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An econometric forecasting model for Tennessee feeder cattle prices

Joey M. Gross

To the Graduate Council:

I am submitting herewith a thesis written by Joey M. Gross entitled "An econometric forecasting model for Tennessee feeder cattle prices." 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:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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AN ECONOMETRIC FORECASTING MODEL FOR TENNESSEE FEEDER CATTLE PRICES

A Thesis
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Joey M. Gross

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ABSTRACT

Feeder cattle prices have been highly variable. This variability creates difficulty on the part of producers and users in correctly anticipating future prices. This study was intended to develop a price forecasting mechanism which would assist in predicting the price of 500 to 600 pound feeder steers six months in the future in Tennessee.

Two separate forecasting models were developed: (1) an econometric model based on causal variables, and (2) a model based on futures market prices. Data for 1972 through 1981 were used to estimate the parameters of the two models. Data for 1982 were used to test the *ex ante* forecasting accuracy of the models.

The econometric model used a single equation which specified feeder cattle price to be dependent upon the following components of feeder cattle demand and supply: feedlot demand, stocker demand, nonfed slaughter demand, calf production, and quantity of available feeder cattle. Measures of the variables were developed from secondary data. The futures market model used current prices for the feeder cattle futures contract deliverable six months in the future and the first differences of these prices as independent variables to predict prices six months in the future.

The econometric model indicated that feedlot demand eight months in the future, calf production, and current nonfed slaughter demand were statistically significant indicators of Tennessee feeder cattle prices six months in the future. The futures market model indicated that the current futures price for the contract deliverable six months in the future was a significant indicator of prices six months in the future.

Using Theil's U_2 and root-mean-squared-error measures of forecast quality, it was determined that the econometric model outperformed the futures market model for the within-sample period (1972-1981). When the two models were used to forecast prices for 1982 (out-of-sample period) the futures market model outperformed the econometric model. These results made it difficult to determine which model was the best forecastor. Both models outperformed current prices in forecasting futures prices as indicated by Theil's coefficients less than 1. Thus, both models should be of value in forecasting Tennessee feeder cattle prices.

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CHAPTER I

INTRODUCTION

1. OVERVIEW OF THE BEEF CATTLE INDUSTRY

Beef is the most important meat in the American diet, aggregating to more consumption per capita than any other meat. In 1983 the average person consumed 79 pounds of beef, 62 pounds of pork and 52 pounds of broiler meat. In recent years beef consumption has been declining relative to broiler consumption, which has increased steadily since 1950. Recent studies have shown that most of the gain in broiler consumption has been at the expense of pork consumption (Nelson, p. 8). Although recent trends in beef consumption per capita have been downward it is apparent that beef's importance will continue.

The beef industry in the United States today is considerably different from what it was preceding World War II. Prior to 1950 most of the beef consumed in this country was grass fed, with milk and meat often coming from the same animals.

Agricultural specialization and improvements in the technology of milk production permitted the beef producing sector to grow into an almost separate and distinct industry (Nelson, p. 1). With this transformation in the beef industry brought about by the advances in technology there was a shift to grain feeding of beef animals. This shift was facilitated by relatively low grain prices.

2. PHASES OF BEEF PRODUCTION

The modern beef production complex can be divided into four distinct phases: cattle raising, cattle feeding, packing and processing, and distribution.

Cattle raising consists of calf production from breeding herds and stockering operations which grow larger feeder cattle from light calves. Numerous small operations constitute this stage of beef production. Although there are some large operations, most raise cattle as a secondary or supplemental enterprise. In 1978, of the more than 1 million farms reporting beef cows, 58 percent had 20 head or fewer (Nelson, p. 1). While the trend in this stage of production is toward larger operations many small ones will continue to exist for the foreseeable future.

Feedlots apply intensive feeding of grain to feeder animals to produce slaughter weight fat cattle. Farmer-owned and commercial feedlots characterize the cattle feeding phase of production. Farmer-owned feedlots usually do not stock animals year-round but feed cattle during periods of slack labor and plentiful grain. However, commercial feedlots are typically single-entity enterprises either owning the cattle or custom feeding them for another owner. Most of these feedlots are located in the Western Corn Belt or Plains states.

Packing and processing transform live animals into meat and other products. Packing and processing typically take place in federally inspected plants. Current trends indicate beef slaughtering companies are moving their plants farther west; closer to fed cattle supplies. The most recent innovation in beef slaughtering has been the shift to boxed beef. Boxed beef allows packers to package and ship specific primal cuts to purchasers rather than shipping the whole carcass. This has facilitated efficiency and standardization in distribution.

The final stage is distribution. Packers ship beef to retail outlets where consumers can purchase it. These outlets are divided into two classifications: retail food stores; and the hotel, restaurant and institutional business.

3. PROBLEM AND OBJECTIVES

The usual assumption regarding agricultural production is that production decisions are made well in advance of the time period when the product enters market channels. Therefore, quantity supplied is usually considered to be predetermined in short-term price or demand analysis.

Short-term prices for agricultural products respond to changes in economic variables. Price fluctuations on a day to day basis result from the interaction of current quantity supplied and demand. Usually, quantity supplied is less stable on a day to day basis than demand. The quantity supplied of a commodity on any given day is a result of many individual decisions by sellers. The interaction of sellers and buyers in the market determines the current price for a commodity. Working (p. 195) has shown that current cash prices may also be influenced by expected (future) changes in factors influencing prices.

Longer-term prices for agricultural products exhibit somewhat persistent patterns of behavior through time. Factors contributing to observable patterns of behavior include the biological character of agricultural production, seasonal variation in climatic conditions and the expansion or contraction of production in response to favorable or unfavorable prices. Usually, production expansion during periods of favorable prices leads to larger quantities and lower prices in future periods. Lower prices induce less production and decreased quantities, which in turn lead to higher prices. Continued expansion and contraction of production is primarily responsible for cyclical price patterns.

Most prices for agricultural products exhibit some seasonality in production and marketing patterns. The biological growing season is responsible for much of the seasonality of crop prices. For livestock prices, seasonal patterns result from seasonality of feed supplies, climatic conditions and the biological nature of the production process (Tomek and Robinson, p. 170). Forecasts of future prices can be reliably made if the past seasonal and cyclical characteristics remain uniform during the forecast period.

Although seasonal and cyclical elements frequently are stable, the lag between planning and production often alters the most efficient allocation of resources. Producers often base production decisions on prevailing prices, justifiably, but these decisions frequently do not turn out to be optimum because of unexpected future price movements. Although futures markets may offer some guidance to future price movements, they are frequently unsatisfactory as indicators of regional and local prices. If producers had more information on future price trends in their local markets, a more efficient allocation of resources could be expected.

The beef industry in the United States has exhibited cyclical movements of cattle numbers and prices since data became available on an annual basis in 1867 (U.S.D.A.

publication No. 1430, p.1). The cattle cycle is usually considered to be the most important influence on producer incomes and cattle prices. Producers alternate between "boom" and "bust" as prices vary inversely with cattle numbers.

This cyclical behavior of the industry is responsible for a misallocation of resources. The following synopsis of the cycle shows how the misallocation of resources is promoted.

During the upturn of the cycle, when prices and cattle raisers' incomes are rising, heifers are held off the market for future production. This results in smaller marketings of lighter cattle for feeding and eventual slaughter and further upward pressure on prices. Collective actions of cattle raisers result in an oversupply of breeding stock. As the increased production of lighter animals from the increased breeding stock enters marketing channels, the result is an over supply of slaughter animals. This oversupply creates downward pressure on prices and producers' incomes. Producers then rush to liquidate herds, releasing breeding stock and further depressing prices. As cattle herds become sufficiently small and producer incomes again begin to rise, the cycle repeats itself (U.S.D.A. publication No. 1430 p. 2). Cattle raisers, stockering operations and feedlot operators could make their future production decisions more efficiently if an estimation of the future prices of feeder cattle was available and reliable.

The objective of this study was to develop a method for forecasting monthly prices of Tennessee feeder cattle. The specific objectives were:

1. To develop an econometric model to predict 500 to 600 pound Tennessee feeder cattle prices six months in the future.
2. To develop a forecasting model based on the use of the futures market to predict 500 to 600 pound Tennessee feeder cattle prices six months in the future.
3. To evaluate the two models and to determine which is the superior indicator of Tennessee feeder cattle prices six months in the future.

4. SUMMARY OF PAST RESEARCH

Considerable economic research has been conducted on the beef cattle industry. Most of this effort has been directed at the slaughter cattle and retail sectors of the industry.

A review of past studies directed at the industry will help to put this study in perspective. Although most of the research has not been directed specifically at the feeder cattle sector, some general information can be gained by an examination of studies which have included this sector in their overall objectives.

Maki, 1959, studied the market interrelationships between markets at different levels in the market channel for beef and pork. Using quarterly data, two models were developed of market relationships. The first model considered the dressed (wholesale) meat market as the critical pricing level, where prices adjusted to predetermined levels of quantities. The second model considered the national retail market as the critical pricing level. Wholesale and farm prices were assumed to adjust to changes in retail prices through retail and wholesale pricing margins. These pricing margins were then used to determine prices at other levels of the market. Using these margins it was discovered that a one cent per pound increase in the wholesale price of beef was associated with a 0.7 cent per pound increase in the average beef cattle price and a one cent per pound increase in the average retail price of beef. Using these price reactions, margins were calculated for retail to wholesale prices and wholesale to farm prices. Maki concluded that these margins cannot be considered fixed and the effects of volume and price changes should be explored.

Trierweiler and Erickson, 1965, studied the supply responses of the cow - calf operator in 23 homogeneous regions of production in the United States. Structural economic models were developed for the number of beef calves born in each of the 23 states and for the U.S. as a whole. Using stocker - feeder calf prices, number of cows on hand at the beginning of the year, range or pasture conditions, and time as independent variables, supply responses were calculated. Percentage change in the number of beef cows as a result of a one percent change in the stocker - feeder price lagged three years was found to be small. Response to range or pasture conditions, lagged one and one - half years, was slightly greater than the response to the stocker - feeder price. Response to the technological (time) variable was very small.

A 1970 study of monthly farm level demand for cattle and hogs by Hayenga and Haecklander showed that prices at the packer level were responsive to quantities slaughtered, personal income, and seasonal price changes expressed as [0,1] dummy variables. Cattle and hog supply were found to be responsive to their respective prices and inventory levels.

Spreen, Shonkwiler and Chang conducted a 1981 study on the effects feeder prices and feed costs have on fed cattle prices. Using monthly Omaha fed cattle prices and Kansas City feeder prices (600 to 700 pounds) they determined that feeder cattle prices do not lead slaughter prices and that slaughter cattle prices do not lead feeder cattle prices. Their feed cost index was a weighted average of Chicago corn prices and Decatur soybean meal prices. Three statistical tests (Granger, Sims and Haugh-Pierce) for causality were employed to test the significance of these variables. The Granger and Sims tests suggested that feed costs lead both feeder cattle and fed cattle prices. The Haugh - Pierce test showed joint dependency between feeder prices and slaughter prices. The authors concluded that:

> ...This result implies that when forecasting steer prices, not only should the past history of steer prices be examined, but also the past history of feed costs (p.9.)

A 1974 study conducted by Davis focused on the quarterly supply and demand relationships for feeder cattle in the United States. Eight behavioral equations and two market clearing equations were developed to determine the relationships among the feeder cattle, slaughter cattle and retail sectors of the beef industry.

Davis hypothesized that the major factors affecting the price of feeder cattle were the current quantity of feeder cattle, the price of corn, the number of head on feed, the current price of slaughter cattle, short-term interest rates and a seasonal variable. Factors hypothesized to affect the quantity of feeder cattle supplied were the current price of feeder cattle, calf crops lagged two quarters, a seasonal variable and a time variable. Wholesale prices were connected to retail prices by a marketing margin equation.

Results indicated that the price and quantity of feeder cattle were determined simultaneously. Quantity of feeder cattle and prices of slaughter cattle were found to be the major factors influencing the price of feeder cattle. Quantity of feeder cattle was found to be influenced by current price of feeder cattle and time.

One of the objectives of the current study was to develop a model based on the futures market to forecast prices for Tennessee feeder steers. These markets have been shown to be good forecasters of the prices of some commodities. A study conducted by Just and Rausser compared the futures market to several large scale econometric models used by price forecasting firms. Their study considered futures markets for corn, soybeans, live hog, and live cattle. Using two common statistical measures of forecast quality (root mean squared error and root mean squared percentage error), the authors concluded:

> It appears that futures market inefficiencies are not serious and that econometric models do a poorer job of including all relevant exogenous forces, forecasting them, and transforming them into pure forecasts than the aggregate intelligence of the futures market. (p.207)

The literature suggests several factors contribute to the determination feeder cattle prices. Feed costs, prices of slaughter cattle, short-term interest rates, and quantity supplied of feeder cattle have been shown to be important in feeder cattle price determination.

CHAPTER II

ECONOMIC MODELS

1. THEORETICAL FRAMEWORK

The theory of derived demand implies that a product that is to be processed or changed in form will possess a demand curve that is derived from the demand curve for the final product. The demand for feeder cattle can therefore be viewed as demand derived from the demand for retail beef. However, cattle feeders will demand feeder cattle only if they can make a profit on their final product (slaughter cattle). This indicates that the demand for feeder cattle by cattle feeders depends not entirely on the demand for slaughter cattle but also on the cost of transforming feeder cattle into slaughter cattle. This cost of transformation makes up the cattle feeder's minimum margin.

From the theory of consumer behavior we can draw certain conclusions about feeder cattle demand. Initially we can confirm consumer behavior at the retail level; essentially that price and quantity consumed of retail beef vary inversely. This implies a downward sloping demand curve. An increase in the price of retail beef will induce consumers to purchase less (assuming all other things such as income and the price of substitutes are held constant).

From the above deduction we can conclude that a shift in consumer demand for retail beef will involve a corresponding shift in the demand for slaughter cattle, which will influence the demand for feeder cattle. Changes in the cattle feeder's minimum necessary margin will also alter feeder cattle demand. This rationale illustrates how feeder cattle demand is derived from retail beef demand.

Supply of feeder cattle is based on expected returns by producers. Producers seek to maximize net returns. Profits for the producer are maximized when the marginal cost of the last unit of input is equal to the marginal value of the added output. This is stated in economic terms as marginal cost equals marginal revenue. The supply curve of an individual producer can be derived from the producer's marginal cost curve. For forecasting purposes it is useful to know the market supply curve rather than the supply curve of an individual producer. The market supply curve expresses the relationship between price and quantity that will be offered for sale by all producers in the market.

Market supply curves for feeder cattle are subject to supply shifters such as increases in input prices, changes in technology (i.e. better breeding practices), and changes in returns from the production of products that compete for inputs. Seasonality resulting from climatic factors also influence the quantity of feeder cattle available at any one time.

A model to forecast Tennessee Feeder cattle prices must take into account the pertinent variables that influence price and quantity movements. These variables must also be quantifiable and readily measured in order for the model to have any usefulness.

2. OVERVIEW OF THE ECONOMETRIC MODEL

Factors which influence Tennessee feeder cattle prices in the future must be brought together in an economic model if a means of predicting these prices with some confidence is to be developed. The economic framework from within which the demand and supply for feeder cattle are determined has been discussed. This framework suggests factors to be included in the model.

Demand and supply relationships for the feeder cattle sector were quantified based on five components of demand and supply:

1. Feedlot demand
2. Stocker demand
3. Nonfed slaughter demand
4. Calf production
5. Quantity of available feeder cattle

The economic model to forecast Tennessee feeder cattle prices may be represented as follows:

$$P_t = f[FD_{t+2}, FD_t, FD_{t-2}, FD_{t-4}, FD_{t-6}, SM_{t-6}, NFS_{t-6}, NFS_t, CC_{t-6}, AFC_{t-6}, P_{t-6}]$$

Where:

$FD_{t\pm i}$ = feedlot demand

SM_{t-6} = demand for cattle for stockering

NFS_{t+i} = nonfed slaughter demand

CC_{t-6} = U.S. calf crop

AFC_{t-6} = available feeder cattle supply

P_{t-6} = price of Tennessee feeder cattle in time period t-6

t-6 represents the current month and t represents the month six months in the future. Rationale for inclusion of each of the variables is discussed in the following sections.

A. Feedlot demand for feeder cattle

Feeder cattle are generally purchased for further feeding. As such they are considered a factor of production. Feeder cattle are the primary input for cattle feeders. As the price of the cattle feeder's output increases the price will be bid up for his primary input. This implies that as slaughter cattle prices increase feeder cattle prices will also increase, *ceteris paribus*.

Other important highly variable costs of production to the feedlot operator are corn, soybean meal (protein supplement) and short-term interest rates. As these costs of weight added to cattle in the feedlot increase, the feedlot operator will be willing to pay less for feeder cattle, *ceteris paribus*. The combination of these costs of feedlot weight gain and the price of slaughter cattle should be an important factor in determining demand for feeder cattle.

In the model, the variable $FD_{t \pm i}$ quantifies the relationship between slaughter cattle prices and costs of feedlot weight gain. $FD_{t \pm i}$ was calculated by subtracting cost of feedlot gain from slaughter cattle futures or cash prices for the appropriate time period. Cost of feedlot gain was calculated as a weighted average of corn futures, soybean meal futures and the current short term interest rate.

As $FD_{t \pm i}$ increases, it will be more profitable for cattle feeders to buy feeder cattle and feed them to slaughter weight. Therefore, $FD_{t \pm i}$ was hypothesized to have a positive influence on Tennessee feeder cattle prices.

B. Demand for feeder cattle for stockering

Stocker cattle demand is influenced by the profit available to the stocker operator. These producers purchase lighter feeder (400 to 500 pound) cattle and graze or feed them to heavier weights (600 to 700 pounds) to be placed in feedlots. As lighter feeder cattle prices decrease relative to heavier feeder cattle prices these producers are better able to make a profit on their purchase of the lighter feeder cattle for stockering.

The variable used to represent stocker demand in the model is the stockering margin (SM_{t-6}). This variable was calculated by subtracting current cash prices for 600 to 700 pound feeder steers from current cash prices for 400 to 500 pound feeder steers.

As SM_{t-6} decreases the current demand for lighter (400 to 500 pound) feeder cattle will increase causing current prices to increase. However, these producers feed or graze the lighter cattle to heavier weights, thereby increasing the supply of heavier feeders four to eight months in the future. This, theoretically, should have a negative effect on the future price of feeder cattle.

As SM_{t-6} increases, it will not be as profitable to purchase the stockers and feed them to heavier weights; causing lower demand and lower prices for light feeders in the near term. The lighter cattle will be available for immediate placement in feedlots for feeding to slaughter weight, decreasing the future supply of heavier feeders. With a decreased future supply of the heavier feeders there should be a corresponding increase in price in the future. Based on this rationale, it was hypothesized that SM_{t-6} would have a positive relationship with Tennessee feeder cattle prices six months in the future.

C. Demand for feeder cattle for slaughter

Demand for feeder cattle for slaughter was hypothesized to be related to the price differentials between slaughter cattle and feeder cattle. The variable to represent demand for feeder cattle for slaughter ($NFS_{t \pm i}$) was calculated by subtracting feeder cattle prices from slaughter cattle prices. Current cash prices were used for the current price series (NFS_{t-6}) and futures prices were used for the price series six months in the future (NFS_t). Since feeder cattle prices are generally higher per hundredweight than slaughter cattle prices, low feeder cattle prices or high slaughter cattle prices will be associated with larger values for $NFS_{t \pm i}$. When slaughter cattle prices are high relative to feeder cattle prices (i.e. when $NFS_{t \pm i}$ increases) demand for feeder cattle for slaughter was hypothesized to increase. If packers can purchase lighter cattle relatively cheaper than fed cattle, they will tend to purchase and slaughter the lighter cattle to meet the demand for some kinds of meat. As this price difference becomes larger, the demand for feeder cattle for slaughter should increase causing feeder prices to increase. Thus, the hypothesized signs on the variables NFS_t and NFS_{t-6} are positive.

D. Calf crop

Supply components are also important elements affecting feeder cattle prices in the future. Two variables used to represent elements of feeder cattle supply were included in the model. The first of these was the U.S. calf crop (CC_{t-6}).

The basic quantity of feeder cattle available for all purposes during a given year will be determined by the calf crop during that year and the immediately preceding year. Large calf crops lead to larger feeder cattle supplies and vice versa. Thus, there should be an inverse relationship between current and immediately past calf crops and feeder cattle prices. Because of this inverse relationship between calf crop numbers and feeder cattle prices, CC(t-6) was hypothesized to have a negative influence on Tennessee feeder cattle prices in the immediate future.

Annual calf crop numbers were taken from U.S.D.A. Livestock and Meat Statistics for the appropriate year.

These numbers were then centered on July 1 and interpolation was used to obtain an annual number for the calf crop on a monthly basis.

E. Quantity of feeder cattle

The second variable used to represent supply was the quantity of feeder cattle over 500 pounds, on farms but not in feedlots (AFC_{t-6}). As the quantity of available feeder cattle increases, current prices should decrease and vice versa. The biological nature of cattle production prevents current supply from changing to meet current demand. A large quantity of feeder cattle causes prices to drop until the quantity clears the market. The opposite is true if there is a small quantity of feeder cattle. Therefore, $AFC_{(t-6)}$ was hypothesized to have a negative influence on Tennessee feeder cattle prices in the immediate future. The quantity of available feeder cattle is estimated by U.S.D.A. on a quarterly basis. Monthly interpolation was necessary to accommodate the monthly model specification.

F. Current feeder cattle price

Observation of the industry suggests that producers seem to expect future prices to continue along the same path as current prices. In other words, if current prices are low, the expectation is that prices will continue to be low. Conversely, if current prices are high, they are expected to remain high. These types of expectations tend to be self-fulfilling in the short run because producers tend to expand breeding herds when prices are high and liquidate herds when prices are low. However, in the longer run these short run decisions tend to cause prices to adjust downward if they are currently high, or upward, if they are currently low. Since this analysis seeks to forecast prices six months into the future the short run affect should be dominant. Therefore, the hypothesized sign for current Tennessee feeder cattle prices (P_{t-6}) is positive.

3. OVERVIEW OF THE FUTURES MARKET MODEL

One of the objectives of this study was to develop a model based on the futures market to predict Tennessee feeder cattle prices. Since futures prices are, at any point in time, considered to reflect the collective, informed wisdom of thousands of buyers and sellers, these prices provide a price forecasting mechanism which should take account of all available information on factors affecting future prices.

Although Tennessee feeder cattle prices are local prices, the general price trends should be the same as those of futures market prices. In theory, futures prices and cash prices should be identical in the delivery month of the futures contract, excluding differences in quality and transportation costs (Tomek and Robinson, p. 233).

The economic model constructed to forecast prices of Tennessee feeder cattle using the futures market is:

$$P_t = f[FP_{t-6}, \Delta FP_{t-6}]$$

where:

P_t = cash prices of Tennessee feeder cattle occurring in time period t.

FP_{t-6} = futures market prices for feeder cattle for time period t, occurring in time period t-6.

ΔFP_{t-6}=change in the futures market price for feeder cattle for time period t, from time period t-7 to time period t-6.

The futures market model uses average futures prices (FP_{t-6}) for contracts for delivery in time period t, but occurring in time period t-6, to predict cash prices (P_t) in time period t. FP_{t-6} represents the average price of feeder cattle futures contracts for time period t, occurring in time period t-6. Time period t-6 is the period from which the forecast is made. Monthly averages of Thursday settlement prices for feeder cattle futures on the Chicago Mercantile Exchange were used. It was hypothesized that FP_{t-6} would be positively correlated with P_t.

A second variable, ΔFP_{t-6}, was constructed to account for variability in prices not accounted for by the market's current forecast. This variable represents the change in contract prices for time period t occurring from time periods t-7 to t-6. Evidence is available suggesting less variability in futures prices than in the corresponding cash prices (Tomek and Robinson, p. 266). Therefore, it can be assumed that the futures market might tend to underestimate price swings in cash markets. It was hypothesized that ΔFP_{t-6} would be positively correlated with cash Tennessee feeder cattle prices.

The statistical method of estimating these models will be presented in the next chapter.

CHAPTER III

STATISTICAL MODELS AND PROCEDURES

The previous chapter dealt with the formulation of the economic model to forecast Tennessee Feeder Cattle prices. Models to statistically estimate the parameters of these relationships will be presented in this chapter.

1. THE STATISTICAL MODELS

The statistical models use the variables suggested by the previously discussed economic models. The linear functional form was used for both models based upon ease of estimation and use and upon the lack of empirical or theoretical evidence to suggest other approaches. In the following discussions B_i represents a coefficient to be estimated.

A. Statistical Model To Estimate the Econometric Model

Statistical estimation of the econometric model to forecast Tennessee feeder cattle prices six months in the future used the following functional form:

$$P_t = B_0 + B_1FD_{t+2} + B_2FD_t + B_3FD_{t-2} + B_4FD_{t-4} + B_5FD_{t-6} + B_6NFS_t + B_7NFS_{t-6} + B_8CC_{t-6} + B_9AFS_{t-6} + B_{10}SM_{t-6} + B_{11}P_{t-6} + B_{12}D_1 + B_{13}D_2 + e$$

where:

t represents the month for which the forecast is to be made.

$t - 6$ is the "current" time period or the period from which the forecast is to be made.

P_t = cash price of 500 to 600 pound medium frame, number 1 muscled Tennessee feeder cattle to be forecasted[1].

FD_{t+2} = implied value for feeder cattle eight months in the future. This value was calculated using slaughter cattle futures eight months in the future minus cost of gain eight months in the future. Further explanation of the cost of gain variable will be presented in a later section.

FD_t = implied value for feeder cattle six months in the future. This value was calculated using slaughter cattle futures six months in the future minus cost of gain six months in the

[1]All cattle prices used in the study were in dollars per hundredweight.

future.

FD_{t-2}= implied value for feeder cattle four months in the future. This value was calculated using slaughter cattle futures four months in the future minus cost of gain four months in the future.

FD_{t-4}= implied value for feeder cattle two months in the future. This value was calculated using slaughter cattle futures two months in the future minus cost of gain two months in the future.

FD_{t-6}= implied current value of feeder cattle. This value was calculated using slaughter cattle cash prices minus current cost of gain.

NFS_t = indicator of demand for feeder cattle for slaughter six months in the future. This variable equals slaughter cattle futures minus feeder cattle futures. Both price series used were monthly averages of Thursday settlement prices on the Chicago Mercantile Exchange (Chicago Mercantile Exchange Yearbook, 1972-1983).

NFS_{t-6}=indicator of demand for feeder cattle for slaughter in the current period. This variable is feeder cattle cash prices subtracted from slaughter cattle cash prices. Monthly averages of Oklahoma City cash prices for medium frame number 1 steers weighing 600 to 700 pounds were used for the feeder cattle price series while monthly averages of Omaha cash prices for choice slaughter steers weighing 900 to 1100 pounds were used for the slaughter cattle price series (U.S.D.A. Livestock and Meat Statistics, 1972-1983).

CC_{t-6}= the previous year's annual United States calf crop in thousands. Data were interpolated to mid-months by centering each year's calf crop on July and interpolating between years to obtain an annual number for each month (U.S.D.A. Livestock and Meat Statistics, 1983).

AFC_{t-6}=the available quantity of feeder cattle variable. This variable represents the current number of steers and heifers over 500 pounds not on feed in thousands. Quarterly data were interpolated to obtain monthly data. (U.S.D.A. Livestock and Meat Statistics,1983).

SM_{t-6} =the current stockering margin. This variable was calculated using cash Oklahoma city prices for medium frame number 1 steers weighing 600 to 700 pounds subtracted from cash Oklahoma

City prices for medium frame number 1 steers weighing 400 to 500 pounds (U.S.D.A. Livestock and Meat Statistics, 1972-1983).

P_{t-6} = the cash price of medium frame #1 muscled 500 to 600 pound feeder steers from 14 reported auction markets in Tennessee (Tennessee Agricultural Statistics, 1983).

D_n = a set of 0,1,-1 dummy variables used to account for seasonal price variability (Pindick and Rubinfeld). The year was divided into three periods using mid-month price indices calculated from 1972 - 1981 data on Tennessee feeder cattle prices. The dividing dates between periods were chosen in such a way as to obtain the greatest possible consistency of price level within each period. These periods were October through February; March through May; and June through September. D_1 was set to 1 and D_2 to 0 for the October through February period; D_1 was set to 0 and D_2 to 1 for the March through May period; and D_1 and D_2 were set to -1 for the June through September period[2].

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[2]Although the year is normally divided into quarters, the pattern in the indices suggested three divisions of different lengths would be more appropriate to represent the seasonal price pattern.

e = The error term .

Data availability and deviations from the form compatible with that needed will be discussed in a later section.

B. Statistical Model to Estimate the Futures Market Model

The futures market model was estimated statistically using the following specification:

$$P_t = \hat{B}_0 + \hat{B}_1 FP_t + \hat{B}_2 \Delta FP_t + e$$

where:

P_t = the cash price for 500 to 600 pound medium frame, number 1 muscled feeder steers from 14 reported auctions in Tennessee, during month t (Tennessee Agricultural Statistics, 1983).

FP_{t-6} = the monthly average of Thursday settlement prices for feeder cattle futures on the Chicago Mercantile Exchange. These prices are for contracts for delivery in month t but the prices occur in month t - 6 (Chicago Mercantile Exchange Yearbook, 1972-1983). For nondelivery months, futures prices were interpolated between adjacent delivery months.

ΔFP_{t-6}= the difference in the monthly average of Thursday settlement prices for feeder cattle futures on the Chicago Mercantile Exchange from month t - 7 to month t - 6, for contracts for delivery in month t (Chicago Mercantile Exchange Yearbook, 1972-1983).

e = the error term .

The statistical method used initially to estimate the desired parameters was ordinary least squares (OLS). The normal statistical assumptions applying to this method were employed. Discussion of problems with the OLS estimation procedure will be presented later.

2. TIME PERIOD USED IN THE STUDY

Monthly observations on the variables were obtained for the years 1972-1982. A longer period of time was desirable, however, some data series were not available in a useful form prior to 1972.

Data series for 1972-1981 were used to obtain estimates of the parameters. Data for 1982 were then used to determine the effectiveness of the model in forecasting post-sample prices.

3. DATA

Data were selected for this study so as to make it possible for users to obtain the data necessary to utilize the model for forecasting. Secondary data were used from various sources.

A. Futures Market Prices

The data series on futures market prices were obtained from the yearbooks of the applicable commodity exchange (Chicago Mercantile Exchange Yearbook, Chicago Board of Trade Yearbook, 1972-1983). Although these yearbooks are generally all-inclusive of a price series, some data for short periods not included in the yearbooks were obtained from The Wall Street Journal. or other financial news source.

Futures contract specification for the grains remained uniform over the period of the study (except for very minor contract changes). However, futures contract specification for feeder cattle did not remain uniform over the period. The feeder cattle contract changed according to the changes in the U.S.D.A. grading system in 1977. Prior to the grading changes contracts specified Choice grade feeder cattle. After the U.S.D.A. grading standards were changed, Medium Frame No. 1 muscle thickness cattle were deliverable. Since these two standards are essentially the same, the change in the grading standards had minimal effects on the uniformity of prices for the contracts.

Contract months traded for several of the commodities changed over the period. However, this does not pose a great problem for the homogeneity of the data series. A change in the contract months traded does not change the underlying relationship among the futures prices.

All FD_i (feedlot demand) variables were calculated as slaughter cattle futures minus the cost of feedlot gain. Ideally, the feedlot operator would base his production decisions, and therefore his demand for feeder cattle, upon cost of gain during the feeding period and fed cattle futures prices applicable to the period when the fed cattle would be marketed. This implies availability of fed cattle futures prices applicable six months in the future from the time feeder cattle are purchased. Thus, in order to measure the feedlot demand for feeder cattle six months into the future, prices for fed cattle futures contracts 12 months in the future should be used.

However, futures prices for fed cattle were not available beyond eight months in the future during the early part of the 1972 through 1982 period of the study. Thus, the data to construct the feedlot demand (FD_{t+i}) variable were not available beyond eight months in the future. The most distant variable (eight months) which could be used was FD_{t+2}. Feedlot demand variables were specified at two-month intervals from the current period up to the eight-months limit (FD_{t-6},FD_{t-4},FD_{t-2},FD_t,FD_{t+2}).

Slaughter cattle futures were monthly averages of Thursday settlement prices on the Chicago Mercantile Exchange (Chicago Mercantile Exchange Yearbook, 1973-1983).

B. Cost of Gain

Cost of gain[3] was calculated as a weighted average of corn futures prices, soybean meal futures prices and current short term interest rates (U.S.D.A. Agricultural Finance Databook, 1983). Corn futures prices were a monthly average of Thursday settlement prices for No. 2 yellow corn on the Chicago Board of Trade. Soybean meal futures were a monthly average for Thursday settlement prices of soybean meal on the Chicago Board of Trade (Chicago Board of Trade Yearbook, 1972-1983). All corn prices used were in dollars per bushel. Prices for soybean meal were in dollars per ton.

Interest rates used were the most common interest rate charged on non-real estate farm loans (U.S.D.A. Agricultural Finance Databook, December 1983). The interest rates were used in decimal form (e.g. .11 represents 11 percent).

For the current time period cash prices were used for corn and soybean meal. Cash corn prices were the monthly average for Chicago No. 2 yellow corn in dollars per bushel (Chicago Board of Trade Yearbook, 1983). Cash soybean meal prices were monthly averages of Decatur, Illinois soybean meal prices in dollars per ton (Chicago Board of Trade Yearbook, 1983).

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[3]Construction of this variable was as follows: (1 + interest/4) x ((45 x corn price) + (.135 x soybean meal price)) + ((interest/2) x (6 x feeder cattle price)).

Although futures contracts for the respective commodities are not traded for every month, a representative price can be calculated by interpolation between the futures contracts nearest to the desired month. This method was used to estimate prices for nondelivery months for all futures price series used in the study.

C. Demand for Feeder Cattle For Slaughter

As previously discussed, low feeder cattle prices or high slaughter cattle prices were hypothesized to be associated with an increase in demand for feeder cattle for slaughter. Two variables were included in the model to indicate demand for nonfed slaughter, one for demand for feeder cattle for slaughter six months in the future (NFS_t) and one for current demand for feeder cattle for slaughter (NFS_{t-6}).

Price series used to calculate the variable to indicate demand for feeder cattle for nonfed slaughter in the current period (NFS_{t-6}) were average cash prices from the Oklahoma City market for feeder steers, for the applicable weights. Cash prices for slaughter cattle were average prices for the Omaha market for 1000-1100 pound choice slaughter steers (U.S.D.A. Livestock and Meat Statistics, 1983). These particular price series were chosen based on volume of trading at these respective markets. The markets were most active for the respective commodities and seemed to express representative cash prices for the nation, excluding transportation costs. For the variable to indicate demand for nonfed slaughter six months in the future (NFS_t), futures prices for feeder cattle and slaughter cattle were used. Linear interpolation between nearest futures contracts was used when necessary to arrive at a price for the contracts six months in the future.

D. Calf Crop

Calf crops were obtained from U.S.D.A. Livestock and Meat Statistics. These numbers represent annual calf crops and must be interpolated to monthly figures to conform to the model specification. The previous year's calf crop was centered on July 1. Interpolation between July 15 of the previous year and July 1 of the current year allowed the data to be used as a monthly series (CC_{t-6}).

E. Supply of Available Feeder Cattle

The available feeder cattle supply numbers (AFC_{t-6}) represented the number of steers and heifers over 500 pounds not yet on feed. These figures are available on a quarterly basis from the U.S.D.A. reporting services (U.S.D.A. Livestock and Meat Statistics, 1972-1983).

Interpolation to a monthly basis was necessary to conform to the model. This interpolation was accomplished by assuming that the quarterly figures were for the middle month of the respective quarter and interpolating to arrive at cattle numbers for the two months between the middle of each quarter.

F. Tennessee Feeder Cattle Prices

Data for the dependent variable (P_t, Tennessee feeder cattle prices) were taken from the Annual Bulletin of the Tennessee Crop Reporting Service (Tennessee Agricultural Statistics, December 1983). These prices reflect the monthly average price paid for 500 to 600 pound, medium frame number 1 muscled feeder steers at 14 auctions in the State. These data are available on a monthly basis from the Tennessee Crop Reporting Service. This price lagged six months (P_{t-6}) was also used as an independent variable to test the effectiveness of past prices in forecasting future prices.

G. Stockering Margin

Monthly averages of Oklahoma City cash prices for medium frame number 1 muscled feeder steers were used to calculate the stockering margin variable (SM_{t-6}). This market was the most active in the nation for feeder cattle sales. U.S.D.A. reports these prices on a monthly basis (U.S.D.A. Livestock and Meat Statistics, 1972-1983).

Data on interest rates were the most common interest rate charged on non-real estate farm loans, obtained from the U.S.D.A. Agricultural Finance Databook. These rates are available on a quarterly basis. Interpolation to monthly figures was necessary. Linear interpolation was used. These rates were used because they are applicable to most short-term rates charged to farmers for production loans.

H. Feedlot Demand

The cost of gain figures used to calculate the feedlot demand variable (FD_{t+i}) were determined based on consumption of grain and protein supplement, interest on these feed costs, and interest on the purchase of the animal. U.S.D.A. Livestock and Poultry Situation assumes that the average feeder steer, as it grows from a 600 pound feeder animal to an 1100 pound slaughter animal, consumes 45 bushels of corn and 270 pounds (.135 tons) of soybean meal. These feed consumption averages were used to determine the cost of feed consumed by the average feeder animal. The monthly average prices for feed inputs were multiplied by the applicable consumption numbers and interest rate to determine a cost of feedlot gain for the feeder steer.

Interest for three months was used to calculate interest on feed costs, based on a six month feeding period. Only three months was used because the operator would not be paying interest on the total feed cost during the six months the animal is on feed. It was assumed however, that the operator would be paying interest on the feeder animal cost during the entire six month feeding period. Interest on the purchase price of the animal was calculated based on this assumption (see footnote on page 34).

4. MULTICOLLINEARITY

Multicollinearity is one of the most common problems encountered when using econometric methods. The independent variables may not actually be causally related but exhibit a common variation over time.

A high degree of correlation among independent variables could result in coefficients which are highly imprecise (Maddala p.190). Kane (1968) states that this problem also results in high standard errors of the estimated coefficients. This implies that some variables could be considered statistically nonsignificant when in fact they are significant.

Small levels of multicollinearity are common in regression analysis and are not serious. It is necessary, therefore, for the researcher to determine the level of multicollinearity present among the variables. The usual methods of determining the degree of multicollinearity are that of a) regressing each of the independent variables on the other independent variables, or b) calculating correlation coefficients among the independent variables. If some of the independent variables appear to be linear functions of the others, it is assumed that multicollinearity is serious enough to warrant attention. It appeared, a priori, that several of the variables in the econometric model might be correlated. Therefore, the data were analyzed for multicollinearity and corrective actions taken as described later.

5. AUTOCORRELATION OF RESIDUALS

Another statistical problem generally encountered with time series data is serial correlation among error terms. This type of correlation is known as autocorrelation. Autocorrelation results from time effects. The level of a variable in one time period is correlated with the level of the variable in immediately adjacent time periods (Younger p.285).

Due to the use of time series data in this study, autocorrelation was expected to be a problem. Several causes of autocorrelation have been noted in the literature. Omitting a relevant variable from the regression equation may result in the error term representing the influence of the omitted variable which is autocorrelated (Younger). Mispecification of the functional form of the model also has been shown to result in autocorrelation (Maddala).

Autocorrelation tends to bias the estimates of the standard errors of the regression coefficients. Bishop has also shown that it results in inflation of the coefficient of determination (R^2).

A common statistical test to determine whether autocorrelation is present is calculation of the Durbin-Watson (d) statistic. This statistic can be used to test for either positive or negative first order autocorrelation.

CHAPTER IV

STATISTICAL RESULTS

Parameters of the statistical equations were estimated using multiple linear regression techniques. If the appropriate assumptions are met these regression techniques result in coefficients that are minimum-variance unbiased linear estimates of the parameters.

The individual parameter estimates were evaluated on the basis of their statistical significance and their *a priori* hypothesized sign. Correlation among the independent variables was also examined to determine the degree of multicollinearity present. The Durbin-Watson (d) statistic was used to test for autocorrelation among the error terms.

1. STRUCTURAL FORM OF THE ECONOMETRIC MODEL

Monthly observations on the variables included in the econometric model were collected and ordinary least squares applied to estimate the parameters. Preliminary results of the regression indicated that multicollinearity and autocorrelation were problems.

A correlation matrix using the independent variables included in the model was calculated. Results of these calculations are presented in Table 1. The table indicates

TABLE 1. CORRELATION COEFFICIENTS OF INDEPENDENT VARIABLES FROM THE ECONOMETRIC MODEL, 1972-1981.

	FD_{t+2}	FD_t	FD_{t-2}	FD_{t-4}	FD_{t-6}	SM_{t-6}	AFC_{t-6}	CC_{t-6}	NFS_{t-6}	NFS_t	P_{t-6}
FD_{t+2}	1.00	0.99	0.98	0.96	0.91	0.69	-0.12	-0.77	-0.64	-0.72	0.95
FD_t	0.99	1.00	0.99	0.97	0.92	0.68	-0.15	-0.76	-0.65	-0.74	0.96
FD_{t-2}	0.98	0.99	1.00	0.99	0.94	0.68	-0.18	-0.75	-0.63	-0.73	0.96
FD_{t-4}	0.96	0.97	0.99	1.00	0.96	0.63	-0.20	-0.76	-0.55	-0.69	0.94
FD_{t-6}	0.91	0.92	0.94	0.97	1.00	0.57	-0.12	-0.77	-0.44	-0.65	0.89
SM_{t-6}	0.69	0.68	0.68	0.64	0.57	1.00	-0.24	-0.60	-0.80	-0.82	0.81
AFC_{t-6}	-0.12	-0.15	-0.18	-0.20	-0.12	-0.24	1.00	0.006	0.26	0.19	-0.21
CC_{t-6}	-0.77	-0.76	-0.75	-0.76	-0.77	-0.60	0.006	1.00	0.59	0.76	-0.78
NFS_{t-6}	-0.64	-0.65	-0.63	-0.55	-0.44	-0.80	0.26	0.59	1.00	0.88	-0.76
NFS_t	-0.72	-0.74	-0.73	-0.69	-0.65	-0.82	0.19	0.76	0.88	1.00	-0.85
P_{t-6}	0.95	0.96	0.96	0.94	0.89	0.81	-0.21	-0.78	-0.76	-0.85	1.00

that a high degree of multicollinearity existed among the feedlot demand variables, as expected. Maddala suggests one of the solutions to the problem of multicollinearity is dropping some of the correlated variables from the model. Assuming that the original model was correctly specified, the estimates of the coefficients resulting from a regression in which variables have been dropped to correct for multicollinearity are biased. However, the variances of the estimates are smaller than if the correlated variables were not dropped from the regression equation.

Due to the high degree of multicollinearity present among the feedlot demand variables (Table 1) the decision was made to drop several of them from the model. Based on the assumption that the feedlot operator would consider fed cattle futures and cost of gain up to twelve months in the future the only feedlot demand variable retained in the model was the one applying to the period eight months in the future (FD_{t+2}) from the forecast date (t-6). Although feedlot demand variables farther than eight months in the future are desirable, data limitations prohibit the calculation of these values. As discussed earlier, futures market data are not available on a regular basis to permit calculation of the feedlot demand variable beyond eight months in the future.

Past cash prices for Tennessee feeder cattle (P_{t-6})

were also dropped from the model. Results from the initial regression indicated that these prices were not statistically significant and were also correlated with the feedlot demand variable retained in the model.

The Durbin-Watson test revealed the existence of serious autocorrelation of residuals (d = .64). Autocorrelation was corrected by using the SAS AUTOREG procedure. The details of this procedure can be found in the SAS Users Guide.

The statistical form of the econometric model, after modifications to correct for multicollinearity was:

$$P_t = \hat{B}_0 + \hat{B}_1 FD_{t+2} + \hat{B}_2 AFCS_{t-6} + \hat{B}_3 CCt\text{-}6 + \hat{B}_4 NFS_t + \hat{B}_5 NFS_{t-6} + \hat{B}_6 SM_{t-6} + \hat{B}_7 D1 + \hat{B}_8 D2 + e$$

Variables are defined as before (pp. 26-29).

The statistical results of the regression are presented in Table 2. The overall regression was significant at the 99 percent confidence level. The value of R^2 indicated that the model explained 76.25 percent of the variation in feeder steer prices six months in the future in Tennessee. Table 2 reveals that three of the variables included in the model were statistically significant at the 95 percent confidence level. The seasonal dummy variables were not significant at this level, although their estimated coefficient was greater than their standard error.

TABLE 2. RESULTS FROM THE ECONOMETRIC MODEL, 1972-1981.

Explanatory Variable	Notation	Estimated Coefficient	Estimated Standard Error	t Value	Probability > t
Intercept		203.2555	32.5609	6.242	0.0001
Feedlot demand	FD(t+2)	0.0247	0.0118	2.090	0.0394
Available feeder cattle supply	AFC(t-6)	-0.00014	0.00019	-0.759	0.4499
Calf Crop	CC(t-6)	-0.0035	0.0006	-5.451	0.0001
Nonfed slaughter demand	NFS(t)	-0.8485	0.2154	-3.940	0.0002
Nonfed slaughter demand	NFS(t-6)	0.0335	0.1485	0.225	0.8222
Stockering margin	SM(t-6)	0.0903	0.1933	0.467	0.6416
Seasonal					
Dummy Variables	D(1)	-0.7019	0.6471	-1.085	0.2809
	D(2)	0.8901	0.6763	1.316	0.1915
		R^2 = 0.7625			

The coefficient on feedlot demand (FD_{t+2}) eight months in the future (.0247) was over twice the value of the standard error (.0118). The t-value of this coefficient (2.090) indicated that the variable was statistically significant at the 95 percent confidence level. The positive sign of the coefficient was also consistent with the previously hypothesized sign. These results imply that feedlot demand is an important variable in explaining feeder steer prices six months in the future, in Tennessee.

Although the sign of the coefficient calculated for the available feeder cattle supply (AFC_{t-6}) was consistent with economic theory, the t-value of this coefficient (-.0759) indicated that the variable was not significant at the 95 percent confidence level. The standard error of the estimate (.00019) was also greater than the coefficient (.00014), an indication that the variable is not a good indicator of future feeder steer prices in Tennessee. Although this supply variable theoretically should be an important factor in price determination these statistical results tend to indicate otherwise.

These results indicate that United States calf crop (CC_{t-6}) is an important factor in forecasting feeder steer prices in Tennessee. The estimated coefficient (-0.0035) of this variable was over five times the value of the standard error of the estimate (0.0006). The t-value of the coefficient (-5.451) indicated that the variable was statistically significant at the 95% confidence level.

The variable for nonfed slaughter demand six months in the future (NFS_t) was significant at the 95 percent confidence level (t-value = -3.940). The negative sign of the coefficient of this variable was not consistent with the a priori hypothesis. Although it was hypothesized that this variable would have a positive relationship with future feeder steer prices in Tennessee, the opposite was observed. Since this variable is calculated by subtracting feeder cattle futures from slaughter cattle futures, a potential explanation for this negative relationship is that larger differences between slaughter cattle futures and feeder cattle futures prices are associated with lower feeder cattle prices. In this case the observed relationship may be merely arithmetic rather than causal.

The current demand for nonfed slaughter (NFS_{t-6}), represented by cash prices, did have the previously hypothesized sign. The calculated t-value (0.225), however, was not statistically significant at the 95 percent confidence level. If current demand for nonfed slaughter is in fact an important factor in forecasting future feeder steer prices in Tennessee, it could possibly be better indicated by other means of measurement.

The demand for feeder steers for stockering, represented by the stockering margin, resulted in a coefficient with the hypothesized sign. The t-value (0.467), however, was not significant at the 95 percent confidence level.

Although neither of the seasonal variables were statistically significant, results indicated that feeder cattle prices tended to be lower during the October through February (D_1=1) period than for the March through May period (D_2=1). These results are consistent with the conventional wisdom regarding the seasonal price pattern for feeder cattle.

In summary, the structural form of the econometric model can be stated as the equation:

$$\hat{P}_t = 203.2555 + 0.247 (FD_{t+2}) - 0.00014 (AFC_{t-6}) - 0.0035 (CC_{t-6}) - 0.8485 (NFS_t) + 0.0335 (NFS_{t-6}) + 0.0903 (SM_{t-6}) - 0.7019 (D_1) + 0.8901 (D_2)$$

Variables are defined as before (pp. 26 through 29).

Although only three of the variables were statistically significant at the 95 percent confidence level, and one variable did not carry the hypothesized sign, the overall results of the regression appeared to be satisfactory. The results of this regression indicate that although the model is an imperfect forecaster of feeder steer prices six months in the future in Tennessee, the model does do a respectable job of forecasting these prices within the sample period (R^2 = 0.7625).

2. STRUCTURAL FORM OF THE FUTURES MARKET MODEL

For the futures market model, monthly observations on feeder cattle futures prices and the monthly change in the feeder cattle futures prices were regressed on cash feeder cattle prices six months in the future using ordinary least squares. Initial results indicated that autocorrelation among the error terms was severe. The calculated value of the Durbin-Watson d statistic was 0.579, providing evidence that autocorrelation was significant. The SAS AUTOREG procedure was used as the means of dealing with the autocorrelation in the futures market model.

Using this procedure, the independent variables were again regressed on the feeder cattle price six months in the future. The calculated coefficients and other statistics are presented in Table 3.

The overall regression was significant at the 99 percent confidence level. The t value from Table 3 (6.792) indicates the feeder cattle futures price variable (FCF_{t-6}) for the forecast period was significant at the 99 percent confidence level. These results indicate that the futures price for the month six months in the future is

TABLE 3. RESULTS FROM THE FUTURES MARKET MODEL, 1972-1981.

Explanatory Variable	Notation	Estimated Coefficient	Estimated Standard Error	t Value	Probability > t
Intercept		17.5965	6.0611	2.903	0.0051
Feeder Cattle Futures	FCF	0.6751	0.0994	2.903	0.0051
Change in Feeder Cattle Futures	ΔFCF	-0.2079	0.2022	-1.028	0.3079

$R^2 = 0.4239$

a good indicator of the cash price of Tennessee feeder steers six monthsin the future. The positive sign of the coefficient was consistent with the *a priori* hypothesis.

The variable representing the differences in futures prices from the previous month (ΔFCF_{t-6}) was not significant at the 95 percent confidence level. The sign of the variable also indicated that the variable did not have a relationship with Tennessee feeder steer prices six months in the future which was consistent with the *a priori* hypothesis.

Results from the regression on the variables included in the futures market model indicated the following structural model:

$$P_t = 17.5965 + 0.6751\ (FCF_{t-6}) - 0.2079\ (\Delta FCF_{t-6})$$

3. COMPARISON OF THE TWO MODELS

A higher R^2 resulted from the regression of the econometric model ($R^2 = 0.7625$) than from the regression of the futures market model ($R^2 = .4239$). Although a high R^2 is desirable, the model with the highest R^2 will not necessarily produce the best forecasts (Younger, p. 480). Regression equations obtained from one set of data may not produce good results when applied to another set of data. The coefficients produced from the regression are "data dependent". They will tend to vary from sample to sample. Therefore, other statistical measures should be used to determine the model that produces the best forecasts.

Root-mean-square-error[4], or the standard deviation of the error term, measures the variability of the predicted values about the actual values. For a linear model, the actual values will lie on either side of the straight line produced by the regression equation. The smaller the error terms, the more accurate the forecasts of the model for the data set used to fit the model.

Another measure used to compare forecasting ability between models, as well as comparing econometric forecasts to current "no-change" price forecasts is Theil's U_2 statistic. This statistic is calculated from the equation:

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

where: P_t is the price forecast from the model for time period t.

The U_2 statistic equals zero when the model's forecasts are perfect. It equals one when the model's forecasts for time period t are equally as accurate as

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

$$RMSE = \sqrt{\frac{\Sigma(\hat{P}_t - P_t)^2}{n}}$$

where: $\hat{P}_t$ = forecasted price for time period t.
P_t = actual price in time period t.
n = number of observations.

forecasts generated by the assumption that the price remains unchanged from time period t-6. When the value of U_2 is greater than one the model's forecasts are less accurate than the "no-change" price assumption. Therefore, the lower the value of U_2 the better the model's forecasts. Table 4 presents the root-mean-square-error and the Theil's U_2 statistics for the econometric model and the futures market model for the within sample period.

Both root-mean-square-error and Theil's U_2 (3.6969 and 0.3630, respectively) were lower for the econometric model than for the futures market model (5.1840 and 0.5090, respectively) using data for the within sample period, 1972-1981. Both models produced a Theil's U_2 less than one, implying that the models' forecasts were better than those resulting from assuming future prices for time period t will remain the same as current prices (time period t-6). The econometric model appeared to do a better job of forecasting prices than the futures market model for the within sample period.

4. POST SAMPLE PREDICTIVE ABILITY OF THE MODELS

As stated previously, a regression equation produced with one set of data may not produce forecasts which are accurate for another set of data. Data for 1982 were used to determine the forecasting ability of the two models

TABLE 4. ROOT-MEAN-SQUARE-ERROR AND THEIL'S U_2 STATISTIC FOR THE ECONOMETRIC MODEL AND THE FUTURES MARKET MODEL, 1972-1981.

Model	Root MSE	Theil's Coefficient
Econometric	3.6969	.3630
Futures Market	5.1840	.5090

using data that were not included in the original regressions. Forecasted prices were then compared with actual prices, again using the root-mean-square-error and Theil's U_2 statistic to determine forecast accuracy. These results are presented in Table 5.

Based on the results presented in Table 5, the futures market model appeared to do a better job of forecasting prices for 1982 than the econometric model. Both root-mean-square-error and Theil's U_2 statistic were lower for the futures market model than for the econometric model for the 1982 data. The futures market model appeared to provide more accurate forecasts for 1982 prices than it did for the within sample period (1972-1981) based on the RMSE measure. Root-mean-square-error from the futures market model for the within sample period (5.1840) was substantially greater than for the 1982 data (3.3990). Theil's U_2 , however, was higher for the 1982 period than for the within sample period for the futures market model (.7185 compared to .5090). Although root-mean-square-error for the econometric model for the 1982 data was only slightly higher than for the within sample period (4.2031 compared to 3.6969), the Theil's U_2 statistic was significantly higher (.8885 compared to .3630).

In the final analysis, both models appeared to do a respectable job of forecasting prices for the within sample

TABLE 5. ROOT-MEAN-SQUARE-ERROR AND THEIL'S U_2 STATISTIC FOR THE ECONOMETRIC MODEL AND THE FUTURES MARKET MODEL, 1982.

Model	Root MSE	Theil's Coefficient
Econometric	4.2031	.8885
Futures Market	3.3990	.7185

period, 1972-1981. The econometric model forecasted prices more accurately than the futures market model for this period. Forecasts from the futures market model were more accurate for the 1982 data than those from the econometric model. Although the econometric model did a poorer job of forecasting prices for the 1982 data, the futures market model appeared to forecast almost as well for this period as it did for the within sample period. The forecast accuracy of both models, based on the Theil's U_2 statistic, was superior to current prices in forecasting future prices. Although these forecasts are imperfect, reasonably accurate forecasts can be generated for feeder steer prices in Tennessee, six months in the future. Table 6 presents the actual and predicted values for both models for 1982. Figure 1 illustrates the actual and predicted values from both models for the post-sample period.

5. USING THE MODELS TO FORECAST PRICES

A few notes on using the models to forecast prices are in order. As stated previously, the futures markets do not provide prices for every month needed to forecast cash feeder cattle prices. Interpolation between the nearest futures contracts is necessary to obtain a representative price for the months not traded on the applicable commodity exchange. Also, the U.S. calf crop for the current year is

Table 6. ACTUAL AND PREDICTED PRICES FOR THE FUTURES MARKET AND ECONOMETRIC MODELS, 1982.

Month	Actual	Futures Market Forecast	Econometric Model Forecast
	- - - - - - - - $ per cwt. - - - - - - - - - - - - - -		
Jan.	61.38	57.80	57.75
Feb.	63.69	58.99	58.38
Mar.	62.32	59.90	59.38
Apr.	59.88	60.72	60.02
May	58.66	61.93	60.00
June	58.75	61.17	59.12
July	62.84	61.61	58.99
Aug.	65.75	63.00	59.79
Sep.	69.15	63.05	61.61
Oct.	67.75	62.64	62.00
Nov.	65.00	62.33	61.55
Dec.	62.90	61.82	60.10

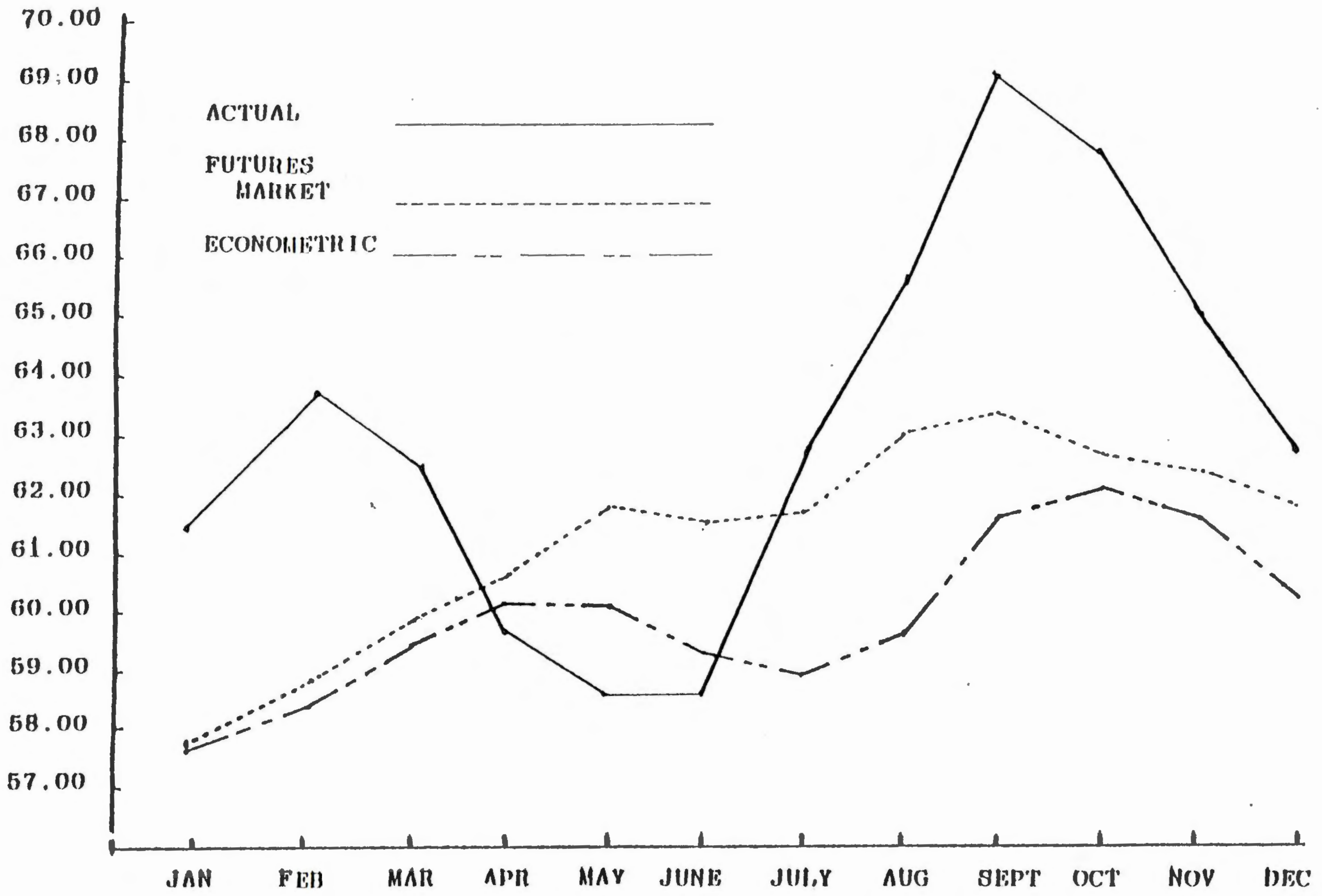

FIGURE 1. ACTUAL AND PREDICTED VALUES FOR THE ECONOMETRIC AND FUTURES MARKET MODELS, 1982.

not known from U.S.D.A. sources in advance. However, persons using the forecast should have a general idea of the direction of movement of calf crops. This general idea will have to be quantified and used as the calf crop numbers in order to interpolate annual calf crop numbers for each month[5].

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[5]For example, if last year's calf crop was 49 million head and the forecaster assumes that calf crops will be smaller this year than last, he may assume a calf crop of 48 million or 47.5 million head for the current year and base the interpolations on this figure.

CHAPTER V

SUMMARY AND CONCLUSIONS

1. SUMMARY

Cattle producers and feedlot operators have been plagued with periods of "boom" and "bust" over the past several decades. Favorable prices for producers lead to increased herd size, overproduction, and low prices in future periods while unfavorable prices lead to herd liquidation, underproduction, and high prices in future periods. Producers may have a tendency to base future production decisions primarily on current prices, which may or may not reflect market conditions for future prices. Producer incomes might become less volatile if production decisions could be based on better information about future price movements for inputs and products.

The objectives of this study were to: 1) develop an econometric forecasting model to predict 500 to 600 pound Tennessee feeder cattle prices six months in the future; 2) develop a forecasting model based on the futures market to predict 500 to 600 pound Tennessee feeder cattle prices six months in the future; and 3) to evaluate the two models and determine which is the superior forecaster of Tennessee feeder cattle prices six months in the future.

To achieve these objectives, two models were specified and least squares regression techniques employed to estimate the model parameters. Based on economic theory and knowledge of the industry, an econometric model was specified to forecast 500 to 600 pound Tennessee feeder cattle prices six months in the future. A second model was specified based on the futures market to forecast feeder cattle prices in Tennessee. Parameter estimation for both models was achieved using monthly data from January 1972 through December 1981.

The models were then used to forecast monthly prices for January 1982 through December 1982. Using two common statistical tests to evaluate forecast accuracy, the models were examined on their post-sample forecasting accuracy.

The econometric model developed to predict future feeder cattle prices in Tennessee was based on components of supply and demand hypothesized to have an effect on future feeder cattle prices. These components were:

1. Demand for feeder cattle for feedlots.
2. Demand for feeder cattle for slaughter.
3. Demand for feeder cattle for stockering operations.
4. Calf Crops.
5. Quantity of available feeder cattle.
6. Current prices of feeder cattle in Tennessee.

Feeder cattle were considered to be the final product of the cattle raiser and the major input to the cattle feeder. Variables used in the model were the implied value of feeder cattle to the feedlot operator, demand for feeder cattle for slaughter, the stockering margin, U.S. calf crops, quantity of available feeder cattle, and the current price of feeder cattle in Tennessee. Dummy variables were included in the model to account for seasonal variation in prices.

The futures market model used: a) monthly futures prices occurring during the forecast month for contracts deliverable in the period to be forecast, and b) the change in these prices from the previous month, as variables to forecast Tennessee feeder cattle prices.

Data series used to measure the variables were chosen with consideration of their ability to reflect the actual levels of the variables. The data series were also chosen to make it possible for persons needing forecasts from the models to be able to obtain the necessary data.

Results of the regression on the variables included in the econometric model indicated that the feedlot demand eight months in the future was a significant predictor of feeder cattle prices six months in the future at auction markets in Tennessee. This variable was positively correlated with the dependent variable, as hypothesized. To reduce the initial problem of multicollinearity encountered, all feedlot demand variables except FD_{t+2}

were dropped from the model. Although the quantity of available feeder cattle was correlated with the dependent variable in the direction hypothesized (negatively), it was not a statistically significant predictor of the dependent variable. United States calf crops were a significant predictor of the dependent variable and the sign was positive as hypothesized. Implied demand for feeder steers for slaughter six months in the future was a significant predictor of the dependent variable. However, this variable's correlation (negative) with the dependent variable was opposite that hypothesized. The current implied demand for feeder steers for slaughter was correlated (positively) with the dependent variable as hypothesized, but the coefficient was not significant. The stockering margin resulted in a coefficient that was positively correlated with the dependent variable as hypothesized, however, the coefficient associated with this variable was not statistically significant. Current prices for feeder cattle were dropped from the model to reduce multicollinearity. Neither of the seasonal variables were statistically significant.

Results of the regression on the variables included in the futures market model indicated that the current price of the contract deliverable six months in the future was a significant indicator of cash Tennessee feeder cattle prices six months in the future. The variable representing the difference between last month's futures prices and this month's futures prices was not a significant predictor of cash feeder steer prices in Tennessee six months in the future. The change in futures prices from the previous month had a relationship with Tennessee feeder cattle prices opposite that hypothesized.

Statistical measures to test and compare the predictive ability of the models were used to compare both models for the within sample period. These statistical comparisons were the root-mean-square-error and Theil's U_2 coefficient. The results of these tests indicated that the econometric model was a better indicator of feeder cattle prices six months in the future at auction markets in Tennessee, for the within sample period. Both models' forecasts were superior to current prices in forecasting the dependent variable.

The estimated parameters of the models were then used to estimate monthly prices for feeder cattle six months in the future for January 1982 through December 1982. The statistical tests mentioned above were then employed to measure the accuracy of both models' out-of-sample forecasts. Based on these tests, it appeared that the futures market model was a better indicator of Tennessee feeder cattle prices six months in the future for the out-of-sample period. The forecast accuracy of both models was superior to current prices for the out-of-sample forecasts.

2. CONCLUSIONS

Cattle feeders and cattle raisers should be better able to plan production using information provided by the two models presented in this thesis. Although the models are imperfect forecasters of future feeder cattle prices in Tennessee, they do provide a useful guide to future price movements. Both models provide a better guide to future price movements than current prices provide.

Further research might improve the predictive ability of the econometric model, as well as develop a better model using the futures market as a forecasting device. One particular improvement might be the use of Tennessee basis data in calculating the cost of feedlot gain, which is a major part of the feedlot demand variable used in the econometric model. Basis movements were not accounted for in the econometric model but might be an important factor in forecasting prices for Tennessee. Since the calculation of this variable involves the use of futures contracts on three different commodities, using a basis to localize the prices involved might be beneficial to the model's forecasting ability.

Although the cattle cycle and its implications may not be eliminated in the near future, its impact on producer incomes can be lessened by research into price movements. Forecasts can provide information which may lessen the severity of income swings for operators affected by the cycle.

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