2	0.718	0.529	0.431	0.373	0.324	0.272
12	519.61	8	0.219	0.177	0.147	0.134	0.086	0.048
18	521.95	14	0.055	0.043	-0.001	-0.036	-0.010	0.002
24	524.40	20	0.009	0.025	0.038	0.017	0.035	0.051
30	525.87	26	0.031	0.007	-0.003	0.014	0.045	0.023
36	529.00	32	0.032	0.033	0.058	0.047	-0.011	-0.011

The transfer function 2 model was estimated as:

$$B_t = 1.41911 + \underset{(0.001497)}{0.0131288\ TR_t} - \underset{(0.61723)}{2.65286\ CS_t} + E_t$$

$$(1 + \underset{(0.05576)}{0.051858B^{18}})\ (1 - \underset{(0.07331)}{0.20801B^{35}} - \underset{(0.07284)}{0.24276B^{36}})\ E_t = 0.81983 + e_t$$

where CS is the contract change dummy and TR is the transportation cost index. E_t is the regression residual which is the input series for the ARIMA portion of the model. The variable e_t is the residual from the ARIMA model.

The standard error estimate for the model was 1.92466. The lag 18 parameter estimate was not statistically significant which differs from the transfer function 1 model. The estimate for the AR(18) autoregressive parameter was -0.51858 with a t-ratio of -0.93. The AR(35) autoregressive parameter estimate was 0.20801 with a t-ratio of 2.84. The AR(36) autoregressive parameter estimate was 0.24276 with a t-ratio of 3.33.

The transportation cost index (TR) parameter estimate was 0.0131288 with a t-ratio of 8.77. This was consistent with its relationship to Tennessee basis and statistical significance in the econometric model. The cash settlement dummy variable (CS) parameter estimate was -2.65286 with a t-ratio of -4.30. The effect of including CS was similar in all three models (econometric model, transfer function model 1, and transfer function model 2) which supports its importance in quantifying the structural shift to a cash settlement feeder cattle contract.

The chi-square Q statistics and autocorrelation of residuals are reported in Table III-7. The Q statistic through lag 36 was 344.30 which was much larger than the critical value of 46.204 for 32 degrees of freedom indicating that the autocorrelation of residuals was large. This was consistent with the AR(18)(35,36) model which, based on the Q statistic, was not adequate in fitting the Tennessee basis. Compared with the Q statistic of 529.00 through lag 36 for the transfer function model 1, the transfer function model 2 was an improvement.

Standard errors of the models at t+18 are applicable since the purpose of this study was to forecast Tennessee basis six months in the future. The lowest standard error at t+18 was associated with the transfer function model 2 and was 1.9247. A standard error of 2.0987 for the transfer function model 1 was the second best standard error at t+18. The third best standard error was 2.1638 at t+18 and was reported for the AR(18)(35,36) model. The AR(1)(35,36) model had a standard error of 2.2170 at t+18.

All time series models had significant AR(35) and AR(36) parameters indicating that there was a significant seasonal effect associated with the Tennessee basis. Both transfer function models reported significance of the dummy variable to represent the futures contract structural change to cash settlement. The AR(18) parameter was significant when used in the AR(18)(35,36) and the transfer function model 1 but was not significant in the transfer function model 2.

Forecast Results

Introduction. The five models which were developed were compared using out-of-sample forecasts for January through April, 1987. Root

Table III-7. Chi-Square and Autocorrelation Coefficients from the Transfer Function Model Using CS and TR for the Tennessee Feeder Cattle Basis, 1977-1986

To Lag	Chi-Square	Degrees of Freedom	Autocorrelations					
6	315.40	2	0.663	0.438	0.328	0.261	0.204	0.144
12	322.22	8	0.085	0.037	0.004	-0.002	-0.046	-0.088
18	335.73	14	-0.066	-0.062	-0.096	-0.12	-0.064	-0.001
24	338.32	20	-0.032	-0.034	-0.025	-0.053	-0.032	-0.011
30	343.38	26	-0.035	-0.059	-0.069	-0.041	-0.013	-0.04
36	344.30	32	-0.014	-0.003	0.029	0.025	-0.018	-0.018

mean square error, Theil's U_2 coefficient and graphical comparisons of forecasts were used. The RMSE statistic is the square root of the average of squared differences between forecasts and actual prices over a number of time periods. The smaller the RMSE the more accurate the forecast. Theil's U_2 statistic compares the model forecast to a naive no-price-change forecast. The U_2 coefficient is bounded by zero which indicates perfect forecasts. A coefficient of 1 indicates the model and the no-price-change forecasts are equally accurate. Values above 1 indicate that the model forecast is less accurate than the no-price-change forecast [8, p. 345]. The formulas used to calculate the RMSE and Theil's U_2 statistic are given in Appendix 1. Forecasts of basis and graphical representations of forecasts and actual basis are contained in the following pages. Model predictions were made six months into the future starting with July 1-10, 1986, from which the basis was forecast for January 1-10, 1987. The last forecast was for April 21-30, 1987, made from November 21-30, 1986.

Econometric model. The actual and predicted values for the econometric model are reported in Table III-8. Errors range from -\$1.19 per hundred weight (cwt) to \$2.01 per cwt with a RMSE equal to \$0.93. Theil's U_2 coefficient was 0.30 which indicated that the predictive ability of this model was superior to the naive no-price-change forecast. Figure III-1 graphically compares the actual and predicted values for Tennessee basis for January through April, 1987.

AR model 1: (1)(35,36). Basis forecasts generated by the AR(1)(35,36) model are shown in Table III-9. The actual Tennessee basis

Table III-8. 1987 Tennessee Feeder Cattle Basis Forecasts from the Econometric Model by 10-Day Period

10-Day Period		Actual Basis	Forecast Basis	Error
January	1-10, 1987	3.15	4.31	1.16
	11-20, 1987	2.67	4.69	2.01
	21-31, 1987	3.28	4.52	1.24
February	1-10, 1987	3.99	4.44	0.45
	11-20, 1987	4.52	3.33	-1.19
	21-28, 1987	3.07	3.24	0.17
March	1-10, 1987	2.77	3.31	0.54
	11-20, 1987	2.20	2.86	0.66
	21-31, 1987	2.00	2.24	0.24
April	1-10, 1987	1.44	1.43	-0.01
	11-20, 1987	0.08	0.68	0.60
	21-30, 1987	-0.63	0.34	0.97

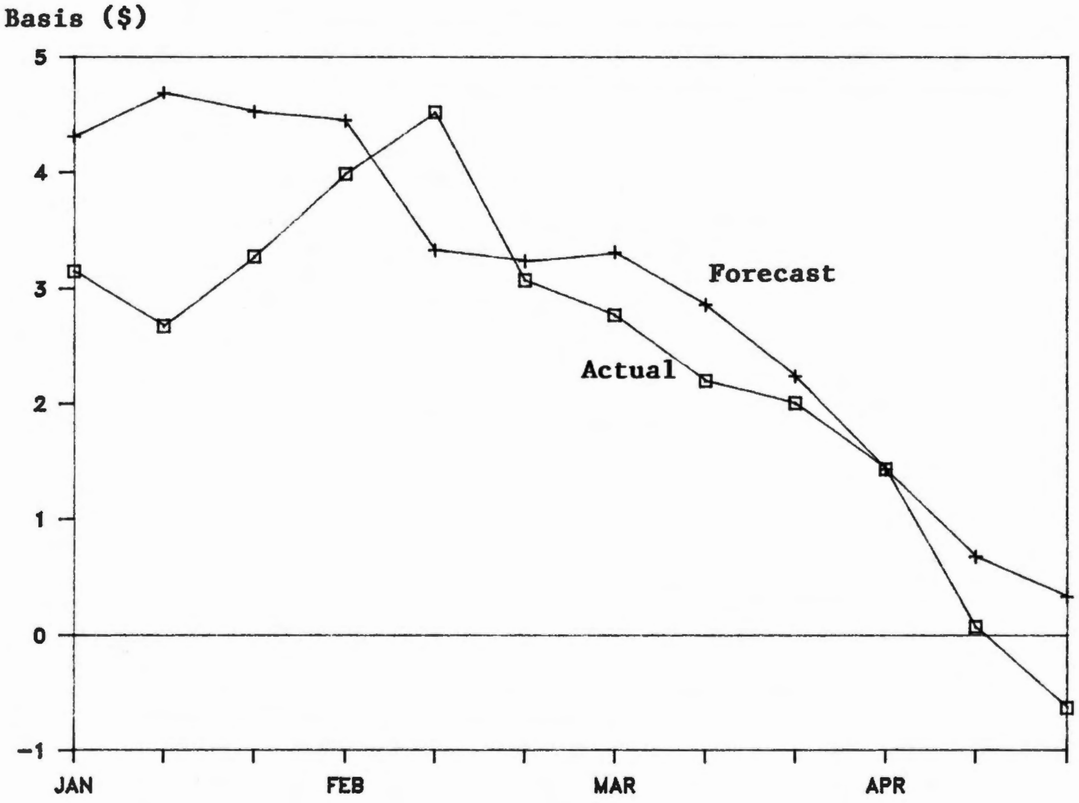

Figure III-1. 1987 Actual and Forecast Basis from the Econometric Model

Table III-9. 1987 Tennessee Feeder Cattle Basis Forecasts from the AR(1)(35,36) Model by 10-Day Period

10-Day Period		Actual Basis	Forecast Basis	Error
January	1-10, 1987	3.15	7.00	3.85
	11-20, 1987	2.67	6.92	4.25
	21-31, 1987	3.28	6.69	3.41
February	1-10, 1987	3.99	6.35	2.36
	11-20, 1987	4.52	6.13	1.61
	21-28, 1987	3.07	6.08	3.01
March	1-10, 1987	2.77	5.83	3.06
	11-20, 1987	2.20	5.53	3.33
	21-31, 1987	2.00	5.08	3.08
April	1-10, 1987	1.44	4.68	3.24
	11-20, 1987	0.08	4.18	4.10
	21-30, 1987	-0.63	4.57	5.20

and error are also reported. The errors ranged from \$1.61 to \$5.20 with RMSE equal to \$3.49. Theil's U_2 coefficient was 1.12 which indicates that the naive no-price-change forecast would be a better model. Figure III-2 compares the actual and forecast Tennessee basis for January through April, 1987, in graphical form.

All forecasts using this model are overestimates as is indicated by all positive error terms. This is probably explained by the failure of an ARIMA model to represent the structural shift in the time series associated with the initiation of the cash settlement futures contract.

AR Model 2: (18)(35,36). Table III-10 shows the forecast basis, actual basis and errors for the AR(18)(35,36) model. RMSE was \$3.01 compared to \$3.49 for ARIMA model 1. The errors ranged from \$1.19 to \$4.75. The exclusively positive errors probably result from the fact that the cash settlement contract change was not represented in the model. Theil's U_2 coefficient was 0.97 which indicates that AR model 2 is slightly superior to both the no-price-change model and AR model 1. Figure III-3 shows the graphical comparison of actual and predicted Tennessee basis values.

Transfer function model 1: Cash settlement dummy variable. The first transfer function model showed improvement over both AR models due to inclusion of the cash settlement dummy variable. RMSE was \$1.08 with errors ranging from -\$1.85 to \$1.54. Table III-11 reports the actual, predicted and error values. Theil's U_2 coefficient was 0.35 which indicates this model is better than the naive no-price-change model.

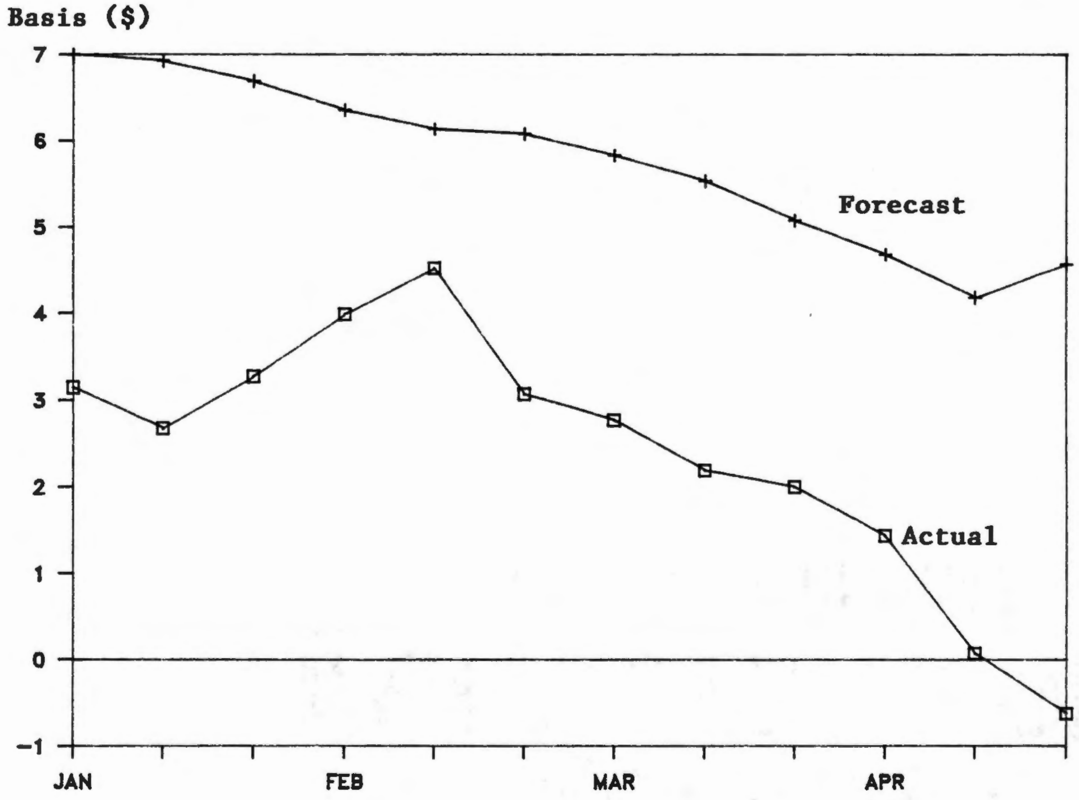

Figure III-2. 1987 Actual and Forecast Basis from the AR(1)(35,36) Model

Table III-10. 1987 Tennessee Feeder Cattle Basis Forecasts from the AR(18)(35,36) Model by 10-Day Period

10-Day Period		Actual Basis	Forecast Basis	Error
January	1-10, 1987	3.15	7.46	4.31
	11-20, 1987	2.67	7.42	4.75
	21-31, 1987	3.28	7.07	3.79
February	1-10, 1987	3.99	6.37	2.38
	11-20, 1987	4.52	5.71	1.19
	21-28, 1987	3.07	5.56	2.49
March	1-10, 1987	2.77	5.16	2.39
	11-20, 1987	2.20	4.68	2.48
	21-31, 1987	2.00	3.98	1.98
April	1-10, 1987	1.44	3.03	1.59
	11-20, 1987	0.08	2.47	2.39
	21-30, 1987	-0.63	3.38	4.01

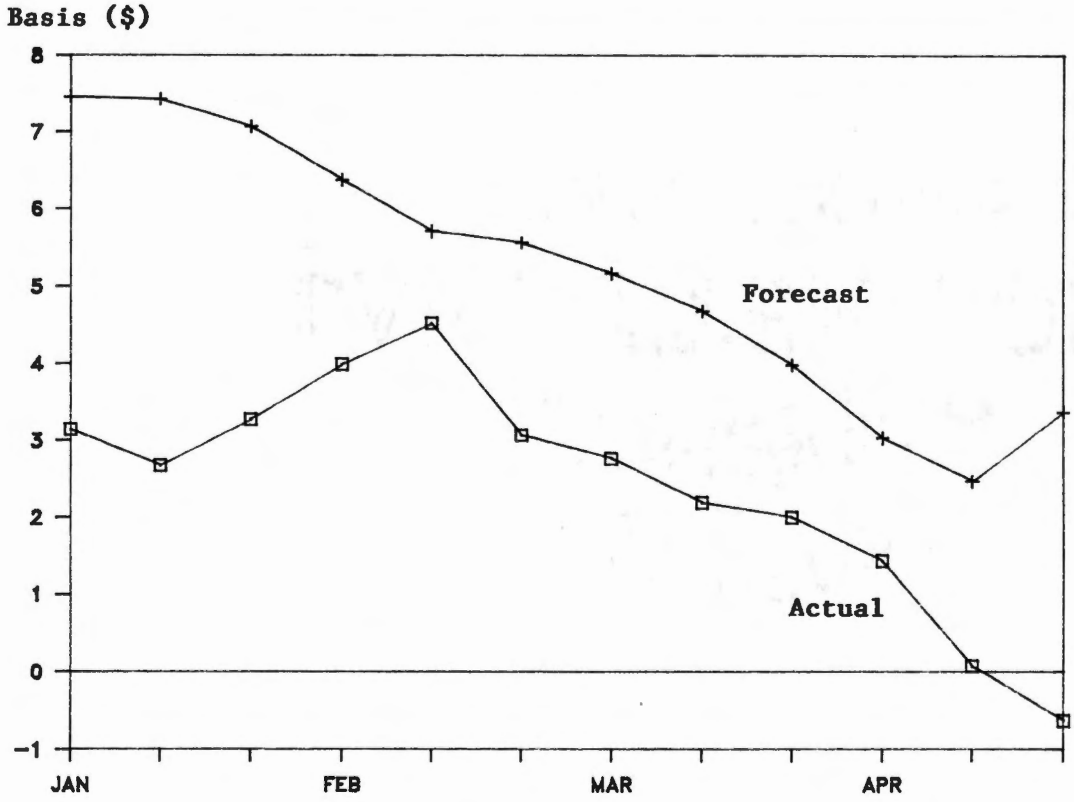

Figure III-3. 1987 Actual and Forecast Basis from the AR(18)(35,36) Model

Table III-11. 1987 Tennessee Feeder Cattle Basis Forecasts from the Transfer Function Model Using CS by 10-Day Period

10-Day Period		Actual Basis	Forecast Basis	Error
January	1-10, 1987	3.15	4.30	1.15
	11-20, 1987	2.67	4.21	1.54
	21-31, 1987	3.28	3.84	0.56
February	1-10, 1987	3.99	3.17	-0.82
	11-20, 1987	4.52	2.67	-1.85
	21-28, 1987	3.07	2.51	-0.56
March	1-10, 1987	2.77	2.12	-0.65
	11-20, 1987	2.20	1.59	-0.61
	21-31, 1987	2.00	0.87	-1.13
April	1-10, 1987	1.44	0.01	-1.43
	11-20, 1987	0.08	-0.67	-0.75
	21-30, 1987	-0.63	0.29	0.92

Figure III-4 is the graphical comparison of actual and predicted Tennessee basis values for January through April, 1987.

This transfer function model differed from AR(18)(35,36) only by the inclusion of the cash settlement dummy as an exogenous variable for the regression portion of the model. Because of the cash settlement variable, forecasts were more accurate and errors were both positive and negative.

Transfer function model 2: Transportation cost index and cash settlement dummy variable. Transfer function model 2 was an improvement over transfer function model 1. RMSE was \$0.87 and errors ranged from -\$1.36 to \$1.99. Theil's U_2 coefficient was 0.28 which indicates this model is better than the naive no-price-change model. Table III-12 reports the forecast basis, actual basis and error values. Actual and forecast Tennessee basis values are compared in Figure III-5 for January through April, 1987. The inclusion of the economically significant transportation cost index improved the forecasting ability of transfer function model 2 compared to transfer function model 1.

The RMSE and Theil's U_2 coefficient for each of the five models for the out-of-sample forecasts are reported in Table III-13. The best model based on these criteria was the transfer function model 2 using both the transportation cost index and the cash settlement dummy variable. The econometric model was a close second differing from the transfer function model 2 by 0.02 for the Theil's U_2 coefficient and \$0.07 for the RMSE. The transfer function model 1 using the cash settlement dummy variable differed from the econometric model by 0.05

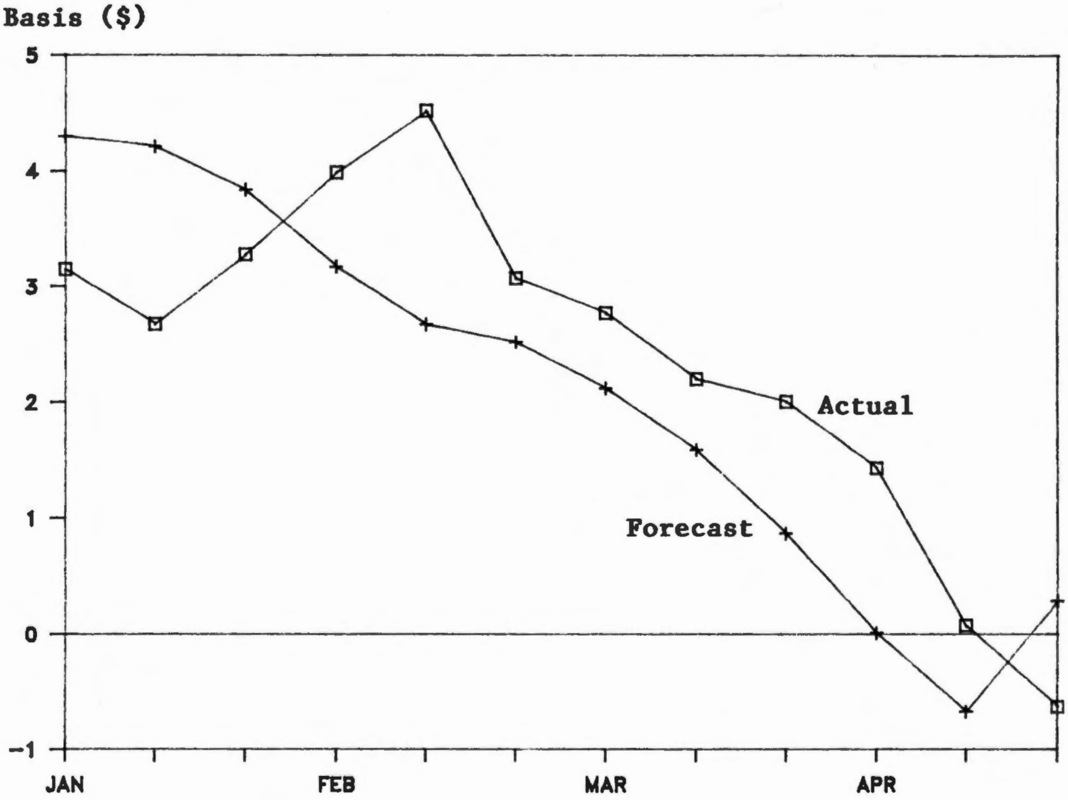

Figure III-4. 1987 Actual and Forecast Basis from the Transfer Function Model Using the Cash Settlement Dummy Variable

Table III-12. 1987 Tennessee Feeder Cattle Basis Forecasts from the Transfer Function Model Using CS and TR by 10-Day Period

10-Day Period		Actual Basis	Forecast Basis	Error
January	1-10, 1987	3.15	4.05	0.90
	11-20, 1987	2.67	3.89	1.22
	21-31, 1987	3.28	3.60	0.32
February	1-10, 1987	3.99	3.28	-0.71
	11-20, 1987	4.52	3.16	-1.36
	21-28, 1987	3.07	3.09	0.02
March	1-10, 1987	2.77	2.86	0.09
	11-20, 1987	2.20	2.30	0.10
	21-31, 1987	2.00	1.75	-0.25
April	1-10, 1987	1.44	1.39	-0.05
	11-20, 1987	0.08	0.68	0.60
	21-30, 1987	-0.63	1.36	1.99

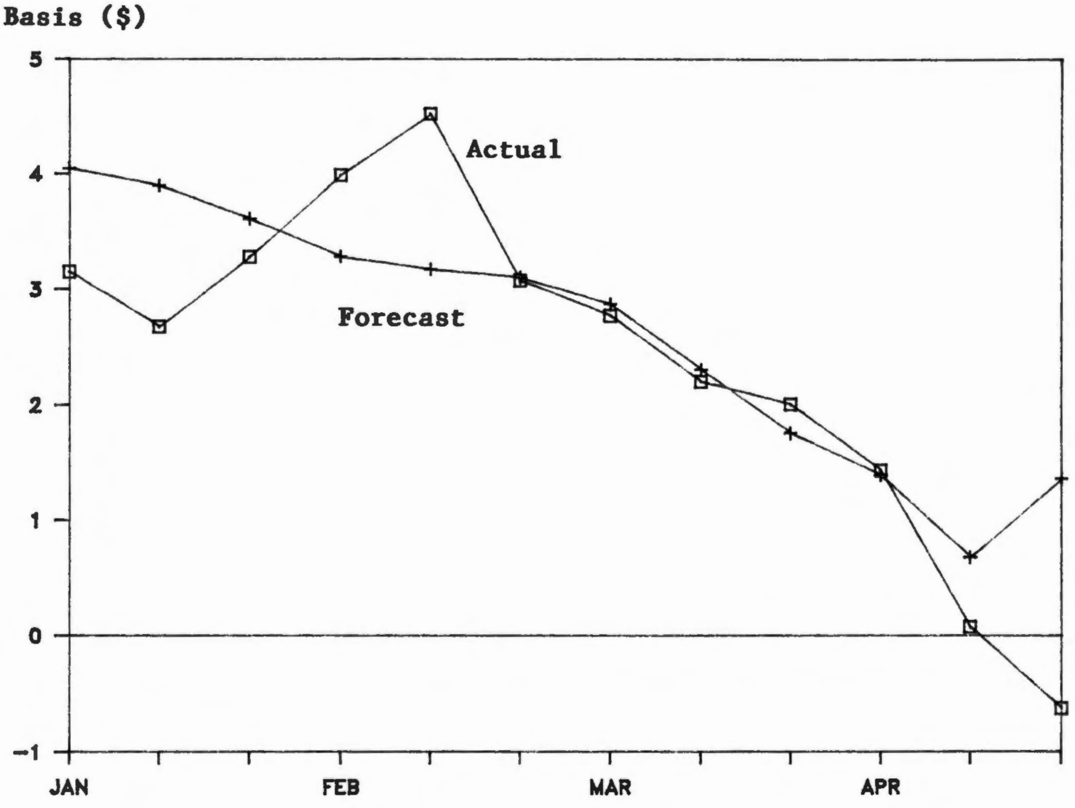

Figure III-5. 1987 Actual and Forecast Basis from the Transfer Function Model Using the Transportation Cost Index and the Cash Settlement Dummy Variable

Table III-13. RMSE and Theil's Inequality Coefficients for Out-of-Sample Forecasts from Estimated Models for January Through April, 1987

Model	N	RMSE	Theil's U2
Econometric	12	0.94	0.30
ARIMA (1)(35,36)	12	3.49	1.12
ARIMA (18)(35,36)	12	3.01	0.97
Transfer function with CS	12	1.08	0.35
Transfer function with TR and CS	12	0.87	0.28

for the Theil's U_2 coefficient and by $0.14 for the RMSE. There was an obvious decrease in the forecasting ability of the ARIMA models compared with the transfer function models and econometric model. The AR(18)(35,36) model was superior to the AR(1)(35,36) model.

CHAPTER IV

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

An understanding of basis is essential for the feeder cattle producer/hedger using the feeder cattle futures market. For the Tennessee feeder cattle producer, daily basis for 1977 through 1986 ranged from -\$8.33 to \$16.75 per hundred pounds. This fluctuation in basis hinders the effectiveness of hedging by the Tennessee feeder cattle producer.

To limit risk from fluctuations in the price level, hedging can be used but this forces speculation in the basis. Basis is never known with certainty until the hedge is offset and feeder cattle are marketed locally. The problem this study addressed was forecasting the basis for the marketing period when hedges would be lifted by offsetting futures contract positions and selling feeder cattle in the local market.

Models. Five models were used to forecast the Tennessee basis. All models were estimated using Tennessee basis for 1977 through 1986. January through April, 1987, was the time period used to compare forecasts generated by the model to actual Tennessee basis. The estimated models were: 1) an econometric model, 2) a time series AR(1)(35,36) model, 3) a time series AR(18)(35,36) model, 4) a transfer function model using the cash settlement dummy variable and 5) a transfer function model using the cash settlement dummy variable and transportation cost index.

The econometric model included five independent variables to represent transfer costs, feeder cattle supply, phase of the cattle cycle, local market conditions and futures price level. A dummy variable to represent the feeder cattle futures contract specification change to cash settlement was used as were 36 dummy variables to represent the seasonality of Tennessee basis.

Two different univariate ARIMA models were estimated to forecast basis from past values of Tennessee basis. These time series models were estimated as AR(1)(35,36) and AR(18)(35,36). No differencing was required to achieve stationarity. Moving average components (q) were also inappropriate in modeling Tennessee basis.

Transfer function models combine regression with time series analysis. Two transfer function models were estimated. The first used the cash settlement dummy variable as an exogenous variable for the regression with the AR(18)(35,36) model fitted to the residuals. The second transfer function fit the AR(18)(35,36) model to the residuals generated by a regression using the cash settlement dummy variable and the transportation cost index as exogenous variables.

Data. The variables used in the study were chosen as best representatives of the effects to be measured based on economic theory. Basis was calculated by subtracting daily cash prices for 15 Tennessee auction markets from daily feeder cattle futures prices. The basis was then averaged by 10-day time periods to yield 36 marketing periods per year. This time series was then used in all models.

Calf crop, cattle inventory and cow slaughter numbers were obtained from USDA publications. The transportation cost index was calculated monthly to represent transfer costs. Daily futures prices were averaged by 10-day periods for use as an independent variable. The Tennessee Agricultural Statistics Service provided a monthly grazing conditions index which was used to represent local market conditions. To represent the seasonality of feeder cattle prices, 36 time period dummy variables were used. A dummy variable was also used to represent the feeder cattle futures contract structural change to a cash settlement system which occurred on September 1, 1986.

Estimation and results. The SAS GLM procedure was initially used to estimate the econometric model. Due to problems of positive autocorrelation, the SAS AUTOREG procedure provided the final parameter estimates for the econometric model.

The econometric model explained approximately 32 percent of the variation in Tennessee basis for the years 1977 through 1986. The transportation cost index variable was statistically significant at the 1 percent level and the futures price variable was statistically significant at the 5 percent level. Both the transportation cost index and futures price had the anticipated relationships to basis. Variables included which were not statistically significant but had the anticipated relationship to the Tennessee basis were the grazing conditions index and the calf crop. Cow slaughter as a percent of cow inventory was not significant and did not carry the expected sign. The cash settlement dummy variable and 10 of the 36 seasonal dummy variables were statistically significant at the 1 percent level. Six of the 36 seasonal dummy variables were significant at the 5 percent level.

The ARIMA and transfer function models were estimated using the SAS ARIMA procedure. The AR(1)(35,36) model more adequately fit the time series than did the AR(18)(35,36). When each was used to forecast 18 marketing periods into the future the AR(18)(35,36) model had a standard error of 2.1638 compared to the 2.2170 standard error of the AR(1)(35,36) model. Each of these models always overestimated Tennessee basis when forecasting for January through April, 1987.

The transfer function models were specified using economic logic for the exogenous variables. The cash settlement dummy variable was first used with the transfer function. As expected, it carried a negative sign and was statistically significant at the 1 percent level. For the second transfer function the transportation cost index was added. The index was significant and carried the expected positive sign.

The forecasts made by each model were compared by root mean square error (RMSE), Theil's U_2 statistic and graphically. The best model overall was the transfer function model 2 which used both the transportation cost index and the cash settlement dummy variable. This model had a RMSE of \$0.87 and a Theil's U_2 equal to 0.28. The second best model was the econometric model with a RMSE of \$0.94 and a Theil's U_2 of 0.30. The transfer function model 1, containing the cash settlement dummy variable was third best with a RMSE of \$1.08 and a Theil's U_2 equal to 0.35. The AR(18)(35,36) model provided the fourth best forecasts with a RMSE of \$3.01 and a Theil's U_2 equal to 0.97. The model that provided the poorest forecasts was the AR(1)(35,36) model. This model had a RMSE of \$3.49 and a Theil's U_2 of 1.12.

Conclusions

With the ability to forecast basis, feeder cattle producers in Tennessee will be able to hedge with less basis risk. The models which have been developed will assist the potential hedger of feeder cattle in estimating the price at which he can market feeder cattle. This will enable the backgrounding operator to estimate the selling price of feeders before the decision is made to purchase the animals he intends to background.

The forecasts provided by the transfer function model which contained both the transportation index and the cash settlement dummy variable were the best compared to all models used. The econometric model was second best indicating that the economic variables included should do an acceptable job of forecasting even though the R^2 for the model was only 0.319. The transfer function model using the cash settlement dummy variable was ranked third.

Both the AR(18)(35,36) and AR(1)(35,36) overestimated forecasts of the Tennessee basis for every marketing period. This is probably because neither model was capable of quantifying the shift to the cash settlement system based on the U. S. Feeder Steer Price (USFSP). The basis for Tennessee feeder cattle was smaller under the new contract specification.

The reasons for this are that the USFSP contains markets from regions where prices are historically lower than the market prices for former par delivery points. The USFSP is also based on prices for 600 to 800 pound steers while the former contract specification was for 575 to 700 pound feeders. The elimination of futures delivery costs is also cited as a reason for smaller basis [4, pp. 7-9].

As was indicated by earlier research [1, 10], the size of the Tennessee basis was seasonal. The seasonal dummy variables associated with the third marketing period in February through the end of September were negative indicating lower than average Tennessee basis. October through February 20 showed a positive seasonal basis which indicated higher than average Tennessee basis.

Implications

Tennessee basis can be forecasted using the models developed in this thesis. The transfer function model which combined both regression and time series analysis did the best job of forecasting. The econometric model developed forecasts almost as accurate as the best transfer function model. Pure time series models lacked the ability to account for structural changes in the time series.

The cash settlement feeder cattle contract has only been used since September of 1986. Because of this, only four months (12 marketing periods) of data were available for use in the models during 1986. As more data become available under the new contract system, the ARIMA time series models are expected to do a better job of forecasting Tennessee basis.

Practical application of the forecasting models developed would require the knowledge of use and access to computers by feeder cattle producers in Tennessee. With the advent of more powerful personal computers at lower prices, producers have the potential ability to predict local basis using models similar to the ones developed here.

Hedging using feeder cattle futures as a form of risk avoidance is expected to be more effective using the models to forecast basis. Future research could be done on the effectiveness of the models in hedging strategies for Tennessee feeder cattle. The true test of the models developed would come through practical application.

LIST OF REFERENCES

LIST OF REFERENCES

1. Bishop, Michael B. "Alternative Models for Predicting the Futures Market Basis for Tennessee Feeder Cattle." M.S. thesis, University of Tennessee, December, 1983.

2. Bobst, Barry W. "Location Basis Variability Effects on Slaughter Cattle Hedging in the South and Southern Plains." Southern Journal of Agricultural Economics, Vol. 5, No. 2, December, 1973, pp. 73-77.

3. Bowerman, Bruce L., and Richard T. O'Connell. Forecasting and Time Series, Belmont: Duxbury Press, 1979.

4. Commodity Futures Trading Commission. CFTC Report. Washington, D. C.: March, 1987, pp. 7-9.

5. Ehrich, R. L. "Cash Futures Price Relationships for Live Beef Cattle." American Journal of Agricultural Economics, Vol. 51, 1969, pp. 26-40.

6. Hieronymous, Thomas A. Economics of Futures Trading for Commercial and Personal Profit. New York, N. Y.: Commodity Research Bureau, Inc., 1977.

7. Leuthold, R. M. An Analysis of the Basis for Live Beef Cattle. Research Report 77 E-25, Department of Agricultural Economics, Agricultural Experiment Station, University of Illinois, Urbana-Champaign, October, 1977.

8. ______. "On the Use of Theil's Inequality Coefficients." American Journal of Agricultural Economics, Vol. 57, May, 1975, pp. 344-346.

9. Leuthold, R. M., and W. G. Tomek. "Developments in the Livestock Futures Literature." Livestock Futures Research Symposium, Chicago: Chicago Mercantile Exchange, 1980, pp.39-67.

10. McLemore, D. L. Future Market Basis Patterns for Tennessee Feeder Cattle and Slaughter Hogs. Bulletin 575, Agricultural Experiment Station, University of Tennessee, Knoxville, February, 1978.

11. McLemore, D. L., and J. M. Gross. Econometric and Futures Market Models for Forecasting Tennessee Feeder Cattle Prices. Research Report 86-22, Agricultural Experiment Station, University of Tennessee, Knoxville, December, 1986.

12. O'Bryan, S. L., B. W. Bobst and J. T. Davis. "Factors Affecting Efficiency of Feeder Cattle Hedging in Kentucky." Southern Journal of Agricultural Economics, Vol. 9, No. 1, July, 1977, pp. 185-189.

13. Pindyck, R. S., and D. L. Rubinfeld. Econometric Models and Economic Forecasts. Second Edition, New York, N. Y.: McGraw-Hill, 1981.

14. Purcell, J. C., and M. R. Holmes. Spatial Alignment in Cattle and Calf Prices Between Southern and Central Markets 1968-1976 with Implications. Research Report Number 292, Department of Agricultural Economics, University of Georgia, Athens, September, 1978.

15. SAS Institute, Inc. SAS/ETS User's Guide. Version 5 Edition, Cary, N. C.: SAS Institute, Inc., 1984.

16. Tennessee Agricultural Statistics Service, Nashville, Tennessee. Unpublished Grazing Conditions Index: 1977-1986.

17. University of Tennessee Agricultural Extension Service. Tennessee Market Highlights. Knoxville, Tennessee, 1977-1987.

18. U. S. Bureau of the Census. Statistical Abstract of the United States: 1985. 106 Edition, Washington, D. C., 1985.

19. U. S. Bureau of Labor Statistics. Employment and Earnings. Washington, D. C., January, 1987.

20. U. S. Department of Agriculture. Cattle. Agricultural Statistics Board, National Agricultural Statistics Service, Washington, D. C., February, 1987.

21. ______. Cattle Cycles: How to Profit from Them. Extension Service Miscellaneous Publication 1430, Washington, D. C., March, 1983, pp.11-17.

22. ______. Economic Research Service. Livestock and Poultry Outlook and Situation Report. Washington, D. C., 1985-87.

23. Vollink, W., and R. Raikes. "An Analysis of Delivery Period Basis Determination for Live Cattle." Southern Journal of Agricultural Economics, Vol. 9, No. 1, July, 1977, pp. 179-184.

24. Ward, R., and G. Schimkat. "Futures Trading and Florida's Feeder Cattle Market." Livestock Futures Research Symposium, Chicago Mercantile Exchange, Chicago, 1980.

APPENDIX

APPENDIX 1

The root-mean-square-error can be defined as:

$$\text{RMSE} = \sqrt{\frac{\Sigma(\hat{P}_{t+18} - P_{t+18})^2}{n}}$$

where:

$\hat{P}_{t+18}$ is the forecasted price for marketing period t+18.

P_{t+18} is the actual price for marketing period t+18.

n is the number of marketing periods.

Theil's U_2 statistic can be defined as:

$$U_2 = \sqrt{\frac{\Sigma(\hat{P}_{t+18} - P_{t+18})^2}{\Sigma(P_t - P_{t+18})^2}}$$

where:

P_t is the actual price for marketing period t.

$\hat{P}_{t+18}$ is the forecasted price for marketing period t+18.

P_{t+18} is the actual price for marketing period t+18.

VITA

Andrew James Dodd was born in Corry, Pennsylvania, on July 7, 1962, where he lived until moving with his family to Shelbyville, Tennessee, in 1979. In 1980 he graduated from Shelbyville Central High School. Four years later he received his B.S. in Agricultural Business from the University of Tennessee. While in college, he met his wife the former Sherry Suchomski.

After graduation, he was employed by Merrill Lynch Futures in Chicago, Illinois, as a hedge broker. He relocated to Maryville, Tennessee, after accepting employment with Heinold Commodities in December, 1984.

In September, 1985, he enrolled in the graduate program in Agricultural Economics at the University of Tennessee. The M.S. was awarded in August, 1987.