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John E. Trierweiler

Donald B. Erickson

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John E. Trierweiler and Donald B. Erickson

Economics Department
Agricultural Experiment Station
South Dakota State University
Brookings, South Dakota

STRUCTURAL RELATIONSHIPS FOR NATIONAL AND REGIONAL BEEF CALF PRODUCTION*

John E. Trierweiler and Donald B. Erickson**

*This manuscript is based on a masters' thesis prepared by John E. Trierweiler for the Department of Economics at South Dakota State University.

**Assistant in Economics and Assistant Professor of Economics respectively.

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SUMMARY

This study was primarily concerned with identification of 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 regions and the United States as a whole. Similar structural models were used for comparisons between various regions.

In this model it was assumed that beef production was divided into two relatively distinct areas of specialization: cow-calf operations and feed-lot operations. Primary product of the cow-calf operator was beef calves to be fed, while that of the feed-lot operation was carrying feeder calves through feeding to be slaughtered. Calf production was defined to be the number of beef calves born in each region during 1 year. The sum of the calves born in all the regions equaled the total number of beef calves born within the United States.

Normally supply models are developed using a cost analysis or budgeting approach. Because of the lack of regional data, mathematical models were hypothesized to estimate the individual supply response curves. Various factors which affect the supply of beef calves were used as the independent variables. Four independent variables were used to reflect the supply response in each region.

The stocker-feeder calf price was used to trace out the industry's supply curve, _ceteris paribus_. The number of cows on hand was used to

limit the number of calves that could be born in a region. Range or pasture condition was used to indicate the condition of weather and pasture conditions within each region. The variable time was used to reflect the technological innovations or other unexplained variables which increase or decrease at a constant rate.

The coefficients for cows on hand, lagged 1 year, in the regional calf production equations were generally less than the average calving rate within the regions. In feeding regions the coefficients were generally less than the average calving rate, while in non-feeding regions, the coefficients were about the same as the average calving rate.

The percentage change was low in the number of beef calves as a result of a 1% change in the stocker-feeder price lagged 3 years. This suggested that producers were reluctant to alter their production to any great extent as a result of changes in the stocker-feeder price. The response in calf numbers to changes in range conditions, lagged $1\frac{1}{2}$ years, was slightly greater than the stocker-feeder price. Response to the technology variable was very low.

Cow-calf operators indicated reluctance to make adjustments in output in response to changes in product price, costs of production, and increased technology. Two major reasons for this slow response are the length of time necessary from the beginning of the production period to the marketing of calves as feeders, and the length of time necessary for expansion of the industry's capacity. During these two time periods, producers must speculate as to what the product price, costs of production, and salvage value of culled cows will be $1\frac{1}{2}$ to 4 years in the future.

INTRODUCTION

Livestock is produced in virtually every part of the United States. On farms at the beginning of 1964 were approximately 106 million cattle and calves, 28 million sheep and lambs, and 56 million hogs (table 1). Except for minor increases and decreases, the general trend of cattle and calf inventory for the last 40 years has been increasing. Number of hogs for the same period increased until 1944 but since has generally decreased with minor fluctuations. Similarly, sheep numbers increased until 1942 and since then decreased.

Table 1. Number of Cattle and Calves, Sheep and Lambs, and Hogs on Farms January 1, for U. S. 1923, 1943, 1963 and 1964.[1]

	1923	1943	1963	1964
	(1000 head)	(1000 head)	(1000 head)	(1000 head)
Cattle & Calves	67,543	81,204	103,754	106,488
Hogs	69,304	73,881	58,695	56,007
Sheep & Lambs	36,922	48,196	29,793	28,151

Red meat consumption increased steadily from 1923 to 1964. Meat is basic to the modern diet and meat animals are a mainstay of modern agriculture. Expenditures for meat were a little less than 5% of each disposable income dollar (after income tax) in 1963. Sale of meat

[1]"Livestock and Meat Statistics," Agricultural Marketing Service, Statistical Reporting Service, Economic Research Service, United States Department of Agriculture, Washington, D.C., Statistical Bulletin No. 333, and supplements, Washington, D.C., 1962.

animals provides a third of the income earned by U. S. farmers.[2]

Beef consumption has risen sharply in comparison with other meat products. Within the last 23 years beef consumption per person has increased from 55 pounds to 100 pounds.[3] Beef production is the major agricultural enterprise in the United States.

A comparison between the six regional sections of the United States by the USDA, indicate that the proportional contribution of each of the six regions in calf numbers has not changed much over the past ten years, 1954-1964. There was a slight decrease in the East North Central proportion while the South Central region increased (table 2). Changes in regional slaughter were more evident. There were decreases in the liveweight slaughter as a proportion of the total slaughter in the North Atlantic, South Central, and East North Central regions. The West North Central and the West regions increased their slaughter contribution of the total liveweight slaughter.

The difference between the regions which produce calves and the regions which slaughter cattle indicate that calves do not necessarily remain in the same region where they were produced. The differences between the two time periods are also evident.

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[2]Harold F. Breimyer, "Demand and Prices for Meat," Economic Research Service, United States Department of Agriculture, Technical Bulletin No. 1253, Washington, D.C., December, 1961. Page 1.

[3]"Livestock and Meat Situation," Economic Research Service, United States Department of Agriculture, Washington, D.C., LMS-140, November 1964.

Table 2. Percentage of beef calves and liveweight of cattle slaughtered between six regions for 1954 and 1964.*

	Number of beef calves Produced		Liveweight of cattle Slaughtered	
	1954	1964	1954	1964
	percent	percent	percent	percent
North Atlantic	.6	.5	8.5	7.1
East North Central	11.1	9.7	22.5	17.6
West North Central	40.0	40.6	30.6	33.6
South Atlantic	4.7	4.8	6.5	4.2
South Central	23.9	25.0	14.4	12.0
West	19.7	19.4	17.5	20.5
	100.0	100.0	100.0	100.0

*The regional breakdown is taken from the USDA Crop Reporting Service.

Changes have occurred in recent years which have produced changes in the beef industry. Structural relationships that existed for the producer-feeder are not necessarily important in the operation of the cow-calf operator or the feed-lot operator. Because of these changes, a more thorough knowledge of the supply response of a small regional breakdown of the beef cattle industry should be available to farmers, economists, outlook workers and policy makers in the agricultural industry.

The beef industry is generally divided into two rather distinct areas of production: the cow-calf operators and those that finish the animals for slaughter. The finishing areas are located near the source of the feed supply and generally the range areas produce the feeder calves. Some changes have taken place because of improved technology in transportation, breeding, nutrition and feed conversion efficiency.

These have resulted in changes in the beef calf production industry. In addition, new types of pastures and conversion of land from "surplus" crops to pasture have changed the structure of the cattle industry.

Greatest percentage increase in number of beef cows among the states has occurred in the Southern States and States where number of dairy cows has decreased. The greatest percentage increase of 223.4% from 1954 to 1964 occurred in Wisconsin. There the number of beef cows in 1954 was 47,000 compared with 152,000 in 1964. The States which followed in order of the percentage increase in the number of beef cows were: Kentucky - 125.1%, Tennessee - 119.4%, South Carolina - 93.2%, Arkansas - 69.3%, Georgia - 61.2%, Michigan - 57.7%, North Carolina - 56.6%, Oklahoma - 53.8%, North Dakota - 50.5%, and Mississippi - 50.3%. Average increase in number of beef cows for the United States was 31.2% for the 10-year period. The actual number of some of these states was relatively small in comparison to some other states but the fact remains that the number of beef cows has increased more than 50% in these States the last 10 years.[4]

Eight States had an increase of less than 20% during the last 10 years: Utah - 1.8%, Florida - 2.4%, New Mexico 10.3%, Kansas - 11.3%, California - 12.8%, Nebraska - 15.6%, Montana - 15.6%, and Iowa - 16.9%. Nevada and Arizona decreased number of beef cows 12.5% and 5.4%, respectively, for the 10-year period. South Dakota increased the number of

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[4]"Livestock Slaughter," Statistical Reporting Service, Crop Reporting Board, United States Department of Agriculture, Washington, D.C., Mt An 1-2 (12-64) December 31, 1964.

beef cows 21.1% from 1,260,000 head in 1954 to 1,526,000 head in 1964. This percentage increase was less than the U. S. average. The limited extent of expansion in range areas is evident in these figures.

Changes in number of beef calves being produced in various states are not taking place at a uniform rate. Calves to be fed are produced where beef cows are located while they are fed in areas where feed is most available. Rather than analyze a budget for each State to determine cost of production and then estimate the supply response, a system of regression analysis can be used to depict changes that are taking place in each State or area as the case may be.

Structural economic models, which can also be used for forecasting, were developed for the number of beef calves born in the United States and by specific homogeneous regions of production. Economic models were designed to depict factors that affect the production of beef calves and the response of beef calves to various factors.

Objectives of the Study

The specific objectives of this study were:

1. To determine the beef calf production in the United States by specific homogeneous geographical regions.

2. To develop structural economic models for the number of beef calves born in the United States.

3. To develop structural economic models for the number of beef calves born in specific homogeneous regions.

Data Development

Data used in this study were developed from published reports by the United States Department of Agriculture.[5] Since beef calves born are not directly reported by the Crop and Livestock Reporting Service, the number was estimated by multiplying calving percentages by number of beef cows on hand (appendix A). The calving percentages were not strictly a calving rate, but represent calves born expressed as a percentage of the January 1st inventory of cows and heifers 2 years and older held on farms on January 1. The rest of the data were obtained directly from USDA published reports.

Regional Breakdown

There are no strict criteria for the selection of homogeneous calf producing areas of the United States. Therefore, the areas used were arbitrarily established with the recognition that the particular breakdown selected could considerably affect the results of the estimating equations. The method used to divide the United States into 23 homogeneous regions of production was based on the number of beef calves produced, relative proportionate increase of beef calves, similarity of terrain and weather conditions (figure 1).

Commercial Calf Production

In this study, calf production was defined as the number of beef calves born in each region. The sum of the regions equaled the total

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[5] *Ibid*. "Livestock and Meat Statistics"

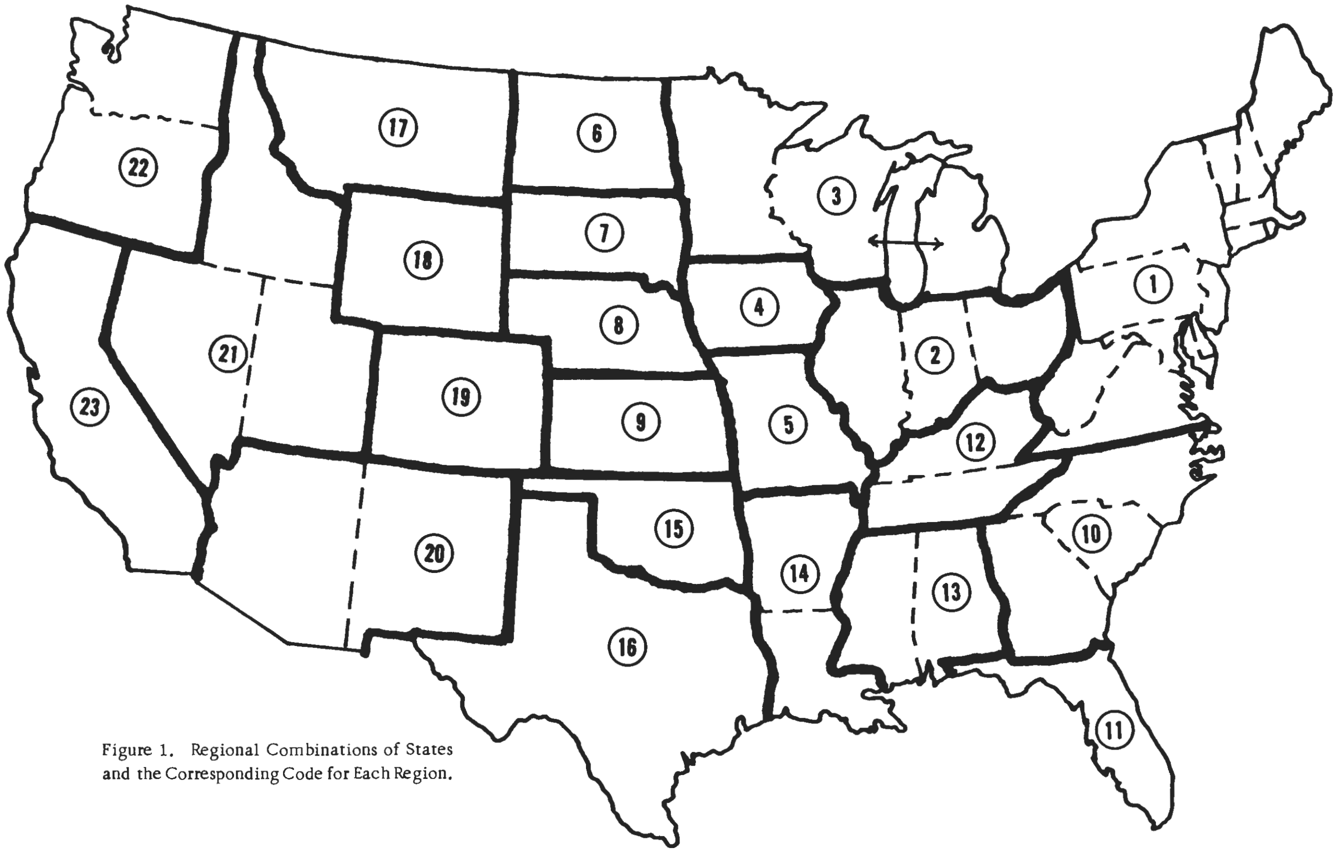

Figure 1. Regional Combinations of States and the Corresponding Code for Each Region.

States in Each of the 23 Production Regions of the United States

Region Number	States
1	Maine - New Hampshire - Vermont - Massachusetts - Rhode Island - Connecticut - New York - New Jersey - Pennsylvania - Delaware - Maryland - Virginia - West Virginia *
2	Ohio - Indiana - Illinois
3	Michigan - Wisconsin - Minnesota
4	Iowa
5	Missouri
6	North Dakota
7	South Dakota
8	Nebraska
9	Kansas
10	North Carolina - South Carolina - Georgia
11	Florida
12	Kentucky - Tennessee
13	Alabama - Mississippi
14	Arkansas - Louisiana
15	Oklahoma
16	Texas
17	Montana
18	Wyoming
19	Colorado
20	New Mexico - Arizona
21	Utah - Nevada - Idaho
22	Washington - Oregon
23	California

*Hereafter referred to as North Atlantic Region number of beef calves born within the United States. The number of beef calves born will be referred to as calf production.

It was assumed that calf production was divided into two distinct types of specialization: the cow-calf operations and the feed-lot operations. The primary activity of the cow-calf operation is the production of beef calves, while that of the feed-lot operation is the feeding of beef calves or yearlings for slaughter.

A distinction was made between feeding and non-feeding regions. Although feed-lot and cow-calf operations existed in both feeding and non-feeding regions, the distinction was made on the basis of the predominant types of operation. Feeding regions were defined as areas where calves and yearlings are normally fed to a slaughter grade by feeding grains and concentrates. Non-feeding regions were considered to be the grass land areas where weight is added primarily by grazing and the use of forage. The feeding regions generally include the Corn Belt, Eastern Plains, Colorado, Arizona, Texas, and California. Non-feeding regions included the Northeast, Mountain, Western Plains, and the Southeast.

As expected, a comparison between the number of cattle on feed on January 1 and the production of beef calves indicates a striking difference between the regions and their relative rank (table 3). Feeding regions generally did not rank high in the production of beef calves with the exception of South Dakota, Nebraska, Texas, and Kansas -- all of which also ranked relatively high in numbers on feed. Each of these was a border region between feeding and non-feeding regions. Each could well have been subdivided into distinct feeding and non-feeding regions if detailed statistics were available.

Table 3. Comparison of rank of regions between cattle on feed and calf production for the top 10 regions.

Region Rank	Cattle on Feed January 1, 1965	Calf Production for 1963
1	Iowa	Texas
2	Ohio-Indiana-Illinois	Nebraska
3	Nebraska	Oklahoma
4	California	Kansas
5	Minnesota-Wisconsin-Michigan	South Dakota
6	Colorado	Alabama-Mississippi
7	Texas	Ohio-Indiana-Illinois
8	Arizona-New Mexico	Missouri
9	Kansas	Kentucky-Tennessee
10	South Dakota	Arkansas-Louisiana

Number of beef calves produced has increased in all regions since 1950. Rather than explain what has happened within each region, they were compared with the total national production of beef calves. Table 4 lists the number of beef calves produced and the proportion of the national production for each of the 23 regions during the years 1950, 1955, 1960, and 1962.

Table 4. Number and percentage of beef calves produced compared with the relative production of beef calves produced in the United States for each of the 23 regions for the years 1950, 1955, 1960, and 1962

Region	1950 Calves Born (1000 head)	1950 Percent	1955 Calves Born (1000 head)	1955 Percent	1960 Calves Born (1000 head)	1960 Percent	1962 Calves Born (1000 head)	1962 Percent
1	269.8	1.88	541.2	2.45	608.4	2.72	686.8	2.82
2	585.3	4.09	1115.3	5.05	1113.3	4.98	1171.9	4.81
3	210.4	1.47	439.2	1.99	501.5	2.24	558.2	2.29
4	558.6	3.90	946.7	4.29	903.6	4.04	935.4	3.84
5	552.4	3.86	950.4	4.30	1032.8	4.62	1092.0	4.48
6	288.8	2.02	522.3	2.37	576.7	2.58	625.2	2.56
7	712.8	4.98	1179.7	5.34	1162.5	5.20	1234.1	5.06
8	956.4	6.68	1388.6	6.29	1334.1	5.96	1436.9	5.89
9	835.2	5.84	1205.7	5.46	1039.6	4.65	1248.3	5.12
10	234.3	1.64	679.2	3.08	698.2	3.12	751.8	3.08
11	345.3	2.41	537.2	2.43	387.7	1.73	591.1	2.42
12	320.1	2.24	605.3	2.74	876.3	3.92	1063.7	4.36
13	488.5	3.41	1093.7	4.95	1147.9	5.13	1197.4	4.91

Table 4 (continued)

Region	1950 Calves Born (1000 head)	1950 Percent	1955 Calves Born (1000 head)	1955 Percent	1960 Calves Born (1000 head)	1960 Percent	1962 Calves Born (1000 head)	1962 Percent
14	548.1	3.83	1057.1	4.79	1075.9	4.81	1124.7	4.61
15	675.0	4.72	1131.0	5.14	1209.3	5.41	1378.7	5.65
16	2872.7	20.08	3431.3	15.54	3533.0	15.80	3821.6	15.67
17	693.7	4.85	1039.6	4.71	1002.6	4.48	1038.3	4.26
18	375.0	2.62	443.7	2.01	478.5	2.14	484.9	1.99
19	528.9	3.70	676.8	3.06	677.3	3.03	733.5	3.01
20	818.0	5.72	874.9	3.95	782.2	3.51	851.1	3.49
21	554.7	3.88	800.3	3.62	771.8	3.45	827.1	3.39
22	394.3	2.75	664.6	3.01	710.6	3.18	778.1	3.19
23	491.4	3.43	756.8	3.43	742.1	3.32	755.0	3.10
Total U.S.	14,309.7		22,080.6		22,365.9		24,335.8	

Nine regions indicated a relative proportion increase of the national beef calf production. Seven regions showed a relative decrease, while the remainder were relatively stable with only small fluctuations in the proportion of beef calves produced.

Increasing Relative Production

An increase in the relative production of beef calves occurred in these regions: North Atlantic (1), Michigan-Wisconsin-Minnesota (3), Missouri (5), North Dakota (6), Oklahoma (15), North and South Carolina-Georgia (10), Kentucky-Tennessee (12), Alabama-Mississippi (13), and Arkansas-Louisiana (14). Farmers in the dairy belt of the North Atlantic, and Michigan-Wisconsin-Minnesota regions, decreased size of their milking herds, shifting resources from milk production to beef calf production. The Southeastern States experienced rapid growth in the relative proportion of beef calf production. Acreage diverted out of cotton production and put into soil conserving pasture land prompted the rapid growth of the cow-calf industry. Another factor was the break up of the small sharecropping farms into larger more efficient farm units. More recently the development of cattle breeds, like the Santa Gertrudis, which have the ability to withstand the extreme humidity and insects, has greatly facilitated expansion of the cow-calf industry in these regions.

Decreasing Relative Production

A decrease in the relative proportion of beef calf production occurred in Nebraska (8), Kansas (9), Texas (16), Montana (17), Wyoming (18), Colorado (19), and Arizona-New Mexico (20). These regions have been the traditional calf-producing areas of the Western Plains and Mountain States where native grasses constitute the available feed supply. The ranges have been stocked close to the technological capacity for years; thus, calf production cannot readily be expanded without shifting resources used in the production of other crops or livestock enterprises to the cow-calf enterprise.

Stable Relative Production

Only slight fluctuations in the relative percentage were evident in Ohio-Indiana-Illinois (2), Iowa (4), South Dakota (7), Florida (11), Utah-Nevada-Idaho (21), Oregon-Washington (22), and California (23) regions. Corn Belt States of Ohio-Indiana-Illinois and Iowa increased production at about the same rate as the national level, reaching their relative peak in calf production during the 1955 period. The far western regions also increased calf production at about the same rate as the national production; although the number of cattle on feed more than doubled, while the number of dairy cattle remained relatively constant.

ECONOMIC MODEL

The economic theory used in this model was the conventional supply theory, where supply is defined as a schedule of quantities that would be offered for sale at different prices during any given time period, other factors remaining unchanged (*ceterus paribus*). The method used in this study involved estimating an economic supply model statistically. The economic model was constructed using certain assumptions which, though not entirely true, were useful for purposes of this estimation. These simplifying assumptions treat the cow-calf industry as purely competitive, and producing only one product. It was also assumed that the marginal cost curve was the same as the supply curve, when marginal costs were greater than average variable cost. This further assumes that the producers act in such a way in the region so as to maximize profits.

Theoretically, there would be a positive relationship between the price of the commodity and the total quantity produced, other variables unchanged. As long as price was greater than minimum average variable cost, any increase in price would result in an increase in production. Thus the average product price for calves was used to trace marginal cost curve, ceterus paribus.

Theoretically, a change in the cost of production will shift the variable cost curve and marginal cost curve. A reduction in the cost of production will result in a decrease in the average variable cost curve and a shifting of the marginal cost curve to the right. This would result in an increase in production on a regional level without any change in price of product. Cost of production can be reflected in pasture conditions of various regions. Technological innovations would also reduce cost of production. This variable was represented by time. The combination of variables and other interactions makes tracing of just one supply curve difficult. There is really no one and only supply curve but rather a whole series of supply curves for each commodity representing all possible conditions. The procedure used tends to estimate the supply response curve rather than the classical supply curve. The aggregate supply response can be envisioned as the sum of the regional production at given prices.

Lagged Time Response

The concept of time has not previously entered in the discussion of marginal costs. The specific supply curve must have a specific time period defined with respect to the factors which are considered to be variable costs and fixed costs. When the analysis is extended over a long period of time with no factors held constant then the concept of the supply curve becomes a supply response curve.

Generally, three broad time periods or periods of adjustments, with different marginal costs curves for the producers, can be distinguished. At one extreme is the short-run period of adjustment which does not allow for a response in production as price changes. During the very short-run, all factors of production are fixed, and these supply curves are characterized by being nearly vertical or almost perfectly inelastic. Only a small portion of the total cow-calf operators could respond to changes in price during this period of adjustment. One example would be if the price of calves increased substantially in the spring of the year the response of increasing the number of calves to be sold the same year would be limited.

At the other extreme is the long-run period of adjustment, in which there is enough time to allow for a complete response in production. This period is characterized by a relatively elastic supply curve which has the property of being reversible in that the same supply curve can show reactions of output to either a rise or fall in price. In the cattle industry, increasing production is a slower process than reducing the number of calves. During the long-run period of adjustment, cow-calf operators can either increase or decrease the aggregate size of the herds throughout the region or shift their operation to an alternative enterprise. Factors of production which are considered fixed in the shorter-run can readily be shifted to other enterprises in the long-run. Variable factors of production in the long-run for the cow-calf operator would include fences, buildings, and range and cropping practices.

The period of adjustment used in this study is the short-run period. This period of adjustment falls in between the short-run and the long-run periods, and is usually distinguished by a period of time too short to make changes in capacity but not in the degree of utilization of the firm's capacity. During this period of adjustment, decisions can be made to buy more or less feed, to feed out or market calves, and to increase or decrease herd size.

The production of beef cattle is a unique industry in agriculture and business. From the time the cow-calf operator makes the decision to increase calf production, until the new heifers start producing new calves to sell, there is a time lag of 3 years or more. The major reason for the time lag is physiological. The planning period for beef calves is 3 months, plus 9 months for the gestation period, and 18 months to 2 years or more to grow the heifers out before they in turn can start producing calves. During the 3-year period the cow-calf operator has several alternatives. The calves can be slaughtered as vealers, (this is seldom done except for dairy calves), held over as replacements in the cow herd or held over as yearlings to be fed.

Statistical Models

The marketing system for calves serves as a mechanism for cow-calf operators to adjust production to changes in the price of calves. However, in any conceivable economic system there are a number of interdependencies and interconnections, and the same is true of the economic system for livestock. Working[6] recognized the difficulty of identifying the forces of supply and demand as depicted in statistical data. He pointed out the difficulty of separating the slopes of supply and demand from shifts in their position. If it is assumed that over a long period of time supply is shifting faster than demand, then an inverse price-quantity relationship will exist. If demand shifts faster than supply, then a positive price-quantity relationship will exist. However, this relationship cannot be defined as the supply curve but should be

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[6]Elmer Joseph Working, "What Do Statistical 'Demand Curves' Show?" Quarterly Journal of Economics, February 1927, Volume 41. Pages 212-235.

considered as the supply response curve. The statistical model should account for the shifting demand curve and also the shifting supply curve as well as estimating the short-run marginal cost curve.

It was hypothesized that beef calves produced was a function of the number of cows on hand, stocker-feeder price, pasture or range conditions, and time. If the proper lags are used for each of these variables, based on the theoretical framework cited previously, the following relationship should exist. Cows on hand, stocker-feeder price, pasture or range conditions, and time will all be positively related to the number of beef calves produced.

In the estimating equation used, some of the variables explained the shifting of the supply function, while others recorded movements of supply along the marginal cost curve. Those hypothesized to be supply shifters included cows on hand and pasture or range conditions, while feeder price was used to record movements along the industry's marginal cost curve. Technology in livestock production (i.e., better breeding stock, improved pastures, medicine, etc.) was difficult to measure, thus, the variable time was used as a representation of the continuing adjustment to technological change as it affected the various regions.

The estimating equations were first fitted using a single stage least squares multiple regression technique. However, because of the presence of intercorrelation between the independent variables it was decided to use a two stage least squares method.[7] This procedure has been receiving a lot of attention in a series of articles in the <u>Journal of the American Statistical Association</u>.[8] This procedure simply involves estimating the model using one or two of the independent variables which are not intercorrelated. The first relationship estimated was:

$$Y_1 = f(X_1) \qquad (1)$$

Where: Y_1 = number of calves born in the United States

X_1 = number of cows 2 years old and older on farms January 1 in the United States, lagged one year

The linear form of equation (1) can be written as:

$$Y_1 = a_1 + b_1X_1 + e_1 \qquad (2)$$

or

$$Y_1 - a_1 - b_1X_1 = e_1 \qquad (3)$$

Where: (e_1) is the error or residual of the observations from the regression line. This error becomes the dependent variable of the second stage. The regression equation is estimated by the following procedure:

$$\text{Let } Y_2 = e_1 + a_1 \qquad (4)$$

It becomes convenient to add a constant or (a_1) to the residuals to eliminate the negative values. This has no effect in the final

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[7] Alternative equations for the single stage method are presented in Appendix B.

[8] These equations are presented (in detail) in Appendix C.

equation. Stated another way:

$$Y_2 = Y_1 - b_1X_1$$

This dependent variable was regressed on the three remaining independent variables.

$$\hat{Y}_2 = (a_2 + b_2X_2 + b_3X_3 + b_4X_4) \quad (5)$$

Where: X_2 = average price of good and choice stocker-feeder calves at the Kansas City market, deflated by the Wholesale Price Index, during the months of September, October, November, lagged 3 years.

X_3 = average pasture conditions in the United States during the fall months of September and October, lagged 2 years.

X_4 = time

Since $Y_2 - Y_2 = e_2$

and substituting

$$Y_1 - b_1X_1 - (a_2 + b_2X_2 + b_3X_3 + b_4X_4) = e_2 \quad (6)$$

This is then equal to

$$Y_1 = a_2 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e_2 \quad (7)$$

The response equation for the calf production in the United States than becomes:

$$\hat{Y}_1 = a_2 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 \quad (8)$$

The regional relationship was hypothesized to be:

$$Y_{1i} = f(X_{1i}) \quad (9)$$

$$Y_{2i} = f(X_2, X_{3i}, X_4) \quad (10)$$

Where: Y_{1i} = number of calves born in the ith region.

Y_{2i} = residual from equation in the ith regions.

X_{1i} = number of beef cows 2 years old and older on farms January 1 in the ith region, lagged 1 year.

X_2 = average price of good and choice stocker-feeder calves at the Kansas City market during the months of September, October, and November, deflated by the Wholesale Price Index, lagged 3 years.

X_{3i} = average pasture or range condition in the ith region during the fall months of September and October, lagged 2 years.

X_4 = time

i = 1...23 representing the regions.

The same statistical relationship was used for each of the 23 regions so that comparisons could be made between them. The usual assumptions that accompany regression analysis were assumed to exist for each of the regions.

Cow-calf operators are reluctant to make changes in the size of their herds because of the length of the period necessary for the production of a single unit of output plus the time necessary for the expansion of the industry's capacity. The production period for beef calves is 1 year. Adjusting production to expand the industry's capacity requires that heifer calves be saved, thus the time period necessary for the production of an additional unit of output is 3 or 4 years.

STATISTICAL RESULTS

All of the coefficients were estimated using the logarithmic form, therefore, the coefficients may be expressed directly as their elasticities.[9] Thus, the condition *ceteris paribus*, other variables in the equation held constant, is applicable as each variable is examined. The same assumption will be used to examine the results of all the estimates. Although the coexistence of a number of economic and non-economic factors are present, their existence will be overlooked at this time.

A number of models were experimented with in order to obtain the estimating equation and at the same time fulfilling restrictions of the study. The restrictions were that the equations must contain at least one variable that reflected the price of the product, a variable for the cost of production, and one biological factor. The biological factor was necessary because of the nature of the product and the length

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[9]Given the estimated equation:

$$\hat{Y}_1 = a_2 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 \qquad (8)$$

The coefficient b_2 or elasticity of stocker-feeder calf price is derived from the above equation in the following manner: The elasticity of a variable with respect to the dependent variable is defined as

$$B_i = \frac{\frac{\Delta Y}{Y}}{\frac{\Delta X_i}{X_i}} = \frac{\% \Delta Y}{\% \Delta X_i} = \frac{\partial \log Y}{\partial \log X_i}$$

Where Δ is defined as a "small change."

Thus, if equation (8) is estimated in logarithmic form and the partial derivation taken with respect to X_2, the b_2 can be expressed as the elasticity of stocker-feeder price with variables X_1, X_3 and X_4 held constant.

of time necessary for expansion of the industry's output. The time period used in the national model was 1950 to 1963.

National Calf Production

The estimated calf production equation in logarithmic form used for the United States was:

$$\hat{Y}_{1t} = .60827 + \underset{(.06990)}{.85019}\, X_{1t-1} \qquad r^2 = .92495$$

$$\hat{Y}_{2t} = .12923 + \underset{(.03844)}{.12278}\, X_{2t-3} + \underset{(.06647)}{.15443}\, X_{3t-2} + \underset{(.01316)}{.01589}\, X_{4t}$$

$$R^2 = .68385$$

Where: $\hat{Y}_1$ = estimated number of calves produced during each time period.

$\hat{Y}_2$ = residual

X_1 = number of cows two years old and older on farms on January 1, lagged 1 year (X_{1t-1}).

X_2 = average price of good and choice stocker-feeder calves at Kansas City per hundredweight, for the months of September, October, and November, deflated by the index of wholesale prices (1957 to 1959 = 100) lagged 3 years (X_{2t-3}).

X_3 = average pasture condition in the United States for the months of September and October, lagged 2 years (X_{3t-2}).

X_4 = time (1950 = 1).

Combining the equations as in equation (8)

$$\hat{Y}_{1t} = .12923 + .85019X_{1t-1} + .12278X_{2t-3} + .15443X_{3t-2} + .01589X_{4t}$$

Combined $R^2 = .97627$

$d' = 1.612$

The signs of all the coefficients in the estimating equations agree with the economic theory as stated previously. The standard errors of the coefficients are in parentheses. Results of the t-test indicated that cows on hand and feeder price were significant at the .01 level, while pasture condition was significant at the .05 level. Although time was not significantly different from zero in the two stage technique employed in this estimating equation, it was thought sufficiently important to include it on the grounds that some of the interaction through time is removed within the estimating system. Results of the F-test indicated that the amount added through the stepwise procedure to the explained variation by the variables cows on hand, feeder price, and pasture conditions was significant. The independent variable in the first stage explained 92.5% of the variation in calf production. The three independent variables in the second stage explained 68.3% of the 7.5% unexplained variation for a total explained variation of 97.6% of the national calf production. The Durbin-Watson test (d') for serial correlation yielded inconclusive results.

The coefficient for beef cows on hand (X_1) was 0.85, indicating that for a 1% change in cows on hand lagged one year, cow-calf operators will adjust production 0.85%. The coefficient appears to reflect the national calving rate for beef cows held over for breeding. Cow-calf operators, therefore, produce beef calves as close to capacity as the number of cows on hand permit.

The coefficient for feeder calf price (X_2) lagged 3 years, indicated that for a 1% change in price, cow-calf operators will adjust production 0.12%. The response to price was inelastic, meaning that cow-calf operators were slow to alter their production plans as a result of a change in price. The slow response of calf production to changes in price results from two inherent characteristics of the cow-calf industry. First, the length of time necessary for the expansion of the industry's capacity and secondly, the length of time from the beginning of gestation to the marketing of the beef calves as feeders. During the planning period, producers must speculate on the price of feeder calves $1\frac{1}{2}$ years in advance.

A 1% change in pasture conditions (X_3) was followed by a 0.15% adjustment in production. Note should be taken that pasture conditions for the national equation were taken as a national unweighted average, and did not consider movements of cattle to other regions where drought may not be prevalent at the time. Secondly, cow-calf operators do not have to speculate about future pasture conditions so far in advance as feeder calf price. If pasture conditions are poor, operators make the choice of reducing the size of their herds, or purchasing feed to supplement the pasture. If pasture conditions are relatively good, herds can be increased by purchasing replacements from regions with relatively poor pasture conditions.

A 0.01% adjustment will be made as a result of a 1% change in time (X_4). Time, representing technology in the estimating equation was very inelastic, indicated cow-calf operators were slow in adoption of new technological innovations. However, technological innovations for cows on hand and pasture conditions were not measured by this variable because increased technology contributed by these two variables had already been accounted for and thus has been held constant.

The coefficients show that the number of cows on hand was the most important factor in predicting calf production, indicating that producer's decisions were based primarily on maintenance of herd size. Adjustments in output explained by changes in pasture conditions and feeder price were small. The major reasons were: difficulties experienced in expanding the size of the herd; inability to carry over range feed; and the problem of forecasting future prices of feeder calves.

<u>Regional Calf Production</u>

The models used for the regional calf production estimates are the same as those of the national. The coefficients for the regional calf production estimates are presented in table 5, with the standard errors in parentheses below each of the coefficients. The results of the first stage, including the coefficients and the r^2, are followed by the results of the second stage of the equation, plus the combined R^2 for the two equations and the values of d'. The time lag for each variable is the

Table 5. Two stage coefficients and standard errors of the regional calf production equations for the period 1950-1962, estimated in logarithmic form

Region	Cows on Hand t-1	1st Stage r^2	Constant	Feeder Price t-3	Pasture Cond. t-2	Time t	2nd Stage R^2	Combined R^2	d'
1	.83277** (.14880)	.74	.14650	-.18357 (.23506)	.24180 (.28188)	.05474 (.20917)	.14	.80**	2.366[b]
2	.77766** (.06972)	.92	.30365	.19433* (.06617)	.03094 (.10967)	.00466 (.05912)	.50	.96**	1.648[b]
3	.86276** (.06265)	.95	-.07905	.13807 (.11262)	.10645 (.21471)	.02316 (.09176)	.31	.96**	1.982[a]
4	.78153** (.08711)	.88	.29119	.11863 (.07775)	.09429 (.07730)	.00923 (.06248)	.46	.93**	1.2716[b]
5	.75799** (.08067	.89	.40913	.09542 (.08735)	.05069 (.03677)	.05653 (.07597)	.31	.92**	1.651[b]
6	.88109** (.06789)	.94	-.66480	.16972 (.09838)	.30657 (.35045)	.11527 (.09972)	.26	.95**	2.028[a]
7	.87313** (.06308)	.95	-.00190	.10049* (.04272)	.05775 (.09051)	.09051* (.04145)	.48	.97**	1.152[b]
8	.75585** (.09762)	.84	.21493	.10845* (.04802)	.17225 (.13655)	.03347 (.04674)	.46	.92**	1.805[b]
9	.64405** (.16988)	.57	.43353	.23901* (.09207)	.09827 (.10574)	.07661 (.07826)	.55	.80**	2.598[b]

Table 5 (continued)

Region	Cows on Hand t-1	1st Stage r^2	Constant	Feeder Price t-3	Pasture Cond. t-2	Time t	2nd Stage R^2	Combined R^2	d'
10	.83525*	.94	.36436	.74635*	-.59004	.03328	.39	.96**	2.059[a]
	(.06313			(.32778)	(.36710)	(.26333)			
11	.62403*	.41	2.95580	.53444*	-1.70889	.37249	.50	.70**	2.429[b]
	(.22701)			(.18542)	(.84135)	(.18020)			
12	.96010**	.92	-.59167	.18031	.19602	.05353	.40	.96**	2.131[a]
	(.08237)			(.11344)	(.11150)	(.10275)			
13	.84991**	.96	.32333	.16702*	-.11222	.01716	.49	.98**	1.706[b]
	(.05403)			(.07031)	(.05979)	(.06259)			
14	.81419**	.92	.32157	.09730	.00295	.01785	.10	.93**	1.568[b]
	(.07078)			(.10241)	(.09074)	(.08834)			
15	.77188**	.86	.27915	.17840	.05818	.02942	.39	.92**	2.142[a]
	(.09382)			(.08654)	(.10654)	(.03710)			
16	.86217**	.77	.37326	.03500	.00111	.00772	.05	.79**	2.065[a]
	(.14071)			(.05878)	(.07593)	(.01782)			
17	.76426**	.77	.35993	.13379	.04943	.04390	.21	.82**	2.364[b]
	(.12729)			(.09507)	(.26239)	(.04419)			
18	.79159**	.61	-.03630	.00808	.26616*	.03728	.47	.79**	2.633[b]
	(.18956)			(.05294)	(.11229)	(.02339)			

Table 5 (continued)

Region	Cows on Hand t-1	1st Stage r^2	Constant	Feeder Price t-3	Pasture Cond. t-2	Time t	2nd Stage R^2	Combined R^2	d'
19	.74602** (.17100)	.63	.32731	.12108 (.06859)	.07821 (.23755)	.03563 (.03142)	.30	.74**	2.407[b]
20	.29470 (.29304)	.08	1.85369	-.00813 (.07178)	.11145 (.17684)	-.01574 (.03240)	.07	.15	2.298[b]
21	.90833** (.07007)	.94	.21950	.06198 (.04228)	-.05462 (.16960)	.00617 (.02027)	.20	.95**	2.115[a]
22	.91408** (.12446)	.83	-.23434	.18760 (.10893)	.13596 (.33859)	-.03831 (.04711)	.35	.89**	2.455[b]
23	.96317** (.11415)	.87	-.69841	.12587 (.07145)	.28949 (.26121)	.02534 (.03116)	.30	.91**	2.545[b]

*Significant at the .05 level.
**Significant at the .01 level.
[a]No serial correlation present.
[b]Inconclusive.
[c]Serial correlation present.

same for the regional equation as it was in the national equation. The time period used in the regional models was 1950 to 1962, due to incomplete data for 1963.

All of the coefficients for the variable, cows on hand, were positive, which is consistent with economic theory. Twenty of the 23 coefficients were significant at the .01 level, and two at the .05 level. The only coefficient that was not significant was the Arizona-New Mexico (20) region. It is believed that this was due largely to fluctuations in calving rates, caused by movements of cows in and out of the region for winter grazing.

Signs of the coefficients for feeder prices were positive in all of the regions except two. The North Atlantic (1) and Arizona-New Mexico (20) regions reflected inverse relationships; however, the coefficients were not significantly different from zero. Neither region was considered an important calf producing area. Of the remaining 21 regions, seven were significant at the .05 level.

Signs of the coefficients for pasture or range conditions were consistent with economic theory in all of the regions except four. North Carolina-South Carolina-Georgia (10), Florida (11), Mississippi-Alabama (13), and Utah-Nevada-Idaho (21) all showed inverse relationships for pasture condition; however, the coefficients were not significantly different from zero within any of these regions. One region, Wyoming (18), indicated the correct relationship which was significant at the .05 level.

Time, used in the two stage technique to represent technology, was positive in all regions except two, Arizona-New Mexico (20) and Oregon-Washington (22). However, they were not significantly different from zero.

The Durbin-Watson test (d') yielded no serial correlation present in seven regions and an inconclusive result in 16 regions.

The coefficient for cows on hand lagged 1 year ranged between .29 in Arizona-New Mexico (20), to a high of .96 in Kentucky-Tennessee (12) and California (23). The coefficients were generally less than the calving rate in most regions (table 6). The calving rates were generally higher in the feeding and borderline regions than in the non-feeding

Table 6. Comparison of average calving rate and the coefficients for the number of cows on hand in feeding, non-feeding, and borderline regions for years 1950 to 1962.

Feeding Regions			Non-Feeding Regions			Borderline Regions		
Region	Ave. Calving Rate	Cows on Hand	Region	Ave. Calving Rate	Cows on Hand	Region	Ave. Calving Rate	Cows on Hand
	Percent			Percent			Percent	
2	88	.78	1	84	.83	6	90	.88
3	89	.86	10	80	.84	7	91	.87
4	93	.78	11	66	.62	8	91	.76
5	92	.76	12	87	.96	9	90	.64
19	88	.75	13	77	.85	15	89	.77
20	81	.29	14	80	.81	16	86	.86
23	85	.96	17	92	.76			
			18	87	.79			
			21	85	.91			
			22	86	.91			

regions. The coefficient for cows on hand, however, were generally greater in the non-feeding regions than the feeding and borderline regions. This relationship indicated that in non-feeding regions cow-calf operators were more reluctant to shift resources or adjust production than cow-calf operators in feeding or borderline regions.

The coefficients (table 7) for stock-feeder price ranged between -.18 in North Atlantic (1) and .75 in North Carolina-South Carolina-Georgia (10). Although all of the regions were relatively inelastic, the non-feeding regions were generally slightly more elastic than feeding regions. Calf production in the non-feeding regions of the Southeast were more responsive to changes in the stocker-feeder price than non-feeding regions in the mountain and western regions. The major feeding regions in the Corn Belt, plus Colorado (19) and California (23), all had stocker feeder price coefficients ranging from .10 to .19. Four regions, Texas (16), Wyoming (18), Arizona-New Mexico (20) and Utah-Nevada-Idaho (21), suggested almost no response in calf production to a change in price. The North Atlantic (1) indicated an inverse price-quantity relationship. This region, however, was not considered to be a large beef calf producing region.

The coefficients for pasture or range conditions ranged between a -1.71 in Florida (11) and .21 in North Dakota (6) and were generally more elastic in feeding regions. In the southeastern regions of North Carolina-South Carolina-Georgia (10), Florida (11), and Mississippi-Alabama (13), pasture conditions were inversely related to the number

Table 7. Coefficients of regression for stocker-feeder price, pasture or range conditions, and time, broken down by feeding, non-feeding, and borderline regions.

Region	Stocker-Feeder Price	Pasture or Range Condition	Time
Feeding Regions			
2	.19	.03	.005
3	.14	.11	.02
4	.12	.09	.01
5	.10	.05	.06
19	.12	.08	.04
20	-.01	.11	-.02
23	.13	.29	.03

Region	Stocker-Feeder Price	Pasture or Range Condition	Time
Non-Feeding Regions			
1	-.18	.24	.05
10	.75	-.59	.03
11	.53	-1.71	.37
12	.18	.20	.05
13	.17	-.11	.02
14	.10	.003	.01
17	.13	.05	.04
18	.01	.27	.04
21	.06	-.05	.01
22	.19	.13	-.04

Region	Stocker-Feeder Price	Pasture or Range Condition	Time
Borderline Regions			
6	.17	.31	.12
7	.10	.06	.09
8	.11	.17	.03
9	.24	.10	.08
15	.18	.06	.03
16	.03	.001	.01

of beef calves produced and, thus, inconsistent with economic theory. The coefficients for pasture conditions in these regions were, -.59, -1.71, and -.11, respectively. In addition for the non-feeding regions, Arkansas-Louisiana (14), Montana (17), and Utah-Nevada-Idaho (21), indicated no relationship between pasture or range conditions and the number of beef calves produced. The response of the borderline regions closely resembled the feeding regions.

The coefficients for technology were inelastic in all regions except Florida (11). The inelastic response suggested cow-calf operators, were slow in adoption of technological innovations. No real pattern developed for feeding vs. non-feeding regions of production. In Florida, the coefficient for technology was .37, indicating a relatively more elastic response in the production of beef calves for a change in technological innovations than other regions.

South Dakota's (7) livestock production was generally divided into cow-calf operations in the western part, and feed-lot operations in the eastern. Western South Dakota is mainly non-feeding grassland areas, while the eastern section was characterized by intensified feed grain production. Thus, South Dakota can be classified as a borderline region between feeding and non-feeding area. The coefficient for cows on hand (.87) was slightly less than the calving percentage of .91. The coefficient for stocker-feeder price (.10) was more elastic than range conditions (.06), indicating the cow-calf operators in South Dakota respond more to change in the stocker-feeder price than changes in the range conditions. The coefficient for technology (.09) was greater than the national average, (.01) indicating that cow-calf operators on an average accepted technological innovations a little faster than the cow-calf industry as a whole.

CONCLUSIONS

In the cow-calf industry major supply responses are not instantaneous. Because of physiological characteristics and the reluctance of cow-calf operators to make major changes in the size of their herds, supply responses may take 3 years or more. Decisions to increase size of the herd nationally could take 3 years or more before actual increases in number of beef calves born. The decision to decrease the number of cattle can be implemented faster because of the quicker process of liquidation by slaughter.

The identification of similar supply responses for the cow-calf operators in various homogeneous regions of production was developed. The objective to develop structural economic supply models for the number of beef calves born included various factors applicable in all the regions. The factors influencing the supply response of cow-calf operators included: stocker-feeder calf price, which traced out the industry's supply curve; one biological factor, cows on hand which reflected the industry's capacity; one cost factor, range or pasture conditions which shifted the average cost curve and subsequently the industry's marginal cost or supply curve; and time, which reflected constant increases in technological innovations or other unexplained variables which increase or decrease at a constant rate.

The coefficients of the stocker-feeder prices, pasture and range conditions, and technology were inelastic. Thus, cow-calf operators were reluctant to make adjustments in output in response to change in product price, costs of production, and increased technology. The two major reasons for this inelastic response appear to have been: length of time necessary from beginning production period to marketing of the calves as feeders, and length of time necessary for the expansion of the industry's capacity. During these two long-time periods, producers must speculate as to what the product price will be, costs of production, and salvage value of culled cows, $1\frac{1}{2}$ to 4 years in advance.

Cow-calf operators produce as close to capacity as the number of cows on hand and range or pasture conditions permit. More emphasis is placed upon changed in pasture or range conditions by producers than changes in the stocker-feeder price. Cow-calf operators are more likely to increase the size of the breeding herd by saving heifers when the stocker-feeder price increases, even to the point of over-stocking the ranges. However, if the stocker-feeder price decreases, producers are not likely to adjust production by decreasing the size of the breeding herd, assuming that range conditions remain relatively stable.

Cows on hand and pasture or range conditions can be considered as a reflection of production costs. Comparisons between the coefficients for costs of production and product price indicate that cow-calf operators will more readily respond to changes in the cost of production than to changes in the price of the product. Major reasons are that producers have a better idea of their costs, (i. e., value of breeding stock, range conditions, feed costs) but must speculate about future prices that will be received for their product years in advance. Thus, making the cow-calf industry a cost orientated industry. Current prices are used as a guide of what future prices are expected to be, which is not too satisfactory because of variation.

In feeding regions, as opposed to non-feeding regions, the coefficients for costs of production were relatively more elastic. This relationship suggests that in feeding regions, where producers had high fixed cost, they were more responsive to a change in cost of production than producers in non-feeding, low fixed cost regions. In three non-feeding regions in the Southeast, pasture conditions were inversely related to quantity produced. This was due to a shift from the production of cotton plus the incorporation of small share cropping farm units into larger farm units for the commercial production of cattle and calves. As cotton acres were diverted from production, the surplus acres were planted to pastures. The livestock industry then expanded the herds with little regard to changing pasture conditions.

Coefficients for stocker-feeder price in all of the regions reflected little change in production as a result of changes in the price. Although all of the regions were relatively inelastic, the non-feeding regions were generally more elastic than feeding regions. The low fixed cost in non-feeding regions implies that producers could respond more to a change in price than producers in the high fixed cost feeding regions. The relatively smaller feed-lot operators were more adaptive to moving in and out of calf production than cow-calf operators in large feeding regions. Cow-calf operators in non-feeding regions were characterized by long-run adjustments, because their only alternatives were substitute enterprises, i.e., sheep production. On the other hand, small feed-lot operators could more readily shift resources from the fattening of beef calves to the production of beef calves. In two regions, North Carolina-South Carolina-Georgia (10) and Florida (11), the coefficients for feeder price were relatively more elastic. In both regions, pasture acreage was in a surplus due to reduced acreage of tobacco and cotton. Therefore, adjustments in output could be made to changes in the stocker-feeder price conditions in the short time period.

Although all regions increased in total numbers of beef calves produced, certain areas increased their relative proportion of the total national production. The Southeastern regions increased their relative production of beef calves faster than any other section of the United States because of the introduction of better pasture management, new grasses, and new breeds of cattle such as the Santa Gertrudis that have the ability to withstand extreme humidity and insects. Other contributing factors were the reduction of cotton and tobacco acreages, combined with the breakup of the small share-cropping farm into larger more efficient farm units. Northeast and North Central regions increased their relative proportion of the beef calf production by decreasing the size of dairy herds which resulted in the shift of resources to cow-calf operations.

The traditional calf producing regions of the Western Plains and Mountain States decreased their relative proportion. Cow-calf operations in these regions have been well established for years. The limiting factor in these regions is the virtual total reliance on grazing of native pastures for feed supply.

Regions in the Corn Belt and the Pacific Slope have increased their production at about the national rate. In the Corn Belt, emphasis has been placed on feed-lot operations while the Pacific States have increased feed-lot operations, combined with rapidly growing populations which have decreased available range areas.

APPENDIX A

Data Development

Calf production in this study refers to the number of beef calves born. The data were taken from published reports by the United States Department of Agriculture. Number of beef calves born, hereafter referred to as calf production, was not directly reported by the reporting service, but could be computed from secondary data. The procedure used for estimating the number of calves produced was as follows:

$$T.C.P._i = \Sigma \, [\, (CF)_j \quad X \quad (R)_j]$$

T.C.P. = total calf production in thousand head in ith region.

C.F. = cows two years old and older on farms on January 1.

R. = calving rate expressed as the percentage of calves born to the number of cows two years old and older on farms on January 1.

i = 1,2, --- 23 regions

j = 1,2, --- n states in region

This procedure was used to estimate calf production in each of the 23 regions. In regions where more than one state was represented, each state was computed individually, and the results summed to find the total calf production for each region.

Price Series Data

The stocker-feeder price at Kansas City was used in both the national and regional estimates.[1] This price series was assumed to better reflect the price received by cow-calf operators for their calves than the national average price received for calves in the United States. The Kansas City market was considered to be the price leader in the stocker-feeder price division, as all other markets tend to follow the Kansas City market.

The fall months of October, November and December were chosen for the price series. During these months the heaviest marketings of feeder calves takes place. The stocker-feeder price series was deflated by the index of wholesale price.

Range and Pasture Conditions

Range conditions were reported for the 17 Western States.[2] Monthly reports on range conditions for cattle were made up from answers received on questionnaires mailed to stockmen by each state's statisticians office. Respondents gave their judgment on current condition of range feed, using a numerical rating system as well as comments on general livestock matters. The numerical equivalent of the range conditions were as follows: 49 or below very bad; 50-59 bad; 60-69 poor; 70-79 fair; 80-89 good; 90-99 very good; 100 and over excellent.

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[1]"Livestock and Meat Statistics," United States Department of Agriculture, Agriculture Marketing Service, Statistical Reporting Service, Statistical Bulletin No. 333, Washington, D.C., 1962.

[2]"Western Range and Livestock," United States Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, Statistical Bulletin No. 331, Washington, D.C., 1963.

Pasture conditions were reported in every state of the continental United States.[3] The data were reported in the same manner as range conditions, with the exception that pasture conditions were reported with special reference to the dairy industry.

The fall months were chosen for pasture or range conditions, because it was at this time cow-calf operators weaned and sold their calves. Decisions were made at this time to hold cows over for the next production period, or reduce the size of the herd. The amount of range feed available was an important factor in the decision of the cow-calf operation, especially with the approach of winter.

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[3]"Agriculture Statistics," United States Department of Agriculture, United States Government Printing Office, Washington, D.C., 1963.

APPENDIX B

Alternate Estimating Procedure

Estimating equations were first fitted using a single step least squares multiple regression technique. Because of bias in the coefficients, it was decided to use a two stage technique. In this section the estimates using the single step technique will be presented.

National Calf Equation

The estimated calf production equation in logarithmic form for the United States was:

$$\hat{Y}_1 = -1.15722 + \underset{(.23901)}{1.12334}\, X_1 + \underset{(.04145)}{.10331}\, X_2 + \underset{(.11049)}{.25643}\, X_3 - \underset{(.06973)}{.06241}\, X_4$$

$$R^2 = .979$$

$$d' = 1.63$$

Where: $\hat{Y}_1$ = number of calves born in the United States

X_1 = number of cows 2 years old and older on farms January 1, lagged 1 year.

X_2 = average price of good and choice stocker-feeder calves at the Kansas City market, deflated by the wholesale price index, during the months of September, October, and November, lagged 3 years.

X_3 = average pasture conditions in the United States during the fall months of September and October, lagged 2 years.

X_4 = time

Bias can be seen in the coefficients. The signs and the value of the coefficients are not consistent with economic theory. Intercorrelation between two independent variables, cows on hand (X_1) and time (X_4), is the major reason for this type of biased relationship. The coefficient of correlation (r) between cows on hand and time was .95.

Time is negative indicating that cow-calf operators, instead of adopting new technological innovations, are retreating to older, less efficient practices. Although this relationship is possible, it is highly improbable and unrealistic.

The coefficient for cows on hand indicates that for a 1% change in the number, cow-calf operators will adjust production 1.12%. The inherent physiological characteristics of cattle dictate that this type of relationship is unlikely. For this relationship to be possible, cow-calf operators would have to produce more units of output than there were units of input.

Region Calf Equations

The estimated calf production equations in logarithmic form for the 23 regions are presented in Table B.1. Generally, most of the regional equations contained bias due to intercorrelations between the two variables, cows on hand (X_1) and time (X_4).

Table B.1. Two stage coefficients and standard errors of the regional calf production equations for the period 1950-1962, estimated in logarithmic form

Region	Constant	Cows on Hand t-1	Feeder Price t-3	Pasture Cond. t-2	Time	R^2	d'
1	1.02774	.26211 (.39232)	-.17699 (.22178)	.15610 (.27235)	.75380 (.51953)	.82	2.774[b]
2	-.90086	1.15440** (.22143)	.21210* (.06779)	.27612 (.19378)	-.34929 (.22311)	.97	2.415[b]
3	-.03034	.80116** (.22894)	.12989 (.12277)	.12509 (.23712)	.09741 (.29228)	.96	1.939[a]
4	-.41509	1.08155** (.14356)	.09877 (.06935)	.16057 (.07897)	.23416 (.12203)	.96	2.312[b]
5	.27008	.82963* (.29348)	.08425 (.10468)	.06154 (.05915)	.00776 (.27595)	.92	1.944[a]
6	-.53323	.69628* (.27530)	.16376 (.10720)	.33259 (.38067)	.31326 (.31149)	.96	1.752[b]
7	-.20496	.87656** (.13099)	.12578* (.04886)	.16605 (.15326)	.05289 (.10203)	.97	2.665[b]
8	.02501	.81329* (.16172)	.12562 (.05643)	.17266 (.17032)	.02030 (.08808)	.92	1.709[b]
9	.43622	.64475** (.17780)	.23896* (.10244)	.09850 (.12444)	.07644 (.09679)	.81	1.029[b]

Table B.1 (continued)

Region	Constant	Cows on Hand t-1	Feeder Price t-3	Pasture Cond. t-2	Time	R^2	d'
10	-.00601	.95493** (.20534)	.32434* (.12961)	-.11404 (.19281)	-.14961 (.35344)	.97	1.424[b]
11	6.79197	.12511 (.25150)	.61084** (.16622)	-3.24431* (1.06567)	.70806* (.23094)	.80	2.393[b]
12	.28469	.26426 (.32537)	.36838* (.13023)	-.01405 (.13632)	1.04895* (.47345)	.97	2.357[b]
13	-.08830	1.01668** (.17299)	.20624* (.08165)	-.06141 (.08002)	.19269 (.22663)	.98	1.817[b]
14	.07267	.91915** (.27343)	.09488 (.10785)	.03779 (.13171)	-.09305 (.30355)	.93	1.721[b]
15	.85083	.57536 (.32937)	.21468 (.11557)	.00660 (.15858)	.11142 (.14875)	.92	1.621[b]
16	1.58593	.48695 (.28888)	.09900 (.07289)	-.00967 (.07299)	.07228 (.04998)	.83	2.296[b]
17	1.94401	.11989 (.46674)	.11194 (.09940)	.15161 (.27767)	.25107 (.16144)	.85	1.656[b]
18	1.67456	.13651 (.24907)	.07960 (.04934)	.20328* (.09053)	.12296** (.03730)	.89	2.844[b]

Table B.1 (continued)

Region	Constant	Cows on Hand t-1	Feeder Price t-3	Pasture Cond. t-2	Time	R^2	d'
19	.82511	.28902 (.23617)	.18676* (.06906)	-.02661 (.21528)	.10213* (.04404)	.83	2.318[b]
20	2.53493	.17086 (.32374)	.07296 (.07425)	-.11248 (.17899)	-.02204 (.03336)	.27	2.744[b]
21	.02171	.98019** (.22739)	.06786 (.04714)	-.05720 (.18023)	-.01133 (.06009)	.95	2.294[b]
22	.78545	.40581 (.29954)	.24987* (.10294)	.13862 (.35543)	.25595 (.12887)	.92	1.872[a]
23	-.10778	.75065 (.43938)	.09667 (.09599)	.29736 (.27356)	.07906 (.11575)	.91	2.217[b]

*Significant at the .05 level.
**Significant at the .01 level.
[a]No serial correlation.
[b]Inconclusive.
[c]Serial correlation.

APPENDIX C

Alternative Variables

Several alternative variables were tried in deriving the national equations for beef calf production. Restrictions at the beginning of the study were based on economic theory stating the equations must contain biological variables that reflect the industry's capacity, variables that reflect cost of production, and variables that reflect the price of the product. The estimates were all made on the national level initially until a satisfactory model was obtained. The regional equations were estimated, using the same functional relationships as the national model. All the equations were estimated, using a single-step least-squares multiple-regression technique.

Beef calf production was assumed to be predetermined in all of the estimating procedures. Various factors which logically appeared to affect the number of beef calves produced were selected. Given the conditions and biological limitations of the cow-calf industry, it was known, *a priori*, that the variables must be lagged at least 1 year, and the effects of a 5-year lag or more would be meaningless. Cows on hand were lagged 1 year and not tested for any other lag period. Various factors representing cost of production were given 1- and 2-year lags and tested statistically. Factors representing the product price were given 2-, 3-, and 4-year lags, and then tested statistically to determine the most appropriate time lag.

A number of variables were selected to represent cost of production including corn price, steer-corn ration, and pasture or range conditions in the fall and the spring. Both corn price and the steer-corn ratio were significant at the .01 level with correct signs for the coefficients. Pasture or range conditions in the fall, lagged 2 years, were significant at the .05 level with the correct sign on the coefficient. Pasture or range conditions in the spring were not significant, although the coefficient had the expected sign. In the final analysis, it was decided to use fall pasture conditions to reflect costs of production. Cow-calf operations were located in predominantly non-feeding areas where corn and other feed grains were not readily available.

Several variables were considered as alternatives to reflect product price. Variables considered were the national average price received by farmers for all grades of cattle, the national average price received by farmers for all grades of calves, and the stocker-feeder price for good and choice calves at the Kansas City market. The national cattle and calf price series were divided on a quarterly basis, thus, giving eight price series. Each of the eight price series were then deflated by the index of wholesale prices and lagged 2, 3, and 4 years, thus, giving 24 total price series. None of the 24 price series was found to be significant at either the .01 or .05 level. The signs on the 2-year lags generally were negative for the price-quantity relationship, while the 3- and 4-year lags generally were positively related. Although all the variables were not significant, the numerical value for the tests of significance was the greatest during the fall quarters.

The Kansas City stocker-feeder price for good and choice feeder calves was finally selected as the product price. The Kansas City market was considered to be the price leader in the stocker-feeder division. The greatest number of marketings of stocker-feeder calves takes place in the fall, therefore, the months of October, November, and December were averaged and deflated by the index of wholesale prices. The Kansas City stocker-feeder price was lagged 2, 3, and 4 years. The signs of the coefficients were correct with the theoretical model in all three lagged time periods. The 2-year lag was not significant at either the .01 or .05 level, while the 4-year lag was significant at the .05 level. The 3-year lag was significant at the .01 level. Therefore, the stocker-feeder price at Kansas City, lagged 3 years, was chosen to represent the product price.

Alternative Models Estimated

Several alternative estimates were made using various combinations of variables and time lags. A few of the hypothesized equations will be presented along with the estimated results. All estimates were made in logarithmic form.

Example 1 where calf production was expressed as:

$$Y_1 = f(X_1, X_2, X_3, X_4)$$

Where: Y_1 = national calf production

X_1 = cows on hand lagged one year

X_2 = stocker-feeder price lagged three years

X_3 = steer-corn price ratio lagged two years

X_4 = time variable (1923 to 1963)

Results:

$$\hat{Y}_1 = .95632 + \underset{(.03962)}{.85622}\, X_1 + \underset{(.03909)}{.12147}\, X_2 + \underset{(.04919)}{.19111}\, X_3 + \underset{(.03956)}{.12541}\, X_4$$

$$R^2 = .93823$$

$$d' = 1.46$$

All of the variables were significant at the .01 level, and 98.9% of the variation in calf production was explained. In addition all the of the coefficient were consistent with economic theory. The test for serial correlation was inconclusive. There were three major disadvantages in using this estimating equation. First, the difficulty of projecting a ratio and the interpretation. Second, a ratio assumes a 1:1 weighting of the variables which is not likely to exist. Third, cow-calf operations are located in predominantly non-feeding areas of production where feed grains are not readily available.

Example 2 where calf production was expressed as:

$$Y_1 = f(X_1, X_2, X_3, X_4, X_5)$$

Where:

Y_1 = national calf production

X_1 = cows on hand lagged one year

X_2 = pasture conditions in the fall lagged two years

X_3 = stocker-feeder price lagged three years

X_4 = pasture condition in the spring lagged one year

X_5 = time (1950-1963)

Results:

$$\hat{Y}_1 = -1.38137 + \underset{(.11946)}{.36630} X_1 + \underset{(.07786)}{.06601} X_2 + \underset{(.02963)}{.24474} X_3 + \underset{(.09985)}{.24474} X_4 + \underset{(.22344)}{.74200} X_5$$

$$R^2 = 99.1$$

$$d' = 1.72$$

The variables X_1, X_3, X_5 were significant at the .01 level and X_4 was significant at the .05 level. The estimate explained 99.1% of the variation in calf production. The signs of the coefficients were all consistent with economic theory except time (X_5). The test for serial correlation was inconclusive. This estimate was not used in the final analysis for two reasons. First, the addition of the fifth variable reduced the degrees of freedom. Secondly, using the two stage multiple regression technique, pasture conditions in the spring (X_4) was not significant, although it did have the correct sign.

Alternate Time Periods

At the beginning of the study, a 40-year time series was arbitrarily chosen. Using statistical experimentation, it was found that this time series was inadequate. Three distinct time series with different statistical relationships existed. The individual time series were the prewar-depression period, the war and immediate postwar period, and the recent period from 1950 to 1963.

The recent period from 1950 to 1963 was selected for this study. This period reflected recent structural changes in the cow-calf industry. This period also included a full cattle cycle, with a build up, a decline and another build up in the cattle numbers.