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To the Graduate Council:

I am submitting herewith a thesis written by Charles Ray Kerley entitled "An Economic Analysis of the Beef Cattle Enterprise in Tennessee Using Multiple Regression on Secondary Time Series Data." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Charles Sappington
Major Professor

We have read this thesis
and recommend its acceptance:

David Brown

B. D. Raskopf

Accepted for the Council:

Hilton A. Smith
Vice Chancellor for
Graduate Studies and Research

AN ECONOMIC ANALYSIS OF THE BEEF CATTLE ENTERPRISE IN TENNESSEE USING MULTIPLE REGRESSION ON SECONDARY TIME SERIES DATA

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Charles Ray Kerley

March 1970

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The author is indebted to Dr. Charles Sappington for the assistance received in preparing the data for the computer and interpreting the output. The interest and patience shown by Dr. Sappington was very helpful in considering both the procedure and the results of this study.

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ABSTRACT

The objective of this study was to determine the extent to which secondary time series data could be used to explain the increase in beef cattle numbers in Tennessee.

Two secondary objectives were to determine if the data suggest that:

1. Dairy and sheep numbers are relevant variables in explaining beef cattle numbers in Tennessee.
2. The concept of opportunity cost along with the cost of hired labor is a relevant variable in analyzing beef cattle numbers in Tennessee.

Secondary time series data for the time period 1925-1965 was used to calculate seven regression estimating equations. The dependent variable estimated is the January 1 inventory number of beef cattle in Tennessee.

The independent variables consisted mainly of enterprises and their product prices that compete with the beef cattle enterprise in Tennessee. The variables were used as proxy variables to evidence changes in opportunity cost associated with alternative agricultural enterprises and to determine the influence of changing competing product prices on beef cattle inventory numbers.

In addition, an index of farm wage rates was used to determine the influence of labor cost upon the adoption or intensification of the beef cattle enterprise in Tennessee. A 0-1 type dummy variable was used to differentiate the World War II period from the preceding and subsequent

years included in the study. Two other variables used were calf prices and cow prices.

Four primary models were calculated. In all the models, most data were averaged for three years with the value of the dependent variable being expressed as a function of the average of the three preceding years observations on the independent variables. The price data in three of the primary models was transformed into ratios by the use of one of three variables. They are: (1) a moving three-year average of cattle prices; (2) a moving three-year average of calf prices; and (3) an index of farm wage rates calculated by the United States Department of Agriculture for Tennessee. The use of ratios reduced the amount of correlation between the independent variables.

Using the results obtained above, three improved models were calculated after removing highly correlated variables. The improved models were calculated and selected as estimating equations on the basis of (1) the economic rationality of the variables included, (2) the amount of multicollinearity present, and (3) the size of the standard error of the estimate.

Sheep and lamb numbers were entered in three of the seven models as an explanatory variable. In all three cases, the b coefficient had a negative sign attached. This indicated that an increase in the three-year average of sheep and lamb numbers had an associated decrease in beef cattle inventory numbers. The time lag was not explicitly defined, but the construction of the model required that it be a function of an average value of the past three years observations on sheep and lamb numbers, along with other variables.

The seven models did not give evidence to support the hypothesis that increasing beef cattle numbers can be explained in part by the decline in dairy numbers. In all but one model, there was a positive b coefficient which implied that increasing dairy cattle numbers have associated increases in beef cattle numbers. This net relationship is not acceptable on the basis of economic reasoning since the two enterprises are considered to be generally competitive. The b coefficients were significant at the .01 level. The negative b coefficient in the one model was not significant.

The index of farm wage rates had a positive b coefficient in all the models in which it was used as an independent variable. This gives support to the contention that <u>ceteris paribus</u> increases in the cost of labor at the farm level should result in shifts from labor intensive enterprise to less time consuming ones and/or tendencies toward a greater utilization of available farm labor. In both cases, beef cattle enterprises could provide the means to accomplish the shift.

The use of a 0-1 dummy variable did not give evidence to support arguments for either a larger or lower intercept value during the World War II years.

In attempting to find an acceptable estimating model, the conclusion was made that for practical purposes, the January 1 inventory number of beef cattle can be written in terms of three explanatory variables. The model is:

$$Yt = 2323.90 - \underset{(1059.60)^{**}}{4883.20X_5} - \underset{(.0172)^{**}}{.5228X_{12}} - \underset{(.2072)^{**}}{1.52X_{13}}$$

R^2 = .9667

Se = 66.31

F = 357.30**

Where:

Yt = The January 1 inventory number of beef cattle in Tennessee

X_5 = [A three-year average of lagged calf prices (dollars/cwt)]/w_3.

w_3 = an index of farm wage rates for Tennessee

X_{12} = a three-year average of lagged corn acreage harvested (1000's acres)

X_{13} = a three-year average of lagged oat acreage harvested (1000's acres)

In conclusion, secondary time series data provided some relationships that may be useful in explaining beef cattle increases in Tennessee. However, cross sectional analysis is needed to analyze the relationships suggested by the models in this study.

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CHAPTER I

INTRODUCTION AND PROBLEM CONSIDERATIONS

I. INTRODUCTION

Agriculture in Tennessee is exhibiting two diverging trends in production. One trend is toward large commercial farms that produce strictly for market sales. The other is a rapid rise in non-commercial farms.[1]

Livestock enterprises have always been an important part of Tennessee agriculture.[2] General advantages of raising beef cattle are said to be many. They can utilize land unfit for profitable farming, provide markets for home grown feeds, grasses, and forage, and help maintain soil fertility. They require relatively small amounts of labor and may be used as a means of returning unprofitable farming land to a paying basis.[3]

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[1] Joe A. Martin and B. H. Luebke, Types of Farming in Tennessee, The University of Tennessee Agricultural Experiment Station, Bulletin No. 311 (Knoxville: The University of Tennessee, March, 1960), p. 26.

[2] Larry M. Boone and Curtis F. Lard, Changes in Tennessee Agriculture by Counties 1954-1964, The University of Tennessee Agricultural Experiment Station, Bulletin No. 435 (Knoxville: The University of Tennessee, December, 1967), p. 16.

[3] David W. Williams, Beef Cattle Production in the South (Danville, Illinois: The Interstate, 1941), pp. 16-20.

II. PROBLEM CONSIDERATIONS

Production Trends

Between 1939 and 1954 beef cattle in the United States increased by 68.8 percent. The most rapid increases were noted in the South where each state had percentage gains greater than the national average. Tennessee's increase during the period was 83 percent.[4]

Since 1954 beef cattle have continued to increase rapidly in Tennessee. Between 1954 and 1964, cattle other than milk cows increased by 57.2 percent while milk cow numbers declined almost 40 percent and sheep and lamb numbers dropped over 65 percent.[5]

Apparent shifts in enterprises in the state have had an important effect on net farm income in Tennessee. In a recent study by Horace A Mitchell, Jr., he concludes that

> Enterprise shifts in Tennessee have moved generally toward small increases in those enterprises that experienced rapidly increasing returns per man hour and rapid increases in enterprises that experienced the smallest increases in returns per man hour. These shifts were also away from those enterprises which were correlated to net income increases and toward those enterprises that were not correlated to net income increases.[6]

The estimated returns from some farm enterprises in Tennessee are published by the Agricultural Extension Service at The University of

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[4] *Ibid.*, p. 22.

[5] Boone and Lard, *loc. cit.*

[6] Horace A. Mitchell, Jr., "A Study of the Causes of the Lag in Net Income Per Farm in Tennessee Compared with Other Southeastern States" (unpublished Master's thesis, The University of Tennessee, Knoxville, August, 1968), p. iv.

Tennessee.[7] The net returns for beef cattle enterprises appear to be relatively uneconomical when compared with net returns from alternative enterprises available. Returns for beef enterprises range from $30.73 per cow for a 30-cow herd of cows and calves fed hay and roughage to a -$6.09 return on a feeder steer not pastured and selling for $22.00 per hundredweight.

The trends noted above present a problem for economic analysis. Assuming farmers act in rational decision-making toward maximizing net farm income, it becomes necessary to identify the relationships associated with the apparent adoption of relatively low income enterprises in Tennessee. Determining the factors related to the adoption of beef cattle enterprises in Tennessee would aid in explaining current agricultural trends in the state.

Review of Literature

Several people have made contributions to the analysis of beef cattle production and supply in the South and other areas. Some of these studies have particular importance to this study.

Williams gives several reasons for the increase of beef cattle production in the South. The collapse of the cotton market, the Agricultural Adjustment Program, and the Soil Conservation Program have resulted in changes in land use from crop production to animal enterprises. In addition, outlets for meat animals have improved in the South. Also,

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[7]Estel H. Hudson and Robert M. Ray, Farm Planning Manual, The University of Tennessee Agricultural Extension Service (Knoxville: The University of Tennessee, Revised edition, June, 1966), pp. 46-53.

there have been great improvements in pastures, forage crops, and breeds of beef cattle along with the use of trench silos as an economical method of feed storage. All have contributed greatly to the increasing presence of the beef cattle enterprise in the South.[8]

However, even with these improvements there still remains the question of profitability to beef producers from a production and market receipts standpoint. In a paper presented to the Southern Farm Management Research Committee in October, 1967, Frank O. Leuthold outlined possible reasons why farmers continue to raise beef cattle or expand their herd size when relative profitableness is low. They are:

1. The beef enterprise generally constitutes only one of several farm enterprises, and thus farmers have difficulty in allocating production costs to the beef enterprise.

2. The increase in beef cattle numbers may be a resultant change due to the decline in other livestock enterprises such as sheep and dairy cattle numbers.

3. Beef production might be a better alternative than leaving land idle.

4. Operators near retirement are less likely to discontinue beef cattle and switch to a new enterprise.

5. Beef cattle production required relatively few management skills and abilities.

6. Beef cattle serve as a ready source of cash.

7. Demand for beef has increased.[9]

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[8] Williams, loc. cit.

[9] Frank O. Leuthold, "Identifying Motivations of Beef Producers" (paper presented to the Southern Farm Management Research Committee, Atlanta, Georgia, October 24, 1967).

In 1958 Charles R. Keisling made a study on beef production in the dark-fired tobacco area of Tennessee. This area includes Cheatham, Dickson, Montgomery, and Robertson counties. He found labor to be an important limiting factor in the area's agricultural production. Keisling says that:

> In the dark-fired tobacco area primary claim on labor is in the production of dark-fired tobacco. On many of these beef cattle farms dark-fired tobacco uses almost half of the total labor used in one year and brings approximately half the total income. When not needed the laborers may be available for the production of beef cattle. In fact, without the production of beef cattle or supplementary products this spare time of the workers would probably go unused and return nothing to total income.[10]

In 1966, Kenneth G. Keynes made a similar study in Campbell County, Tennessee. Emphasis was placed on determining the characteristics of farmers who were producing beef cattle. In the sample of cattlemen, 67 percent were full-time farmers, 28 percent were part-time farmers, and 5 percent were retired farmers. He found that more of the large-volume producers were full-time farmers than was true for small-volume producers.[11]

The large-volume producers' average age and educational level differed from the small-volume producers. They averaged 55 years old and 11 years of education while small-volume producers averaged 52 years of

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[10] Charles R. Keisling, "An Economic Analysis of Producing Beef Cattle in the Dark-Fired Tobacco Area of Tennessee" (unpublished Master's thesis, The University of Tennessee, Knoxville, June, 1958), pp. 20-21.

[11] Kenneth Gordon Keynes, "Production and Management Practices of Selected Beef Cattle Producers in Campbell County, Tennessee" (unpublished Master's thesis, The University of Tennessee, Knoxville, August, 1966), pp. 14-22.

age and nine years of education.[12] A test of significance was not calculated.

Also, the larger-volume producers had fewer total and cropland acreages than low producers. However, this observation is inconclusive because a median instead of a mean was used to differentiate between the two groups.

Thus, with the above mentioned qualifications, large-volume beef producers in Campbell County might be said to be older, more educated farmers with fewer total and crop acreages than small-volume producers.

Other studies such as those by Reutlinger and by Kohls and Paarlberg are useful in considering the handling of chosen variables in a study.

In Schlono Reutlinger's study on short-run beef supply response, he says:

> Assuming firms maximize profits in a competitive industry and assuming fixed technological conditions of production, . . . output is related to prices of the product, to the prices of products related in production, and to the cost of variable factors of production.[13]

Reutlinger uses lagged prices, justifying them on the basis that decisions are made prior to the marketing year, and lagged prices are a reasonable and frequently employed proxy for expected prices.

In a study by Kohls and Paarlberg, corn production was the most important factor in explaining the variation in cattle feeding operations.

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[12] Ibid., p. 21.

[13] Shlono Reutlinger, "Short Run Beef Supply Response," The Journal of Farm Economics, Vol. 48, No. 4 (November, 1966), pp. 909-919.

A large corn crop with consequent lower relative corn prices set off a chain of decisions which tended to increase the number of cattle put on feed. A 10 percent increase in corn production resulted in a 4.2 percent increase in cattle on feed. Two factors associated with 71 percent of the variability of numbers of cattle on feed were U. S. corn production and the margin between October and May good cattle prices. However, they concluded that, for all practical purposes, corn production could be used alone as a relative indicator of the number of cattle on feed the next year.[14]

III. OBJECTIVES OF THE STUDY

The objective of this study is to determine the extent to which secondary time series data can be used to explain the increase in beef cattle numbers in Tennessee.

Two secondary objectives are to determine if the data suggest that:

1. Dairy and sheep numbers are relevant variables in explaining beef cattle numbers in Tennessee.
2. The concept of opportunity cost along with the cost of hired labor is a relevant variable in analyzing beef cattle numbers in Tennessee.

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[14]R. L. Kohls and D. Paarlberg, The Short Time Response of Agricultural Production to Price and Other Factors, Purdue Agricultural Experiment Station, Bulletin No. 555 (Lafayette, Indiana: Purdue University, 1950).

IV. SUMMARY OF ANALYTICAL PROCEDURE

The analytical procedure in this study is multiple regression through the use of least squares. The method of least squares determines intercept and slope estimates so as to make Σe^2, the sum of the squared estimates of sample realizations of the error term, as small as possible. Given the SSE = $\sum_{j=1}^{n} (Y_j - a - bX_j)^2$ least squares attempts to minimize the sum with respect to the choice of a and b. A SSE can be formed from sample observations and an assumed relationship of any mathematical form.[15]

In multiple regression through the least-squares criterion, estimates of parameters are made of an assumed equation which postulates (1) the existence of two or more explanatory variables; and (2) that the parameters to be estimated are those of a linear form, interpretable as intercepts and partial derivatives.[16]

The purpose is to arrive at one or more estimating equations that will allow the objectives of the study to be fulfilled within the framework of sound economic and statistical analysis.

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[15]Edward J. Kane, Economic Statistics and Econometrics (New York: Harper and Row, 1968), p. 220.

[16]Ibid., p. 257.

CHAPTER II

THE THEORETICAL FRAMEWORK AND APPROPRIATE DATA

I. THEORETICAL RELATIONS

Changes in factor prices, opportunity cost, and possibly number of sellers in the market have been observed in cattle production. Demand for beef cattle over time has certainly increased. Numbers of consumers, incomes, prices of related goods, and range of goods available to consumers have changed over the time period (1925-1965) covered by this study. Both a shift in demand and quantity demanded through shifts in the supply function of Tennessee beef cattle have resulted in a condition of increasing prices and increasing supply. Any one or all of these considerations could cause the January 1 inventory numbers of Tennessee beef cattle to increase.

However, beef numbers on farms in Tennessee cannot be explained in full by the general conditions depicted above. Other factors must be responsible for shifts from income intensive enterprises to non-income intensive enterprises such as beef cattle.

One explanation may be in cost associated with farming operations in Tennessee. The costs of production incurred by a firm frequently are thought to consist of the money outlays that the firm must make for resources used to produce its product. However, actual expenditures or expenses of the firm constitute only a part of the cost picture. The opportunity costs are also important.

The cost of production of a particular product is the value of the foregone alternative products that could have been produced with the resources utilized. The cost of resources such as land and labor to a firm are their values in their best alternative use. This value is called opportunity cost.[17]

Since supplies of economic resources in the economy are limited in relation to human wants, resources used by a firm in the production of a product can be obtained only at the expense of other products utilizing the particular resource. Labor, among other factors, is an essential input in farm production. Changes in costs involved with hiring labor may be important in explaining the increased adoption of beef cattle enterprises on Tennessee farms.

The labor cost in producing farm products, as an average, varies from about 9 percent of the total cost in the production of beef cattle to a little over 50 percent for burley tobacco.[18] The lower labor intensity of beef production may be important in explaining the apparent shifts from high to low income intensive enterprises in Tennessee noted by Mitchell.[19]

In association with the above, returns to labor in non-farm endeavors may help explain changing opportunity costs. Assuming farmers

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[17] Richard H. Leftwich, The Price System and Resource Allocation (New York: Holt, Rinehart and Winston, 1966), p. 29.

[18] W. P. Ranney, Labor Requirements on Tennessee Farms, The University of Tennessee Agricultural Experiment Station, Bulletin No. 311 (Knoxville: The University of Tennessee, September, 1960), p. 5.

[19] Mitchell, *loc. cit.*

act in decision-making toward maximizing net income, beef cattle enterprises may have become more important in accomplishing this goal. If opportunity cost conditions dictate that labor is more valuable when sold to industry than applied to farm production, given the Tennessee farmers' relative position of advantage in soil conditions, factor prices, and product prices, then farmers should tend to shift away from labor intensive enterprises toward less time-consuming ones. Some 1964 data from the Elk River Watershed Area of Tennessee have shown that the number of months farm operators worked off the farm was considerably higher for beef and beef-hog operations than for dairy and dairy-hog operations. Those operators with feeder cattle enterprises worked as much as 10.7 months on the average off the farm.[20]

In addition to low labor requirements, the possibility exists that, with a given farm size, land formerly idle can be utilized by beef cattle if adjoining land is shifted into hay and pasture production. Annual data on crop, pasture, and hay production should give evidence of this if it has occurred in Tennessee.

Thus, conditions of labor cost, opportunity cost, and idle land utilization may combine to make beef cow-calf operations more profitable as an increment to total income than applying resources to the production of other enterprises. This would not be applicable to large commercial operations where size and output result in crops remaining profitable

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[20] W. P. Ranney, Livestock Numbers and Practices on Farms in the Elk River Watershed Area of Tennessee, 1964, The University of Tennessee Agricultural Experiment Station, Bulletin No. 406 (Knoxville: The University of Tennessee, July, 1966), p. 61.

even though costs have risen and product prices have decreased or remained relatively unchanged.

II. THE DATA

Definition of Terms

This study is primarily concerned with explaining a supply relation of Tennessee beef cattle. In estimating supply equations, the quantity coming forth in the market is usually the appropriate variable to use as the dependent variable in estimating equations.

In the case of beef cattle production in Tennessee, calves are the primary product marketed. This comes as a result of most beef cattle enterprises in Tennessee being cow-calf operations. In 1965, cow-calf systems accounted for over 90 percent of the beef cattle enterprises in the state.[21] This would support the use of calf marketings in pounds or head as the dependent variable. However, it would be necessary to separate the cattle and calves marketed in Tennessee from neighboring states from the value of the dependent variable each year.

A simpler method is to use the January 1 inventory numbers of beef cattle in Tennessee as the dependent variable in the regression equations. This is clearly a proxy variable for quantities supplied, but it provides a good measure of the prevalence of beef cattle enterprises in the state and thus, an indication of the quantities supplied given assumed calving and replacement rates. When the number of beef cattle increases, the inventory value each year will reflect the adoption or intensification

[21] Keynes, op. cit., p. 2.

of beef cattle production in the state. Identifying this change is the objective of this study.

In addition, since calves are the primary product of beef cattle enterprises in Tennessee, the January 1 inventory of beef cattle each year gives an indication of the amount of calves and cull cows coming forth in a given year, assuming given calving, culling, and replacement rates.

Beef cattle numbers, as used in this study, are all cattle not considered to be dairy animals. The Tennessee Crop Reporting Service divides cattle into two categories--dairy and others. The "others" number each year is used as the dependent variable and is, in this study, synonymous with beef cattle numbers.

Dependence and independence are used to describe variables used in the analysis. The dependent variable, or Y, observation is a January 1 inventory number of beef cattle in Tennessee. Independent variables are those exogenous variables which are thought to have a particular relationship with Y such that the value of the dependent variable can be expressed in terms of the set of exogenous variables.

An estimation model is an equation of some mathematical form which is made up of a dependent and one or more independent variables and is useful in estimating values of the dependent variable.

An independent variable observation, in this study, is the value of the variable in year t, where t = 1925, ..., 1965, expressed as an average of some past number of lagged annual observations such as $X_t = (X_{t-1} + X_{t-2} + X_{t-3})/3$.

Linearity refers to the mathematical form of an equation. An equation is linear in the parameters under ordinary least squares, but it may not be linear in the variables. When a linear equation is transformed such that one or more independent variables are changed, such as in the construction of ratios, the equation is no longer linear in the variables, but it is still linear in the parameters. Interpretation of the parameter is unchanged but the influence of the independent variable is different. All the equations in this study will be linear in the parameters, but some may not be linear in the variables.

The Variables

In attempting to construct estimating equations for estimating the January 1 inventory number of beef cattle in Tennessee, the paper by Leuthold and the study by Reutlinger are used to select some of the variables and transform others into new variables.

From Reutlinger's study, three components are used for choosing variables. They are: prices of product, prices of products related in production, and costs of variable factors of production. Calf prices, cattle prices, and the cost of labor are the three primary variables chosen on this basis. This limits the analysis by excluding other costs such as land costs, cost of capital, and other variable factors of production but the limitation is necessary. Using only one variable factor of production, labor, the hypothesis that labor costs are important in explaining the increased adoption of beef enterprises can be tested. An Index of Farm Wage Rates Paid by Tennessee farmers that is calculated by the United States Department of Agriculture will be used as the variable.

Also, the opportunity costs of raising beef cattle may be indirectly approached by using the product prices of competing enterprises as independent variables. The response of January 1 inventory numbers to changes in the prices of competing products will reflect changing opportunity costs faced by decision makers.

Also, the quantities of competing enterprises will be used to see if a relation exists between increasing beef cattle numbers and declining numbers of other enterprises as suggested by Leuthold. Secondary data on sheep and dairy numbers, land use acreages, and age and educational levels of farm operators should provide variables that will allow comment on points 2, 3, 4, and 5 of Leuthold's suggestions.

Data were taken from two statistical bulletins published by the Tennessee Department of Agriculture and the U. S. Department of Agriculture through the Tennessee Crop Reporting Services. The bulletins are: Agricultural Trends in Tennessee: Crop and Livestock Statistics, 1866-1960 and Tennessee Agricultural Statistics Annual Bulletin 1968.

The data collected are annual observations covering the time period 1925-1965. With only a few exceptions, which will be considered later, the recorded value of each selected independent variable is a lagged observation which is an average of the past three years. For example, the Y_{1925} value of the January 1 inventory number of beef cattle in Tennessee is a function of

$$\frac{X_{i_{1924}} + X_{i_{1923}} + X_{i_{1924}}}{3}$$

for each appropriate independent variable X_i.

The basis for lagging the explanatory variables is the assumption that January 1 inventory numbers are a result of past decisions, by farmers, on the expected market conditions for beef cattle. An average of past conditions and trends is accepted as a proxy variable for past expectations about current market conditions.

A limiting factor in the design of this study is the availability of annual data. Desired information on annual land use in Tennessee, non-farm wage rates, age and educational levels of farm operators, and general indexes of prices paid and prices received by Tennessee farmers is not available for every year of the 1925-1965 time period. The Census of Agriculture provides four-year observations on some of these variables, but often observations are unavailable or do not cover a sufficiently long period of time.

The price data, in addition to being a lagged average, are constructed as ratio variables in some models. Three variables are used to construct the ratios. They are: (1) a moving three-year average of calf prices $[(t-1 + t-2 + t-3)/3]$, (2) a moving three-year average of cow prices, and (3) an index of farm wage rates paid by farmers in Tennessee.

The ratios allowed the price data to be considered in relative terms since prices of cattle, calves, and labor can be expected to change as the general price level changes. The resulting value of the ratio becomes important if one price changes more over time relative to the other's change since a constant ratio value between the prices will exist with respect to price level changes over time.

By using an index of farm wage rates to construct product price-index ratios, a comparison can be made between movements of the prices of various farm products and farm labor cost. Changes in the ratio will evidence changes in returns relative to changes in cost, considering only one factor of production.

When increases occur in the index, enterprises utilizing labor become more or less profitable depending on the movement and the amount of the input required in each enterprise. Ceteris paribus, an increase in the index value causes enterprises with low labor requirements to decrease less in profitability than labor intensive enterprises.

The index of farm wage rates, the average price of cattle, and the average price of calves are all useful as explanatory variables.

In order for resources to be shifted from one production process or industry to another, the one demanding additional resources must be willing to pay an amount that is greater, in real terms, than the particular resources are earning at their present employment. Evidence of a bidding away of farm labor can be seen through the index of farm wage rates.

Ceteris paribus, increases in the index value may represent pressures from a bidding away of labor. Here the assumption is that Tennessee agricultural product prices usually follow the general price level, even though a time lag may be involved, and thus, may be used as an indication of the general price level movements. However, such a strict interpretation is not totally reliable. Minimum wage laws and other institutional constraints are partially responsible for changes in the index of farm wage rates. But institutional constraints cannot explain all the index increases because the availability of farm labor has decreased over the years as the average cost of farm labor at the farm level has increased.

Changes in the index of farm wage rates may come from at least two interrelated sources. One is an increase in labor costs due to changes in input quality resulting from higher educational levels and job training programs and higher labor productivity resulting from increases in technology. The other is a bidding away of labor, even managerial labor, from farm production to non-farm production. Both sources can cause the labor supplied at the farm level to decline and thus, cause the index of farm wage rates to increase.

Evidence of this is the rapid rise of non-commercial farms classified as part-time and residential types whose incomes compare very favorably with the large commercial types. Thus, beef cattle, requiring smaller amounts of labor, may be the alternative to leaving farm property idle.

An additional independent variable that will be used is a 0-1 type dummy variable. This will allow a separation of periods in the study that are suspected of being significantly different from the entire period under study. Examples are the World War II years and the ten-year period 1955-1965.

Estimated Relations

With the three categories of independent variables discussed above--product outputs, product prices, an index of farm wage rates, and a 0-1 variable--a general model can be written algebraically as:

$$Y_t = a + \sum_{i=I}^{I} b_i X_i + \sum_{j=I}^{J} b_j X_j + \sum_{k=I}^{K} b_k X_k$$

where:

Y_t = a January 1 inventory number of beef cattle in year t in 1,000's of head

a = an intercept or constant term.

X_i = a lagged three-year average product price variable i which may or may not, depending on the specific model, be transformed into a ratio by the use of one of three variables W_i; i.e.,

$$\frac{(X_{i_{t-1}} + X_{i_{t-2}} + X_{i_{t-3}})/3}{W_i}$$

where:

W_i = (1) a moving three-year average of lagged cattle prices

(2) a moving three-year average of lagged calf prices

(3) an index of farm wage rates in t-1

b_i = regression coefficient for variable X_i, i=1, ..., I

X_j = a lagged three-year average non-price variable j

b_j = regression coefficient for variable X_j, j=1, .. , J

X_k = all other variables not of X_i or X_j nature; i.e., 0-1 and index farm wage rates as independent variables

b_k = regression coefficient for variable X_k, k=1, ..., K

The Y observation in year t is assumed to be a linear function of the selected independent variables which in most cases are lagged and averaged for three years.

Supply of a product is usually defined as the quantities of a product coming forth at all given prices in a given market at a given time holding constant (1) technology of production, (2) factor prices, (3) opportunity costs, and (4) number of sellers in the market.

In attempting to construct a supply equation with the above model, the data limitations result in a constrained model that mostly considers only opportunity costs associated with the production of beef cattle in Tennessee. However, the variables included are adequate considering the study objectives, even though the usefulness of the model will depend on the extent to which other relevant excluded variables change, their effect on January 1 inventory numbers of beef cattle, and whether or not included variables show the effects by proxy of these excluded variables.

In the statistical models calculated, variables X_i will be numbered from 1 through 10, variables X_j - 11 through 20, and variables X_k will be numbered 21 through 25. The number designation of each variable will be consistent in each of the calculated models even though some will be transformed by the use of the above W_i variables in constructing ratios.

Expected Signs on Independent Variables

Each statistical model describes the empirical relationship between the dependent variable Y and a selected set of independent variables. As noted earlier, the data limitations disallow the use of some variables considered important, but the remaining variables are adequate to meet the objectives of this study.

The variables, with the exception of the index of farm wage rates and 0-1 variables, are primarily competitive enterprises and the observed annual average prices received for these products. The expected sign on competitive enterprises such as cotton, corn, tobacco, and sheep and dairy numbers is negative. Ceteris paribus, increases in competing enterprises or their product prices should have associated decreases in the January 1 inventory number of beef cattle in year t.

Calves are considered to be the primary product from beef cattle production in Tennessee. Since calf numbers are included in the Y observation each year, only the average of lagged calf prices will be used as an explanatory variable. Ceteris paribus, an increase in the three-year average of lagged calf prices should show positive changes in Y_t. Thus, the expected sign on a simple average of lagged calf prices, when used as a variable, should be positive.

The sign attached to cattle prices should be the same as calf prices--an increase bringing about an increase in beef cattle inventory numbers.

Hog numbers and hog prices are used as independent variables in this study to identify, if possible, the relationship between hog and beef cattle enterprises in Tennessee.

In a study of livestock numbers in the Elk River Watershed Area of Tennessee, which includes seven counties of Southern Middle Tennessee, many farms had a combination of livestock enterprises (i.e., beef-hog operations, dairy-hog operations, dairy-beef-hog operations). Hogs were included in most of the livestock combinations.[22]

Although it can be argued that, in a strict sense, the hog enterprise is competitive with beef cattle, it will not be assumed as so in this study for two reasons. First, only small amounts of land are required for hogs, and the labor and capital requirements are not great for certain small scale hog enterprises. Second, in the case where other livestock enterprises have declined, as noted with dairy and sheep, the possibility exists that buildings and equipment can be utilized in hog production without competing with a beef cattle enterprise.

The size of the b coefficient on hog numbers, along with the sign attached, will provide support for accepting or rejecting a hypothesis that hog and beef enterprises are (1) not competitive with respect to land and buildings, and (2) possibly complementary with respect to labor. The expected sign attached to hogs in such a situation would be positive.

It is realized that even with a positive sign attached to the hog numbers variable, no conclusion can be drawn about the actual existence of such a relationship.

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[22]Ranney, Livestock Numbers and Practices on Farms in the Elk River Watershed Area of Tennessee, 1964, p. 61.

CHAPTER III

THE REGRESSION MODELS

I. INTRODUCTION

Four models are formulated initially in attempting to estimate Y_t. Models 1, 2, 3, and 4 use variables taken from the same data matrix for calculating the estimated inventory numbers of beef cattle. Each model takes the form presented in Chapter II.

Interpreting b_i

For simplification the discussion of the b coefficients will be in terms of b_i and X_i. The interpretation also applies to b_j, b_k, X_j, and X_k.

Each b_i has the dimensions of Y over X_i. Each represents the least squares estimate of $[\partial E(Y|X_1, \ldots, X_k)/\partial X_i]$, the partial derivative of the conditional expectation of Y with respect to changes in the level of X.[23] Thus, the b_i enables converting the ceteris paribus changes in each of the explanatory variables into an expected change in the dependent variable. Whenever the i^{th} explanatory variable undergoes some change, the prediction $Y = b_i \Delta X_i$ is made.[24]

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[23]Kane, op. cit., p. 264.

[24]Ibid.

Interpreting Calculated Statistics

R^2, the coefficient of multiple determination, measures the percent of variation in Y that can be explained by the X variables included in the equation.

For specific physical problems, R^2 may be the most important test of a model's goodness of fit. However, the estimation implications of goodness of fit are translated most readily by Se, the standard error of estimate. Ceteris paribus, the smaller the standard error of estimate, the more desirable the model becomes for estimation purposes.[25]

The standard error of estimate shows how closely values of the dependent variable can be estimated from the values of the independent variables.[26]

The R^2 affirms a high analytic validity of a model, but the Se evaluates its estimating value. Thus, for estimating numbers of beef animals on farms in Tennessee, the Se becomes more important than the amount of variation in Y a particular model explains.

The F-ratio is a calculation obtained from the anlaysis of variance table which separates out the amount of variation in Y explained by regression and that left as a residual. The ratio of the greater mean square (regression) to the smaller mean square (residual) is a convenient test statistic for testing the significance of the entire regression model. It is a test to determine whether the estimating

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[25] Ibid., p. 270.

[26] Mordecai Ezekiel and Karl A. Fox, Methods of Correlation and Regression Analysis (New York: John Wiley and Sons, 1959), p. 123.

power of the model is significantly different from that which could be obtained from chance or random estimation. The larger the F-ratio value, the more likely the model is significant.

The b_i regression coefficients show the incremental change in Y for each incremental change in X_i. The standard error of the coefficient is useful in testing for the significance of each b_i. A t-test is used to determine the level at which each b_i is significant. The t-test is defined as:

$$\frac{B - B_o}{S_B} = t_c.$$ [27]

If the population parameter B_o is equal to zero or is set equal to zero for computational purposes, the calculated t_c can be compared to the table t_t value, and the null hypothesis that B is not significantly different from zero can be tested. If $t_c > t_t$ then B can be said to be significantly different from zero at a given level of significance.[28]

Significance at a certain level refers to the probability of getting the b_i value from chance when the true population B_i is equal to zero. At the .01 level there is less than 1 chance in 100 that the actual difference between $B_i = 0$ and b_i might have arisen due to chance.[29]

When multicollinearity is present in the model variables, the significance test of the b_i's may be misleading. The problem arises due to an inability to reject the hypothesis that $b_i = 0$. The b_i coefficients

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[27] Ibid., p. 281.

[28] Ibid., p. 282.

[29] Kane, op. cit., p. 210.

have overestimated standard errors which may cause the significance test to support the hypothesis that the particular b_i is not significantly different from zero. This problem arises whenever, either in the population or in the sample, various explanatory variables stand in an exact or almost exact linear relation to each other.[30]

The results of multicollinearity are parameter estimates that are (1) sensitive to changes in the precise model specification and the precise data set being employed, and (2) possessed of inordinately high standard errors.[31]

II. THE STATISTICAL MODELS

Model 1 uses only averaged and lagged data that are taken from the original data matrix. Model 2 is the same as 1 except all price data averages are transformed into ratios by using a moving three-year average of calf prices. Model 3 is the same as Model 2 except a moving three-year average of cattle prices is used in constructing ratios. And, Model 4 is likewise the same except an index of farm wage rates for Tennessee is used to make the ratios. The Y_t in each model is a January 1 inventory of beef cattle numbers in Tennessee.

In all four models, all of the variables in the Appendix, Table 3, are included in the regressions. However, the models vary with respect to specific variables and the number of variables included.

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[30] Ibid., pp. 277-278.

[31] Ibid., p. 278.

The variation comes from two sources. First, certain of the independent variables are highly correlated. When the step-wise regression program is used, the variables are entered in the order of their contribution to R^2. By using the W_i variables to construct price ratios, the correlations between some of the variables change. The contribution to R^2 from each variable changes slightly thus causing certain variables to add more or less to R^2 than in other models. The magnitude of the changes is small, but a different combination of explanatory variables may enter the regression equation. Secondly, the number of variables included in each model differs because the standard error of estimate is the primary criterion for choosing each model. The regression step with the smallest standard error of estimate is selected as the estimating equation for each model. This results in four models that vary with respect to the number of variables included.

After selecting the four primary models by the above procedure, the models will be improved by (1) reducing multicollinearity in the equation's data matrix by excluding certain of the highly correlated variables, and (2) constructing additional models that include different subsets of these highly correlated variables. The criteria for selecting the improved models from this group of models will be the economic rationality of the variables, the degree of multicollinearity present in the model, and the presence of a relatively low standard error of the estimate.

Model 1

Model 1 for estimating Y_t is:

$$Y_t = 874.02 - 368.76X_1 - 101.33X_6 + 1.75X_8 + .00052X_{12} - 1.13X_{14}$$
$$ {}^{a}(64.042)^{**}\ (35.953)^{**}(5.425)\ (.05765)\ (.1745)^{**}$$

$$+ .2366X_{15} + 2.67X_{21}$$
$$(.0820)^{**}\quad (.2931)^{*}$$

[a]The figure in parentheses below each b_i is the standard error of the coefficient where:

* = significant at the .05 level

** = significant at the .01 level

$R^2 = .9930$

Se = 30.47

F = 662.8**

where:

X_1 = a three-year average of lagged wheat prices (annual average price in dollars/bushel)

X_6 = a three-year average of lagged wholesale milk prices (annual average prices in dollars/cwt.)

X_8 = a three-year average of lagged hog prices (annual average prices in dollars/cwt.)

X_{12} = a three-year average of lagged corn acreage harvested (annual in 1000's acres)

X_{14} = a three-year average of lagged sheep and lamb numbers (annual in 1000's of head)

X_{15} = a one-year lagged summation of dairy cattle numbers (cows + heifers + calves, 1000's head)

X_{21} = an index of farm wage rates calculated by Tennessee Crop Reporting Service for year t-1

Variables X_1 (wheat price), X_6 (milk prices), X_{12} (corn acreage), X_{14} (sheep and lamb numbers), and X_{15} (dairy cattle numbers) are all competitive enterprises with beef cattle production in Tennessee. According to the discussion in Chapter II, the expected sign on these variables is negative. In Model 1, the b coefficient signs on X_{12} and X_{15} do not conform to this expected result. X_{12} is not significant but X_{15} (dairy numbers) is significant at the .01 level. The positive signs are statistical relationships that are not acceptable on economic grounds. In the case of dairy animals, the coefficient b_{15} says that a one unit (1000 head) increase in dairy cattle numbers over the averaged three-year period will have an associated 237 head increase in Y_t. In reality trends of decreasing numbers have been noted as beef cattle numbers have increased.[32] Also, the two enterprises (beef and dairy) compete for land, labor, and capital indicating that they should be negatively correlated.

The sign on variable X_8 (hog prices) is positive. This lends support to the earlier supposition that, in general, hog and beef cattle enterprises are not competitive on Tennessee farms. If increases in hog numbers are positively correlated to Y_t, then it follows that a positive correlation would exist between Y_t and hog prices. However, the b_8 coefficient is not significant.

X_{21} has a positive sign which is consistent with earlier expectations. The b_{21} coefficient is significant at the .05 level and indicates

[32] Boone and Lard, loc. cit.

that a one unit increase in the index of farm wage rates (1) has an associated increase in Y_t of about 2,600 head.

Model 1 has an R^2 of .9930 and an F-ratio of 662.8 indicating that the model explains 99.3 percent of the variation in observed Y using the above variables, and it is significant at the .01 level.

Model 2

The second model uses a price data-calf price ratio instead of the simple average used in Model 1. The ratios are constructed by using a moving three-year average of lagged calf prices as the denominator. The numerator and other particular non-price variables are averaged lagged variables of the same form found in Model 1.

Model 2 for estimating Y is:

$$Y = \underset{}{486.07} - \underset{(680.24)}{188.47X_1} - \underset{(585.610)^{**}}{3095.10X_3} - \underset{(6.1448)^{**}}{20.68X_4} + \underset{(156.38)}{222.81X_7} + \underset{(36.91)^{**}}{228.20X_{10}}$$

$$- \underset{(.144)}{.37X_{11}} - \underset{(.0995)}{.1389X_{12}} - \underset{(.239)^{**}}{2.76X_{13}} - \underset{(.2793)}{.2858X_{14}} + \underset{(.1732)^{**}}{.9593X_{15}} + \underset{(.4585)^{**}}{1.81X_{21}}$$

$$- \underset{(30.76)}{74.76X_{22}}$$

R^2 = .9940

Se = 30.68

F = 381.60

where:

W_1 = price data weight = a moving three-year average of lagged calf prices in dollars/cwt.

X_1 = a three-year average of lagged wheat prices (annual in 1000's acres)

X_3 = [a three-year average of lagged corn prices (annual average in dollars/bushel)]/W_1

X_4 = a three-year average of lagged cattle prices (annual average dollars/cwt.)

X_7 = [a three-year average of lagged sheep prices (annual average dollars/cwt.)]/W_1

X_{10} = [a three-year average of lagged hay prices (annual average dollars/ton)]/W_1

X_{11} = a three-year average of lagged cotton acreage harvested (annual in 1000's acres)

X_{12} = a three-year average of lagged corn acreage harvested (annual in 1000's acres)

X_{13} = a three-year average of lagged oat acreage harvested (annual in 1000's acres)

X_{14} = a three-year average of lagged sheep and lamb numbers (annual in 1000's head)

X_{15} = a summation of dairy cattle numbers lagged one year (cows + heifers + calves, 1000's head)

X_{21} = an index of farm wage rates calculated by Tennessee Crop Reporting Service for year t-1

X_{22} = 0-1 variable (1941-47 = 1, 1925-40 = 0, 1948-65 = 0)

All variables in Model 2 have the expected signs on the b coefficients except X_4 (cattle prices), X_7 (sheep price-calf price ratio), X_{10} (hay price-calf price ratio), X_{15} (dairy cattle numbers), and X_{22} (0-1 variable).

When cattle prices (X_4) increase, it is expected that January 1 inventory numbers in year t should increase. The negative sign indicates the opposite and therefore, is not acceptable on economic grounds.

A positive sign on X_7 and X_{10} indicates that when sheep prices and hay prices increase relative to calf prices during the lagged years an increase in the January 1 inventory numbers of beef cattle in year t should occur. This also is unacceptable economically, for it is expected that increases in sheep prices, and to a lesser extent hay prices, would induce reductions in beef cattle numbers.

X_{15} (dairy cow numbers) has a positive sign on b_{15} implying that increases in dairy numbers result in increasing beef cattle numbers. Since the two enterprises are considered to be competitive in nature, this is not the net relationship expected on the basis of economic rationality.

The negative b_{22} coefficient on the 0-1 variable indicates that the period 1941-47 had lower beef cattle numbers than the trend for the period 1925-65. This is opposite to earlier suspicions.

Model 1 can explain 99.40 percent of the observed variation in Y using the above variables, and it is significant at the .01 level.

Model 3

The third model differs from Models 1 and 2. A moving three-year average of lagged cattle prices is used to construct price ratios with selected price data variables. Model 3 for estimating the January 1 inventory of beef cattle numbers is:

$$Y = 234.52 + 1941.20X_2 - 3132.40X_3 - 21.49X_4 + 19.33X_9 + 129.15X_{10}$$

(1745.70) (786.38)** (5.91)** (17.42) (42.71)**

$$- .1132X_{11} - .1204X_{12} - 2.68X_{13} + .8412X_{15} + 2.09X_{21} - 44.37X_{22}$$

(.1073) (.1054) (.2312)**(.1348)** (.4528)**(26.61)

$R^2 = .9932$

$Se = 32.07$

$F = 380.7$

where:

W_2 = a moving three-year average of lagged cattle prices (annual average in dollars/cwt.)

X_2 = [a three-year average of lagged oat prices (annual average in dollars/bushel)]/W_2

X_3 = [a three-year average of lagged corn prices (annual average in dollars/bushel)]/W_2

X_4 = a three-year average of lagged cattle prices (annual average in dollars/cwt.)

X_9 = [a three-year average of lagged lint cotton prices (annual average in dollars/cwt.)]/W_2

X_{10} = [a three-year average of lagged hay prices (annual average in dollars/cwt.)]/W_2

X_{11} = a three-year average of cotton acreage harvested (annual in 1000's acres)

X_{12} = a three-year average of corn acreage harvested (annual in 1000's acres)

X_{13} = a three-year average of oat acreage harvested (annual in 1000's acres)

X_{15} = a summation of dairy cattle lagged 1 year (cows + heifers + calves, 1000's head)

X_{21} = an index of farm wage rates calculated by Tennessee Crop Reporting Service for year t-1

X_{22} = 0-1 variable (1941-47 = 1, 1925-40 = 0, 1948-65 = 0)

The signs associated with the various independent avriables are logically consistent on all but X_2 (oat price-cattle price ratio), X_4 (cattle prices), X_9 (cotton price-cattle price ratio), X_{10} (hay price-cattle price ratio), X_{15} (dairy cattle numbers), and X_{22} (0-1 variable).

Variables X_2, X_9, and X_{10} are surprising in the sense that they imply that greater increases in lagged competing-product prices relative to the lagged prices of cattle would result in increasing January 1 inventory numbers in year t. This is inconsistent with expected reactions.

In the case of lagged cattle prices, X_4, the negative b_4 coefficient says that Y_t will decrease when the lagged cattle prices increase. Increases in cattle prices are expected to cause beef cattle numbers to increase, assuming the amount of time is sufficient for adjustment.

Model 4

Model 4 uses an index of farm wage rates in Tennessee to construct price ratios with the price data. The index is calculated and published by the Tennessee Crop Reporting Service. Model 4 is:

$$\begin{aligned} Y = 1462.1 &- \underset{(8930.2)^{**}}{71599X_3} - \underset{(685.38)^{**}}{6044.40X_5} + \underset{(728.36)^{**}}{4600.90X_{10}} - \underset{(.10304)^{**}}{.3238X_{11}} - \underset{(.0514)^{**}}{.1941X_{12}} \\ &- \underset{(.16692)^{**}}{2.39X_{13}} - \underset{(.23481)^{**}}{.6786X_{14}} + \underset{(.0867)^{**}}{.6423X_{15}} + \underset{(.21151)^{**}}{.5872X_{21}} - \underset{(19.10)^{**}}{45.16X_{22}} \end{aligned}$$

$R^2 = .9950$

$Se = 27.04$

$F = 589.9$

where:

W_3 = an index of farm wage rates calculated by the Tennessee Crop Reporting Service for year t-1

X_3 = [a three-year average of lagged corn prices (annual average in 1000's acres)]/W_3

X_5 = [a three-year average of lagged calf prices (annual average in dollars/cwt.)]/W_3

X_{10} = [a three-year average of lagged hay prices (annual average in dollars/ton)]/W_3

X_{11} = a three-year average of lagged cotton acreage harvested (annual in 1000's acres)

X_{12} = a three-year average of lagged corn acreage harvested (annual in 1000's acres)

X_{13} = a three-year average of lagged oat acreage harvested (annual in 1000's acres)

X_{14} = a three-year average of lagged sheep and lamb numbers (annual in 1000's head)

X_{15} = a summation of dairy cattle lagged 1 year (cattle + heifers + calves 1000's head)

X_{21} = an index of farm wage rates in Tennessee for year t-1

X_{22} = 0-1 variable (1941-47 = 1, 1925-41 = 0, 1948-65 = 0)

All the variables in Model 4 have the correct signs on the b coefficients except X_{15} (dairy cattle numbers) and X_{22} (0-1 variable). They are incorrect for the same reasons given under earlier models.

The statistical characteristics of Model 4 are noteworthy. The model explains 99.5 percent of the observed variation in Y and is significant at the .01 level of significance. The standard error of the estimate is 27.04 which is lower than the three earlier models.

Also, the b coefficients are all significant at the .01 level of significance even though there is multicollinearity in Model 4. However, the use of the index of farm wage rates reduced the amount of multicollinearity found in Models 1, 2, and 3.

Summary of Models 1-4

Table 1 is a summary of the statistics calculated for the four models. The models are compared with the ultimate purpose in mind of selecting one model for constructing an estimating equation useful for estimating January 1 inventory numbers of beef cattle in Tennessee.

All four models explain more than 99 percent of the variation in observed Y. Any of the models would be sufficient as an estimating equation from the standpoint of variation in Y explained. All are significant at the .01 level.

Since the standard error of the estimate is more important for predictive purposes than R^2,[33] the model chosen should have an acceptable standard error. In Table 1, Models 1 and 4 have lower standard errors than Models 2 and 3.

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[33]Kane, *op. cit.*, p. 270.

TABLE 1

A STATISTICAL SUMMARY OF THE FOUR PRIMARY MODELS

Model	R^2	Se	F-Ratio
Model 1	.9934	30.47	662.8**
Model 2	.9940	30.68	381.6**
Model 3	.9932	32.07	380.7**
Model 4	.9950	27.05	589.9**

**Significant at the .01 level of significance.

Models 1 and 4 are selected from the four as potential estimating equations because of the lower standard errors of estimate and the desirable economic logic of the relationships shown.

On the basis of economic significance, Model 4 appears to be more desirable than Model 1. In the decision-making process, the feasibility of a particular enterprise in a farm operation should be related, among other things, to the income obtained from the output of the enterprise. Important to the profitability of an enterprise is the price received for the output (since inputs are not free) in the market. Thus, it is expected that the price of calves, and to a smaller extent the price of cattle, should be important in explaining the variation in beef inventory numbers in Tennessee. Model 4 includes a lagged three-year average of calf price-index of farm wage rates ratio as an explanatory variable. Model 1 has neither calf prices nor cow prices included.

Also, most of the variables in Model 4 have the correct signs attached to the b coefficients, and all are significant at the .01 level of significance.

In addition, multicollinearity is lower in Model 4 than in the other three models. This can be attributed to the use of the index of farm wage rates in constructing ratios.

III. IMPROVED MODELS

In the preceding section, four models were calculated in an attempt to identify some relationships that are associated with beef cattle production in Tennessee. The purpose of this section is to improve the models by reducing multicollinearity in the equation matrix of Models 1 and 4.

As mentioned earlier, certain variables in these models that have high correlations are removed and entered in separate models to obtain estimating equations that have variables with lower correlations. The models that have acceptable R^2's and Se's along with economic rationality are then selected. Models 5, 6, and 7 are obtained by this procedure.

Also, after the analysis began, the Tennessee Crop Reporting Service issued revised estimates on the time series data used in the four models for the years 1960-65. The revised data gave the opportunity to check the sensitivity of the b coefficients and independent variables' relationship to Y_t in the four models. Recalculation of some of the models using corrected data showed very little change. This was expected since the corrections were small in magnitude and affected only six years of the 41-year time period. However, the corrections were carried through in the data matrix of each of the following improved models.

Model 5

Model 5 is a model formed from variables in Model 4 that are considered relevant in explaining January 1 inventory numbers of beef cattle but have lower independent variable cross-correlation in the equation's data matrix. Model 5 for estimating Y_t is:

$$\underset{}{y = 2251.4} - \underset{(16424)^{**}}{163740X_3} - \underset{(1625.3)}{3163.30X_5} - \underset{(.13384)^{**}}{.5385X_{11}} - \underset{(.32087)^{**}}{1.8424X_{13}} - \underset{(46.414)^{*}}{96.6790X_{22}}$$

R^2 = .9295

Se = 99.10

F = 92.29

where:

W_3 = an index of farm wage rates calculated by the Tennessee Crop Reporting Service for year t-1

X_3 = [a three-year average of lagged corn prices (annual average in dollars/bushel)]/W_3

X_5 = [a three-year average of lagged calf prices (annual average in dollars/cwt.)]/W_3

X_{11} = a three-year average of lagged cotton acreage harvested (1000's acres)

X_{13} = a three-year average of lagged oat acreage harvested (1000's acres)

X_{22} = 0-1 variable (1941-47 = 1, 1925-40 = 0, 1948-65 = 0)

In Model 5 the estimated January 1 inventory numbers of beef cattle in Tennessee is a function of the corn price-index farm wage rates ratio, the calf price-index farm wage rates ratio, cotton acreage harvested, oat acreage harvested, and a disturbance period variable.

The model is significant at the .01 level and explains 92.95 percent of the observed variation in Y over the 1925-65 period.

The standard error of estimate is 99.10 indicating that, within the time period and over the range of the observed data, the expected error in estimating Y from equation 5 is $\pm$ 99,100 head.

The sign on the corn price-index farm wage rates ratio (X_3) indicates that, when the three year average of lagged prices increases relatively more than the index of farm wage rates, beef cattle inventory numbers in year t should decrease. This is the expected relationship between these variables. When the ratio average value increases by one-thousandth of a unit (.001) over the three-year period, there will be an associated 163,740 head decline in Y_t.

The size of b_3 shows a sensitive relationship between corn prices, farm wage rates, and inventory numbers of beef cattle. With a given index of farm wage rates value, corn prices would have to double before the value increases by .001. Since corn prices have not fluctuated that greatly over a three-year period in the past, future changes in the ratio value can be expected to be very small. However, these small increases result in sizable declines in Y_t, according to Model 5. This shows the strong competitive relationship existing between beef cattle and corn enterprises in Tennessee.

Assuming corn prices remain unchanged and the index of farm wage rates increases, or if the latter increases more relative to the former, then the inventory numbers of beef cattle in year t will show substantial increases for small declines in the ratio value. This supports the earlier hypothesis that as labor costs rise relative to product prices received, ceteris paribus shifts should occur from labor intensive enterprises to less time consuming ones such as beef cattle.

The sign on the three year average of lagged calf prices-index farm wage rates ratio (X_5) is also negative. This implies that when calf prices increase relative to labor costs, beef cattle inventory numbers should decline in year t. This is not the expected relationship between these variables. However, when the index of farm wage rates increases more relative to calf prices, Y_t increases. This is consistent with earlier contentions and assumes that the cost of labor is more important in influencing cattle inventory numbers than the price of calves. This assumption is probably best substantiated by cross-sectional analysis, but results from earlier regression analysis support this also. The index of farm wage rates explained more of the variation in Y_t than a simple average of lagged calf prices when each was used as the only explanatory variable.

An alternative interpretation would be that a rise in calf prices follows increases in general prices, including those of alternative enterprises. When the price of alternative enterprises' products increase, assuming labor and other costs do not change, then shifts to other enterprises could make cattle numbers decline. However, such an interpretation cannot be supported by this regression model.

The negative sign on a three-year average of lagged cotton acreage harvested (X_{11}) indicates that increases in the average has an associated decline in beef cattle inventory numbers in year t. The b_{11} implies that a one-unit increase (1000 acres) in cotton acreage harvested has an associated decline in Y_t of about 538 head.

A one-unit change (1000 acres) in the three-year average of lagged oat acreage harvested (X_{13}) has an associated decline in Y_t of about 1,842 head.

The 0-1 variable (X_{22}) in Model 5 is used to distinguish between the World War II years 1941-47 and the previous and following years of this study. The b_{22} coefficient indicates that the intercept or a value was 96.68 units lower than the trend for the entire period 1925-65.

This indicates that the January 1 inventory number was on the average 96,000 head less during the 1941-47 period. The suspicion, however, was that inventory numbers were greater so the sign does not support this conclusion.

Model 6

In Model 6 only three variables are used to estimate Y_t. The estimating equation is:

$$Y = 2323.9 - \underset{(1059.60)^{**}}{4883.20X_5} - \underset{(.0172)^{**}}{.5228X_{12}} - \underset{(.2072)^{**}}{1.5159X_{13}}$$

R^2 = .9667

Se = 66.31

F = 357.30

where:

W_3 = index of farm wage rates calculated by the Tennessee Crop Reporting Service for year t-1

X_5 = [a three-year average of lagged calf prices (annual average in dollars/cwt.)]/W_3

X_{12} = a three-year average of lagged corn acreage harvested (annual 1000's acres)

X_{13} = a three-year average of lagged oat acreage harvested (annual 1000's acres)

Model 6 explains 96.67 percent of the observed variation in Y_t, and it is significant at the .01 level.

The standard error of estimate shows that, within the time period and over the range of the observed data, the expected error in estimating

Y_t from Model 6 is $\pm$ 66,000 head. This is about 34,000 head less than Model 5.

The b coefficients are highly significant and the signs on X_5 (calf prices-index farm wage rates ratio) and X_{13} (oat acreage) are the same as in Model 5. Also the b coefficients on the two variables are similar in numerical value as in the previous model.

Variable X_{12}, a three-year average of lagged corn acreage harvested, as used in Model 6. A one-unit increase in the average of corn acreage harvested over a three-year period has an associated 523 head decline in beef cattle inventory numbers in year t. This is consistent with the assumed competitive relationship between the beef cattle and corn enterprise in Tennessee.

Model 7

Model 7 uses a simple average of the lagged price data variables instead of constructing ratios. The resulting model has desirable qualities, both from a statistical and economic standpoint, for estimating the January 1 inventory numbers of beef cattle in Tennessee. Model 7 is:

$$\begin{aligned} Y = 764.3 &+ \underset{(6.08)^{**}}{14.40X_5} - \underset{(32.75)^{**}}{223.62X_6} + \underset{(.10832)}{.0043X_{12}} - \underset{(.4099)}{.7731X_{13}} - \underset{(.1910)}{.3686X_{15}} \\ &+ \underset{(.0852)}{.0040X_{16}} + \underset{(.5932)^{**}}{2.6416X_{21}} + \underset{(36.530)}{68.1180X_{22}} \end{aligned}$$

$R^2 = .9846$

SE = 48.33

F = 256.9

where:

X_5 = a three-year average of lagged calf prices (annual average in dollars/cwt.)

X_6 = a three-year average of lagged wholesale milk prices (annual average in dollars/cwt.)

X_{12} = a three-year average of lagged corn acreage harvested (1000's acres)

X_{13} = a three-year average of lagged oat acreage harvested (1000's acres)

X_{15} = a one-year lagged summation of dairy cattle (cows + heifers + calves 1000's head)

X_{16} = a three-year average of lagged hog numbers (1000's head)

X_{21} = an index of farm wage rates calculated by Tennessee Crop Reporting Service for year t-1

X_{22} = 0-1 variable (1941-47 = 1, 1925-46 = 0, 1948-65 = 0)

Model 7 explains 98.46 percent of the variation in observed Y and is significant at the .01 level.

The standard error of the estimate is lower than in the previous two models. The expected error in estimating Y_t from Model 7, within the time period and over the range of observed data, is $\pm$ 48,000 head.

Variables X_6 (milk prices), X_{13} (oat acreage), and X_{15} (dairy cattle) reflect the relationship of these enterprises to beef cattle production in Tennessee. All have negative b coefficients which is a characteristic of competitive relationships.

The index of farm wage rates, X_{22}, has a positive b coefficient supporting the hypothesis that, *ceteris paribus*, when labor costs are rising beef cattle numbers increase.

This is attributed to the fact that less labor is required in relative terms than for alternative enterprises available to farmers in Tennessee. A one-unit increase (1) in the index of farm wage rates, in t-1, has an associated increase in beef cattle numbers in year t of 68,118 head. No attempt is made to define an actual period of time needed to adjust to changes in labor costs. It probably is longer than the one year lag used in this model, but the relationship between labor cost and cattle numbers can be estimated (even though it may be an average of the actual time period required) by lagging the index one year.

The 0-1 variable (X_{22}) is also consistent with the hypothesis that beef cattle numbers in the years 1941-47 were greater on the average than the trend of the previous and following years. According to Model 7, the intercept or constant term was 68,000 head greater than the trend for the entire period 1925-65.

The b_5 sign is positive supporting the earlier discussion that *ceteris paribus* increases in calf prices should result in increasing beef cattle numbers. A one-unit increase in the three-year average of lagged calf prices has an associated 14,000 head increase in the January 1 inventory number of beef cattle in year t.

The sign on X_{16}, a three-year average of lagged hog numbers, is positive and not significant. A one-unit (1000 head) increase in the average of lagged hog numbers has an associated increase in Y_t of four head. This supports the suggestion that hogs and beef cattle are not competitive in Tennessee as enterprises. Also, their independence as enterprises is reflected in the small b coefficient which is not significant. The b_{16} coefficient lends support to the argument that hogs and beef cattle cannot be classified as competitive or complimentary as far as production in Tennessee is concerned.

The sign on the three-year average of lagged corn acreage harvested (X_{12}) is positive. This indicates that an increase in corn acreage has an associated increase in beef cattle inventory numbers. This is not the expected relationship of the corn enterprise with the beef cattle enterprise in Tennessee.

Most of the variables in the preceding models were three-year averaged data. The three-year average was used on the assumption that expectations about future market conditions are based on an average of some past number of observations. The three-year average was arbitrarily chosen to average the data.

However, in addition to the preceding models, other models were calculated using a five-year average of prices for cattle and for calves. This was carried out to determine if the relevance of the variables was sensitive to the number of years used to average the data. There seemed to be no meaningful changes coming from this alteration; therefore, a three-year average was used in all of the models presented.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The objective of this study was to determine the extent to which secondary time series data could be used to explain the increase in beef cattle numbers in Tennessee.

Two secondary objectives were to determine if the data suggest that:

1. Dairy and sheep numbers are relevant variables in explaining beef cattle numbers in Tennessee.
2. The concept of opportunity cost along with the cost of hired labor is a relevant variable in analyzing beef cattle numbers in Tennessee.

Table 2 is a summary of the calculated statistics for the seven regression models presented in this study.

Due to data limitations only one point suggested by Leuthold could be examined--the increase in beef cattle numbers may be a resultant change due to the decline in other livestock enterprises.

In Models 1, 2, and 4, sheep and lamb numbers was entered as an independent variable. In these models the b coefficient was negative--indicating that as sheep and lamb numbers increase the January 1 inventory number of beef cattle decreases.

In Model 7 which was improved by reducing multicollinearity and revising the data matrix, the b coefficient on dairy animals was also negative. A one-unit (1000 head) increase in dairy animals (the one-year

TABLE 2

A SUMMARY OF THE CALCULATED STATISTICS FOR THE SEVEN REGRESSION MODELS

Variable[a]	MODEL I	II	III	IV	V	VI	VII
	b_i	b_i	b_i	b_i	b_i	b_i	b_i
X_1 (Wheat-P)	-368.76 (64.04)**	-188.47 (680.24)		-71599 (8930.2)**			
X_2 (Oat-P)			-1941.20 (1745.70)				
X_3 (Corn-P)		-3095.10 (585.61)**	-3132.40 (786.38)**		-163,740 (16424)**		
X_4 (Cattle-P)		- 20.68 (6.14)	- 21.49 (5.91)**				
X_5 (Calf-P)				-6044.40 (685.38)**	-3163.30 (1625.3)	-4883.20 (1059.60)**	14.40 (6.08)**
X_6 (Milk-P)	-101.33 (35.95)**						-223.62 (32.75)**
X_7 (Sheep-P)		222.81 (156.38)					
X_8 (Hog-P)	-1.75 (5.42)						
X_9 (Cotton-P)			19.33 (17.42)				
X_{10} (Hay-P)		228.20 (36.91)**	129.15 (42.71)**	4600.90 (728.36)**			
X_{11} (Cotton-A)		-.37 (.14)	-.1132 (.1073)	-.3238 (.1030)**	-.5385 (.13384)**		
X_{12} (Corn-A)	.00052 (.05765)	-.1389 (.0995)	-.1204 (.1054)	-.1941 (.0514)**		-.5228 (.0172)**	.0043 (.10832)

TABLE 2 (continued)

Variable[a]	MODEL I b_i	II b_i	III b_i	IV b_i	V b_i	VI b_i	VII b_i
X_{13} (Oat-A)		-2.76 (.239)**	-2.68 (.2312)**	-2.39 (.16692)**	-1.8424 (.32087)**	-1.5159 (.2072)**	-.7731 (.4099)
X_{14} (Sheep-N)	-1.13 (.1745)**	-.2858 (.2793)		-.6786 (.2348)**			
X_{15} (Dairy-N)	.2366 (.0820)**	.9593 (.1732)**	.8412 (.1348)**	.6423 (.0867)**			-.3686 (.1910)
X_{16} (Hog-N)							.0040 (.0852)
X_{21} (IFWR)	2.67 (.2931)*	1.81 (.4585)**	2.09 (.4528)**	.5872 (.21151)**			2.6416 (.5932)**
X_{22} (O-1)		-74.76 (30.76)	-44.37 (26.61)	-45.16 (19.10)**	-96.68 (46.41)*		68.118 (36.530)
R^2	.9930	.9940	.9932	.9950	.9295	.9667	.9846
Se	30.47	30.68	32.07	27.04	99.10	66.31	48.33
F-Ratio	662.8**	381.60**	380.7**	589.9**	92.29**	357.30**	256.9**

[a] P = Price, A = Acres, N = Numbers, IFWR = Index Farm Wage Rates.

lagged average) had an associated 368 head decline in Y_t (January 1 inventory number of beef cattle). The one-year lag assumes a fast response of beef cattle numbers to changes in dairy numbers in the previous year. This probably does not approximate the actual time lag involved, but it is not important in this study.

However, in Models 1-4 the b coefficient on dairy animals was positive and significant at the .01 level. This indicates that the argument for declining dairy numbers being partly responsible for increasing beef cattle numbers cannot be supported on the basis of these models.

In Model 6, both corn and oat acreage variables had b coefficients that were significant at the .01 level. In Model 7, which is a desirable model from the standpoint of statistical and economic reasons, oat and corn acreages were the influencing competitive crop enterprises, but the b coefficients were not significant. The difference arises due to the fact that more variables were used in Model 7 than in Model 6. In calculating the models stepwise regression was used. In stepwise regression, variables are entered according to the amount of addition to R^2 each can make. As more variables entered Model 7, part of the variation in Y_t attributed to the two variables was explained by other variables. As a consequence, the b coefficients on oat and corn acreages in Model 7 became smaller and less significant. Also, the sign change on corn acreage from negative in Model 6 to positive in Model 7 can be attributed to this statistical characteristic.

The index of farm wage rates variable, which was used to identify the effects of changing labor cost upon the prevalence of the beef cattle enterprise in Tennessee, has a positive b coefficient in all the models in which it was used as a variable. This lends support to the hypothesis that increasing labor costs result in shifts from high labor intensive enterprises toward less time-consuming ones. It also supports the contention that increasing labor costs result in a more efficient utilization of labor, as noted by Keisling in the dark-fired tobacco area of Tennessee.

In Model 7, the index of farm wage rates (X_{12}) has a b coefficient that is significant at the .01 level and indicates that a one-unit (1) increase in the index value has an associated increase in beef cattle inventory numbers in year t of 2,641 head.

The three-year average of lagged cotton acreage harvested (X_{11}) has a negative b coefficient in all the models in which it was used as a variable. This supports the statement made by Williams that the collapse of the cotton market resulted in increases in beef cattle production in the South. More importantly it reflects the competitive relationship of beef cattle and cotton enterprises for land and labor. In Model 5, the b coefficient is significant at the .01 level and indicates that a one-unit (1000 acres) increase in the value of the three-year lagged average of cotton acreage harvested (X_{11}) has an associated decline in beef cattle inventory numbers in year t of 538 head.

In Model 7, the 0-1 variable (X_{22}) has a positive b coefficient which is consistent with the suspicion that beef cattle numbers were greater in the years between 1941 and 1947 (inclusive) than the trend for the entire study period. According to Model 7, the intercept or constant term was 68,000 head greater on the average.

Since the sign on X_{22} was negative in previous models, no conclusion can be drawn about the World War II years being different, with respect to beef cattle numbers in Tennessee, than the previous and following years trend.

The belief that beef cattle numbers were greater on the average could indeed be in error since motivations of producers were probably influenced by other factors in addition to the normal economic forces. If such was the case then the assumption that labor shortage and/or high labor costs result in shifts from high to low labor-intensive enterprises may not hold for the 1941-1947 period.

As an explanatory equation, Model 7 has the most desirable qualities of either of the other two improved models. It presents Y_t as a function of calf prices, milk prices, corn and oat acreage, dairy and hog numbers, farm wage rates, and a disturbance 0-1 variable. All the variables have the expected sign attached except corn acreage (X_{12}).

Also, Model 7 has a lower standard error of estimate than Models 5 and 6--making it more desirable as an estimating equation.

But, from the standpoint of simplicity and the variation in the observed changes in Y_t explained by the models, Models 5 and 6 are just as acceptable.

For all practical purposes, the January 1 inventory number of beef cattle in Tennessee can be written as a function of three explanatory variables. The function in Model 6 is:

$$Y_t = 2323.9 - \underset{(1059.60)^{**}}{4883.20X_5} - \underset{(.0172)^{**}}{.5228X_{12}} - \underset{(.2072)^{**}}{1.5159X_{13}}$$

R^2 = .9667

Se = 66.31

F = 357.30**

In the above model, Y_t is written in terms of a three-year average of lagged calf prices--index farm wage rates variable (X_5), a three-year average of lagged corn acreage harvested (X_{12}), and a three-year average of lagged oat acreage harvested (X_{13}).

The sign on the calf price-index farm wage rates ratio (X_5) is negative--implying that beef cattle numbers will decrease when calf prices are high relative to the price of labor. This is not the expected economic relationship between calf prices and beef cattle numbers. But, this interpretation of the variable may not be the correct one.

With the index of farm wage rates increases more relative to calf prices, Y_t would tend to increase above previous observations. This relationship assumes that labor costs have more influence on the changes in beef cattle inventory numbers than the price of calves, the principle product from beef cattle production in Tennessee. If such a situation exists, then it does help explain the increased adoption of low income enterprises in the state.

The sign on X_{12} (a three-year average of lagged corn acreages) is negative, and the b coefficient shows a 522 head decrease in Y_t for each unit (1000 acres) increase in the three-year average of lagged corn acreage.

And, the three-year average of lagged oat acreage harvested (X_{13}) has a negative b coefficient implying that a one-unit (1000 acres) increase in the average lagged value of oat acreage has an associated decrease in cattle number in year t of 1,515 head.

Model 6, using the above three variables, explains 96.67 percent of the observed variation in January 1 inventory numbers over the 1925-65 period of study. The model is highly significant (F = 357.30).

The standard error of estimate is 66.31 indicating that, within the time period of the study and over the range of observed data, the expected error in estimating Y_t from Model 6 is $\pm$ 66,310 head.

The reliability of the above model for estimating Y_t depends on the extent to which structural changes, technology of production, number of sellers, and factor prices of other inputs change in the future. No attempt was made to include these variables specifically except to the degree that included variables act as proxies for these supply shifters.

If the variables included in the study have a particular relationship to these excluded variables such that the relationship can be assumed to remain the same in the future, then the model's estimating qualities will not be affected by changes in the excluded variables.

In conclusion, cross-sectional analysis as proposed by Leuthold[34] would provide clearer insight into the reasons for the relationships suggested by the models in this study. The relative effects of calf prices and labor costs on beef cattle numbers is one important point to consider. By carefully surveying the various regions of the state, conclusions can be drawn about this and other relationships found in the seven models of this study.

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[34] Leuthold, op. cit., pp. 8-10.

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APPENDIX

TABLE 3

THE SECONDARY TIME SERIES DATA USED IN THE ANALYSIS

Year	Y_t 1000 Head	X_1 Dollars Per Bu.	X_2 Dollars Per Bu.	X_3 Dollars Per Bu.	X_4 Dollars Per Cwt.	X_5 Dollars Per Cwt.	X_6 Dollars Per Cwt.	X_7 Dollars Per Cwt.	X_8 Dollars Per Cwt.	X_9 Dollars Per Cwt.	X_{10} Dollars Per Cwt.	X_{11} 1000 Acres	X_{12} 1000 Acres	X_{13} 1000 Acres	X_{14} 1000 Head	X_{15} 1000 Head	X_{16} 1000 Head	X_{21} 1910–14=100
1922		1.21	.55	.91	4.10	5.10	2.70	4.45	8.50	23.14	16.50	850	3280	138	330		1546	
1923		1.16	.61	1.01	4.45	5.60	2.93	4.85	7.20	29.72	18.00	1047	3018	124	320		1654	173
1924		1.44	.71	1.14	4.25	5.80	2.85	5.10	7.40	22.83	19.60	930	3100	155	304	607	1340	176
1925	389	1.67	.67	.89	4.80	6.60	2.99	5.60	10.90	17.59	22.00	1146	3162	170	291	620	1035	173
1926	332	1.39	.55	.75	5.40	7.20	3.00	6.70	12.00	11.84	16.40	1089	3036	187	286	626	1015	173
1927	295	1.45	.64	1.01	6.30	8.30	3.03	6.80	10.00	19.59	15.30	912	2884	107	300	646	1025	170
1928	311	1.55	.66	1.12	8.10	10.10	3.03	7.10	8.40	17.90	16.60	1042	2855	102	345	662	1163	167
1929	309	1.29	.64	.96	8.10	10.20	2.83	6.60	9.20	16.74	16.40	1044	2816	93	352	672	1035	170
1930	320	1.01	.54	.86	6.00	8.00	2.51	5.20	9.10	9.04	18.60	1129	2872	102	368	703	982	161
1931	322	.62	.33	.36	4.40	5.50	1.90	3.00	6.70	5.33	11.60	1050	3016	145	386	738	933	129
1932	362	.60	.29	.45	3.50	4.10	1.39	2.50	3.75	6.14	9.20	1063	3046	120	398	769	1075	94
1933	401	.97	.46	.60	3.00	3.75	1.38	2.75	3.50	10.20	10.40	883	2985	108	410	781	1236	94
1934	429	.98	.54	.80	3.15	4.05	1.59	2.60	4.05	12.05	12.60	759	2859	90	394	789	1137	104
1935	444	.94	.47	.83	4.60	6.20	1.94	2.75	8.00	10.91	10.30	750	2802	77	411	743	1002	109
1936	441	1.16	.58	1.07	4.70	6.50	2.03	2.70	9.00	12.00	14.70	797	2858	84	390	722	982	112
1937	375	1.07	.51	.60	6.00	7.80	2.20	2.90	9.50	8.09	12.00	937	2772	80	362	728	992	120
1938	357	.74	.39	.57	5.80	7.80	1.84	2.90	7.50	9.02	8.70	733	2689	85	367	773	1012	120
1939	385	.85	.43	.74	6.30	8.30	1.83	3.10	6.30	8.99	12.00	707	2600	82	394	797	1214	120
1940	414	.86	.47	.72	6.50	8.50	2.00	3.35	5.30	9.37	13.40	715	2704	82	402	812	1450	123
1941	447	1.07	.53	.83	7.80	9.90	2.37	3.40	8.70	16.77	15.10	680	2623	123	398	843	1204	147
1942	466	1.23	.65	1.08	9.40	11.90	2.74	4.30	12.60	18.92	18.70	715	2623	160	398	896	1276	185
1943	518	1.55	.91	1.41	10.10	13.00	3.45	5.50	13.50	19.42	28.30	720	2597	200	402	943	1646	235
1944	570	1.62	1.04	1.41	9.00	11.90	3.50	5.00	12.60	20.64	33.50	660	2415	208	366	914	1778	273
1945	569	1.65	.96	1.56	10.40	13.10	3.48	6.00	13.80	22.21	26.10	590	2125	245	333	880	1316	299
1946	544	2.10	1.07	1.86	13.00	15.30	4.34	7.20	17.40	32.33	25.20	630	2189	245	330	901	1198	340
1947	566	2.38	1.11	2.18	15.20	20.70	4.70	7.40	24.10	32.53	28.80	730	2189	230	323	887	1270	376
1948	536	2.21	1.00	1.31	19.30	24.40	5.10	9.20	23.10	30.01	29.00	820	2255	205	307	873	1308	393
1949	497	1.93	.79	1.34	17.60	23.60	4.08	8.60	18.60	29.10	22.10	895	2120	202	270	927	1269	373
1950	563	2.10	.96	1.63	20.80	26.60	4.02	9.70	18.00	40.18	25.50	630	2141	180	251	938	1371	375
1951	641	2.18	1.04	1.84	26.30	32.30	4.78	13.80	20.40	38.31	32.40	785	2012	133	248	948	1371	428
1952	710	2.14	1.05	1.84	21.50	26.90	5.06	9.70	18.10	36.12	34.80	860	1992	152	255	976	1302	443
1953	798	1.95	.82	1.52	14.00	17.90	4.25	6.20	21.60	33.37	29.20	950	1793	202	255	998	1016	439
1954	812	1.99	.85	1.52	13.40	16.70	3.87	5.30	23.20	34.70	30.60	648	1883	234	275	962	874	428
1955	809	1.98	.80	1.24	13.60	17.30	4.07	5.30	15.90	33.59	24.90	570	1732	236	286	898	970	443
1956	855	1.97	.80	1.34	13.10	16.90	4.13	5.10	14.30	33.15	24.60	543	1663	238	289	887	1183	470
1957	884	1.93	.80	1.37	14.90	18.20	4.09	5.30	17.60	31.72	25.30	465	1397	188	303	845	1218	488
1958	891	1.89	.84	1.19	19.10	24.20	4.11	6.20	19.80	35.41	23.00	400	1411	133	306	792	1206	502
1959	944	1.78	.79	1.12	20.00	26.30	4.20	5.70	14.30	33.78	23.10	510	1496	137	278	782	1242	533
1960	1076	1.77	.79	1.12	17.70	22.60	4.30	5.10	15.20	31.40	25.60	512	1436	100	245	735	1453	541
1961	1176	1.75	.77	1.17	17.50	23.40	4.25	4.70	16.80	34.18	24.90	538	1091	100	208	712	1308	556
1962	1276	1.91	.79	1.18	18.50	24.60	4.16	5.20	16.10	32.78	27.90	538	982	85	181	676	1216	572
1963	1375	1.83	.82	1.20	17.80	23.60	4.24	5.30	15.00	33.38	26.60	504	943	61	154	636	1204	609
1964	1518	1.46	.79	1.25	15.50	20.50	4.37	5.20	14.80	30.21	26.30	502	962	56	111	615	1072	624
1965	1625																	

SOURCES: Agricultural Trends in Tennessee: Crop and Livestock Statistics 1866–1960, a report compiled by the Tennessee Crop Reporting Service (Nashville: United States Department of Agriculture and Tennessee Department of Agriculture, 1964); and Crop and Livestock Statistics: Annual Bulletin 1966, a report compiled by the Tennessee Crop Reporting Service (Nashville: United States Department of Agriculture and Tennessee Department of Agriculture, 1966).

VITA

Charles Ray Kerley was born in Crossville, Tennessee, on January 27, 1943. He attended elementary school in Harriman, Tennessee, and was graduated from Harriman High School in 1961. Two years later he entered Tennessee Technological University, and in June 1967, he received a Bachelor of Science degree in Agriculture. In the Summer of 1967, he was awarded a National Defense Education Act, Title IV Fellowship at The University of Tennessee and began study toward a Master's degree. He received this degree in March 1970, and continued with his graduate work toward the Doctor of Philosophy degree with a major in Agricultural Economics.

He is an inactive member of Delta Tau Alpha and Alpha Gamma Sigma agricultural fraternities. He is married to the former Tommie Ann Malone of Oakdale, Tennessee.