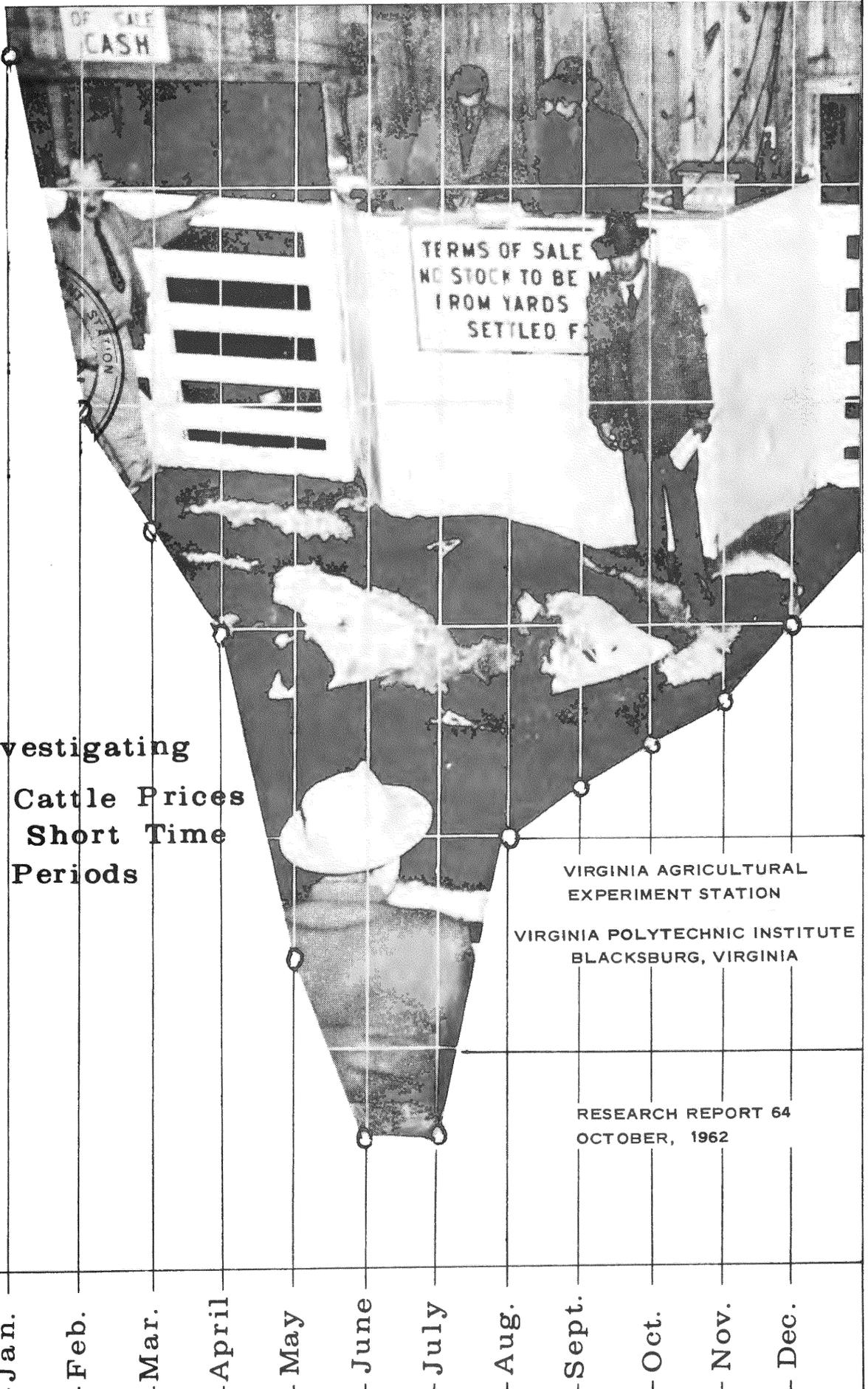


**Investigating
Beef Cattle Prices
For Short Time
Periods**



VIRGINIA AGRICULTURAL
EXPERIMENT STATION
VIRGINIA POLYTECHNIC INSTITUTE
BLACKSBURG, VIRGINIA

RESEARCH REPORT 64
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William D. Anderson, under the direction of Monte E. Juillerat, gathered the data and made all of the statistical calculations included in this publication as a part of his work towards the Master of Science Degree at the Virginia Polytechnic Institute. Extraordinary assistance was given throughout by Paul H. Hoepner, a member of the Agricultural Economics staff. His assistance was invaluable.

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INVESTIGATING BEEF CATTLE PRICES
FOR SHORT TIME PERIODS

William Dyer Anderson* and Monte E. Juillerat**

INTRODUCTION

Prices have the function of allocating resources in a marketing economy. This is done as entrepreneurs consider prices--present and expected--and make decisions based upon their expectations. If their expectations are correct, the resources allocated by the entrepreneur will make their maximum contribution to the net national product. When knowledge of prices is lacking, expectations are frequently faulty. This leads to inefficient resource allocation and a reduction in net national product. Therefore, price knowledge is of interest to all who are involved in production, marketing, and/or consumption of the national product.

Firms operating in a highly competitive market, such as the production and slaughter of beef cattle, have virtually no control over prices. These firms must have knowledge of the factors affecting price if they are to make intelligent decisions. The nature of the decision dictates the time period for which prices must be considered.

Much of the study of prices and price forecasting has lacked the preciseness that is often needed for successful decision making. In this study the author attempts to add to the knowledge of beef cattle prices. Additional price knowledge should lead to more efficient resource use by those in the beef cattle industry.

THE PROBLEM

In recent years there has been a move throughout the livestock and meat segment of the economy toward a more competitive market structure. ^{1/} To firms operating in a competitive market structure with relatively high

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^{1/} Butz, Dale E., and Baker, George L., Jr., The Changing Structure of the Meat Economy, Harvard University, Graduate School of Business Administration, Division of Research, Boston, Massachusetts, 1960, Chapter I.

costs of production an understanding of prices is essential for profit maximization.

Instability of production, prices, and income has constituted a major problem in the livestock economy. The problem of instability has been characteristic of agricultural commodities in general but has been particularly important with livestock. The instability in quantities and prices of livestock and meat has affected producers and consumers as well as firms at all levels of the marketing process. 2/

One of the major ways that has been suggested to solve the instability problem is to improve research and education in prices. The variation which has persisted in spite of continued research in prices attests to the importance of improving this work and of developing more useful and accurate price forecasts. 3/

The varied conditions which affect beef cattle prices have made this agricultural commodity among the most difficult to study. Geographically, beef cattle production is widespread and is taking place under diverse conditions and practices. Within the industry many products and by-products are produced. Not only are there inter-relationships within the beef cattle sector, but there also exist intricate relationships with the rest of the economy.

Wide price variations over time have been characteristic of the beef cattle industry. Both seasonal and cyclical movements have been apparent. These movements have received considerable attention in the past, and there has been an accumulation of general knowledge about them. There is a great amount of variation in beef prices not explained by the cycle or by the season. Very little is known about the specific causes of this variation.

In beef cattle price forecasting most of the available information has been qualitative as in many outlook reports. If a specific forecast was made, it was usually of the yearly average price. This could have been termed an intermediate forecast and would have been of limited use to most entrepreneurs. Intelligent long-run decisions, such as how much to invest, require a knowledge of prices for much longer periods of time. Most short-run decisions, such as when to market, should be made with a knowledge of prices over a very short period of time; generally speaking, the shorter the time period the better.

Very little work has been done in the area of short-term price forecasting. This thesis will be addressed to the problem of forecasting short-term beef cattle prices.

OBJECTIVES OF THIS STUDY

This study attempted to combine existing knowledge about economic theory, animal husbandry, and statistics to increase the body of knowledge in beef cattle prices. The results should give the entrepreneur

2/ Ibid., p. 120.

3/ Ibid., pp. 131-133.

a more objective basis for decision-making than was previously available.

More specifically the objectives were

- (1) to determine the most important variables affecting prices of fed cattle in the short run,
- (2) to establish the relationship between the important independent variables and prices of fed cattle, and
- (3) to develop methods for incorporating the relationships into meaningful short-run predictions of fed cattle prices.

REVIEW OF THE LITERATURE

The review of literature includes only those works that were of specific value in model formulation. A more complete listing of helpful information in the general area of beef cattle prices is included in the bibliography.

Wallace and Judge working at Oklahoma State University did an econometric analysis of the beef and pork sectors of the economy. ^{4/} They formulated complete annual models with the objective of obtaining structural coefficients. As a secondary objective they reviewed some alternative approaches to economic measurement. Their work was valuable as a study in methodology and contributed to variable selection.

At Purdue University, Cox, Eisenach, and Mitchell ^{5/} found that the two most important factors influencing the annual price of beef cattle were price level and total beef production. Those two factors explained 71% of the total variation in the annual farm price of beef cattle in the United States during the period 1931-1950. The remaining 29% of the variation was attributed to such variables as industrial production, per capita disposable income, wages of industrial workers, national income, price of native hides, number of beef cattle on farms, price of hogs, and exports and imports of beef. None of these variables taken independently was found to be significant once the effect of price level and beef production was considered.

Beef production was measured in total pounds of beef slaughtered each year. It was found to be largely associated with the number of cattle on farms, the number in the feed lots, and the condition of cattle on the range. The size of the corn crop influenced the number of cattle on feed, and range conditions influenced the condition of cattle on the range.

^{4/} Wallace, T. D., and Judge, G. G., Econometric Analysis of the Beef and Pork Sectors of the Economy, Oklahoma State University Agricultural Experiment Station, Technical Bulletin T-75, Stillwater, Oklahoma, August, 1958.

^{5/} Cox, C. B., Eisenach, E. J., and Mitchell, M. P., Beef Cattle Prices, Purdue University Agricultural Experiment Station, Bulletin No. 582, Lafayette, Indiana, January, 1953.

The annual demand and supply structure for beef as presented by Fox appears in Figure 1. 6/ This diagram gives a complete illustration of the annual beef cattle market. Later reference will be made to the relationships established by Fox and used in this diagram.

The preceding studies were important in understanding variables affecting yearly prices.

Hassler 7/ made a contribution to methodology by developing a single equation technique for forecasting monthly average prices six months in advance.

The procedure was to develop models which explained annual prices for beef and hogs. Monthly prices were then forecast using the forecasts of annual average prices. The year was divided into two segments-- January-July and August-December. The monthly forecast was made by using linear runs for the 2 six-month periods. Three sets of estimates were made for both the annual and the monthly forecasts. These estimates were chronological revisions as the relevant time period became closer.

The study was restricted to Choice slaughter steers weighing 900 to 1,000 pounds and Choice slaughter hogs weighing from 200 to 220 pounds. The markets used were Omaha and Los Angeles.

The direction of price trends was accurately predicted, but sizeable errors were made in forecasting specific prices. Hassler pointed out that the forecasts would be most useful to firms who plan to use them over a long period of time. The average accuracy would more than offset the errors made on specific occasions.

THE SETTING FOR THE PROBLEM

Before any model can be intelligently formulated, the researcher must be thoroughly familiar with the specific problem area. This section of the thesis is a description of the structure of the beef cattle market.

I. The Supply of Beef

On January 1, 1960, there were 96,236,000 head of cattle and calves on farms in the United States. By January 1, 1961, the number reached an estimated 97,000,000 which was above the previous all-time high inventory of 96,592,000 recorded on January 1, 1955. The farm value of the 1960 number was \$13,149,812,000. 8/

Figure 2 shows the geographic distribution of cattle and calves in 1960.

6/ Fox, Karl A., Econometric Analysis for Public Policy, The Iowa State University Press, Ames, Iowa, 1958 (reprinted 1960).

7/ Hassler, James B., Forecasting Prices of Slaughter Cattle and Hogs, California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 195, May, 1957.

8/ Livestock and Meat Statistics: Supplement for 1960 to Statistical Bulletin No. 230, A.M.S., U.S.D.A., Washington, D.C., June, 1961.

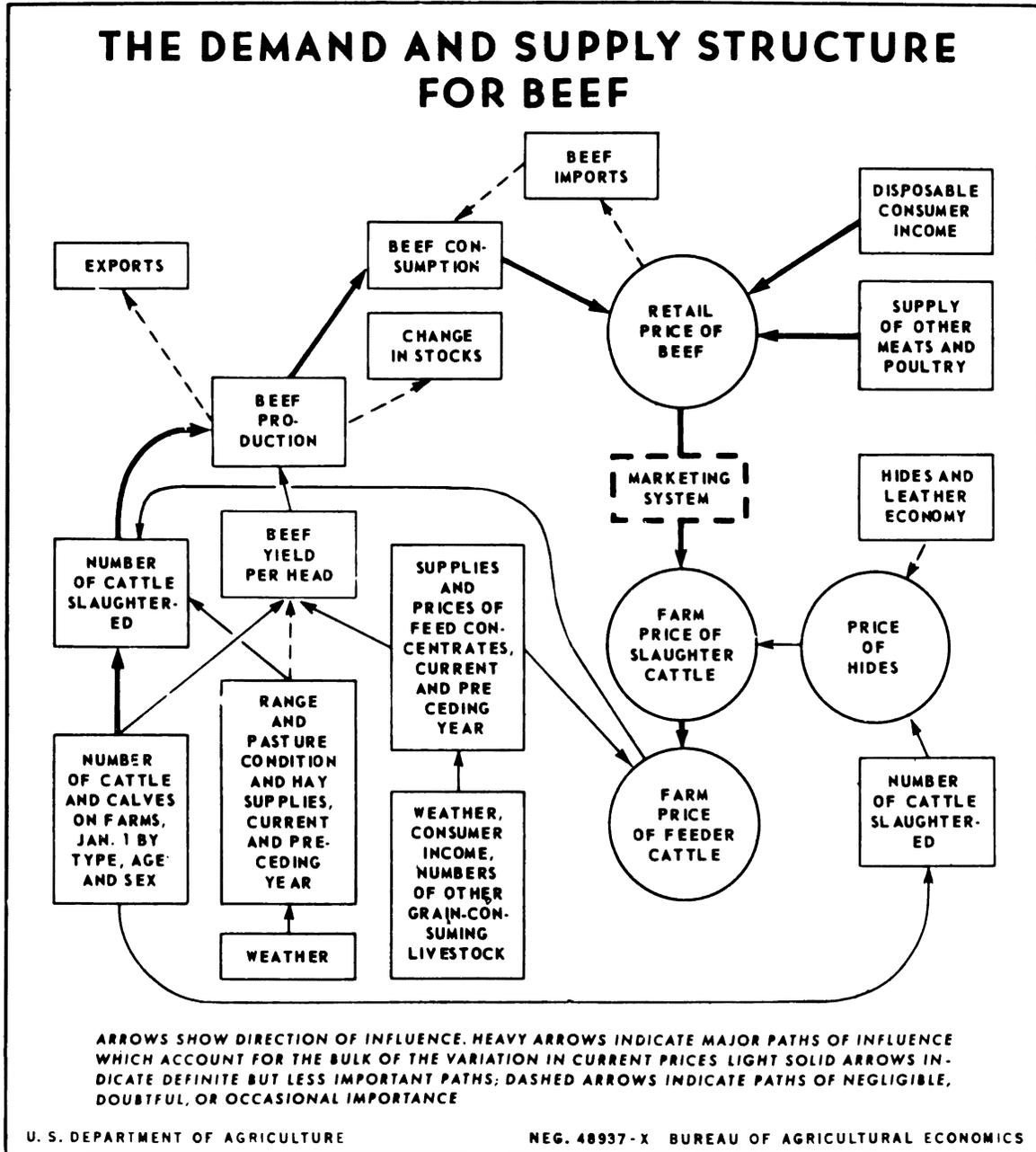


Figure 1



Figure 2. The Geographic Distribution of Cattle and Calves on Farms January 1, 1960.

These animals fall into either of two broad categories according to their primary use. The categories are (1) those kept for milk, and (2) those kept for other uses (primarily beef stock). The cattle and calves in these two groups represent the total potential supply of beef within this country.

As is shown in Figure 3 there has been a decline in milk stock numbers relative to those kept for other uses. Of the January 1960 number, about 31.4% were dairy animals and about 68.6% were non-dairy animals. The 1960 figure of 30,181,000 head was the lowest number of milk cattle recorded since 1921. On the other hand, the 66,055,000 cattle in the non-dairy category was a record high. 9/

The cattle kept primarily for beef can be broadly classified as (1) cattle fed primarily concentrates, and (2) cattle fed primarily roughage. Generally speaking, production factors have brought about a geographic distribution of these groups into two major areas: (1) the Corn Belt, and (2) the Western Range. These two production areas typify beef production in the group classifications listed above even though other regions have increased in relative importance in recent years.

The abundance of concentrates, the high factor-product ratio, 10/ and nearness to markets have been instrumental in bringing about a concentration of cattle feeding in the Corn Belt. About 11% of the cattle and calves on farms on January 1, 1960, were on feed. 11/ Of this number, approximately 65% were located in the North Central States. Figure 4 gives the distribution of fed cattle by regions from 1935 through 1960. Fed cattle have generally constituted about one third of total slaughter marketings. 12/ These cattle are normally marketed in the Prime, Choice, and Good grades.

The cattle fed primarily roughage fall into several minor groups. Breeding stock, stocker and feeder cattle, and calves constitute the major part of the roughage-fed category. This category is typically referred to as non-fed cattle. While production of these animals is more widespread geographically than the former group, the greatest concentration is in the Western Range Area. Abundant acreage of pasture and grass has brought about specializations in production of stocker, feeder, and breeding cattle. Nine Western Range States supply 89% of the stocker-feeder cattle and calves shipped into the Corn Belt. 13/ These same nine states accounted for 45% of the calves

9/ Livestock and Meat Statistics: Statistical Bulletin No. 230, July, 1958, and Supplement for 1960 to Statistical Bulletin No. 230, June, 1961, A.M.S., U.S.D.A., Washington, D.C.

10/ High factor-product ratio relative to such livestock as chicken broilers and market hogs.

11/ Livestock and Meat Statistics, op. cit.

12/ Ibid., and Cattle and Calves on Feed, Crop Reporting Board, A.M.S., U.S.D.A., Washington, D.C.

13/ North Central Livestock Marketing Research Committee, Marketing Feeder Cattle and Sheep, Nebraska Experiment Station, Bulletin No. 410, Lincoln, Nebraska, May, 1952, p. 13.

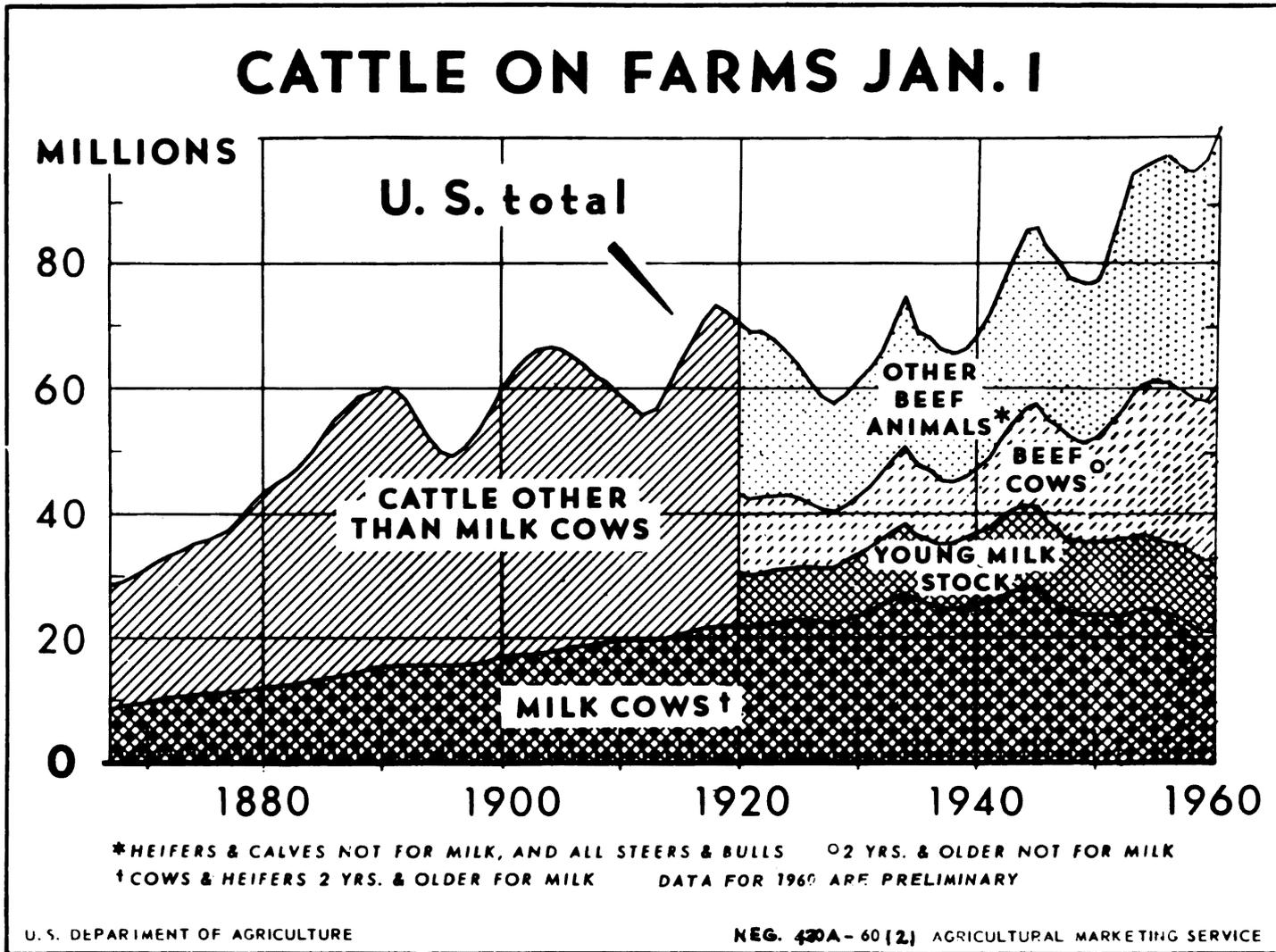


Figure 3

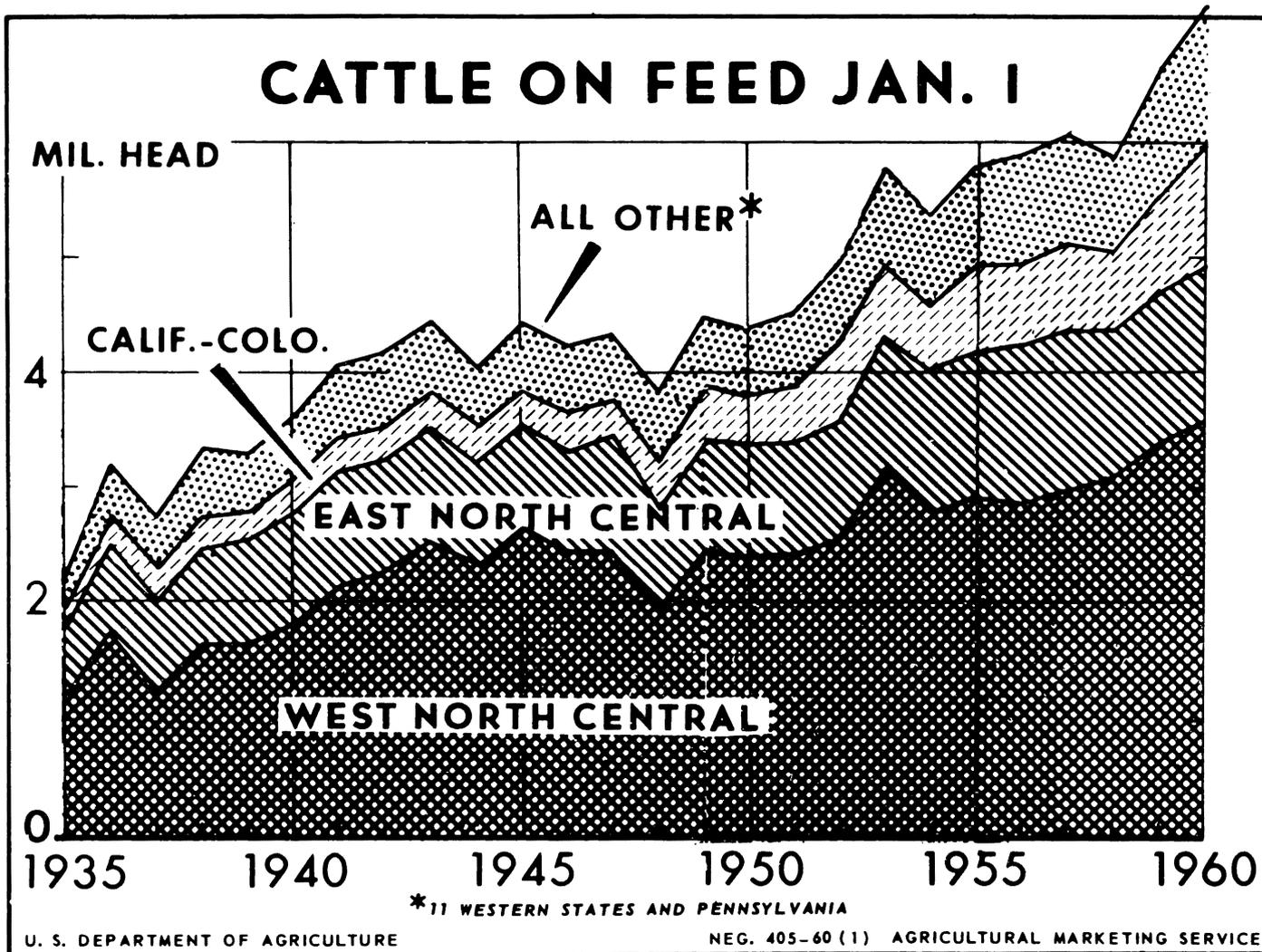


Figure 4

and about 48% of the beef cows 2 years old and older on farms in the United States on January 1, 1960. 14/

In recent years foreign trade has been of little importance to the beef industry of this country. The United States was once a leading exporter of beef, but exports have amounted to less than one percent of total production since 1912 with the exception of a brief period following World War II. 15/ Likewise, imports have not made up an appreciable amount of total production and consumption. 16/

II. The Demand for Beef

Food has made up about 21% of total personal consumption expenditures in the United States in recent years. Meat has accounted for 25-30 percent of consumer's food expenditures. Various species and cuts have competed for the portion of the consumer's dollar that has been spent for meat. 17/

Total red meat consumption per capita increased 17% during the period from January 1, 1951, to January 1, 1960. The increase in population during this same period was 17.3%. The most significant increase in consumption of total red meat was in beef which registered an increase of 52%. In 1960, beef consumption amounted to almost 53% of total red meat consumption. 18/

As with other food commodities, there has been a trend toward more processing, preparation, and packaging of meat and meat products. 19/ The meat packing industry has been one of the major food manufacturing industries, ranking second only to bakeries in the number of employees and third in value added by manufacture. 20/ Fresh and frozen meat accounted for 50.3% of the total meat used according to the one-week spring survey conducted in 1955 by the United States Agricultural Marketing Service. The remaining 49.7%

14/ Livestock and Meat Statistics, op. cit.

15/ Cox, C. B., Eisenach, E. J., and Mitchell, M. P., op. cit., p. 12.

16/ Butz, Dale E., and Baker, George L., Jr., op. cit., p. 5.

17/ Ibid.

18/ Consumption data supplied on request by Economic and Statistical Analysis Division, A.M.S., U.S.D.A., Washington, D.C.

19/ Butz, Dale E., and Baker, George L., Jr., op. cit., p. 8.

20/ Meat Consumption Trends and Patterns, Agricultural Economics Division, A.M.S., U.S.D.A., Agriculture Handbook No. 187, Washington, D.C., July 1960, p. 1.

was processed meat. 21/ There is reason to believe that processed meat has grown in relative importance in recent years. 22/

A popular but erroneous belief with many people was that large amounts of meat were held in cold storage or were frozen. The total cold storage capacity for fresh meat in this country would only carry about two weeks average consumption, 23/ thereby indicating that the cold storage demand for meat is relatively unimportant.

Population distribution into various classes has been important in explaining variation in meat consumption. The following three important factors have influenced both the quantity and kind of meat consumed. 24/

(1) Region

As is illustrated in Figure 5, the West and the North Central States were the greatest beef consumers per capita in the spring of 1955. The South was the lowest.

(2) Urbanization

In all regions except the South total red meat consumption was about the same for urban and farm households. There was, however, a greater variation in beef consumption in rural areas than in urban areas among the regions in the survey. Urban population in the South ate a little less beef per capita than urban populations elsewhere, but rural beef consumption in the South was only about one half that of rural areas in other regions.

(3) Income

According to the 1955 meat consumption study, households with high incomes used more meat per person than the lower income households. The higher income families used more beef and used more of the higher priced cuts per capita. The income elasticity (based on quantity) for all meat was approximately .35. The income elasticity for beef was .4.

Figure 6 presents the market for meat in the United States in the spring of 1955. The North Central and Northeast Regions were the most

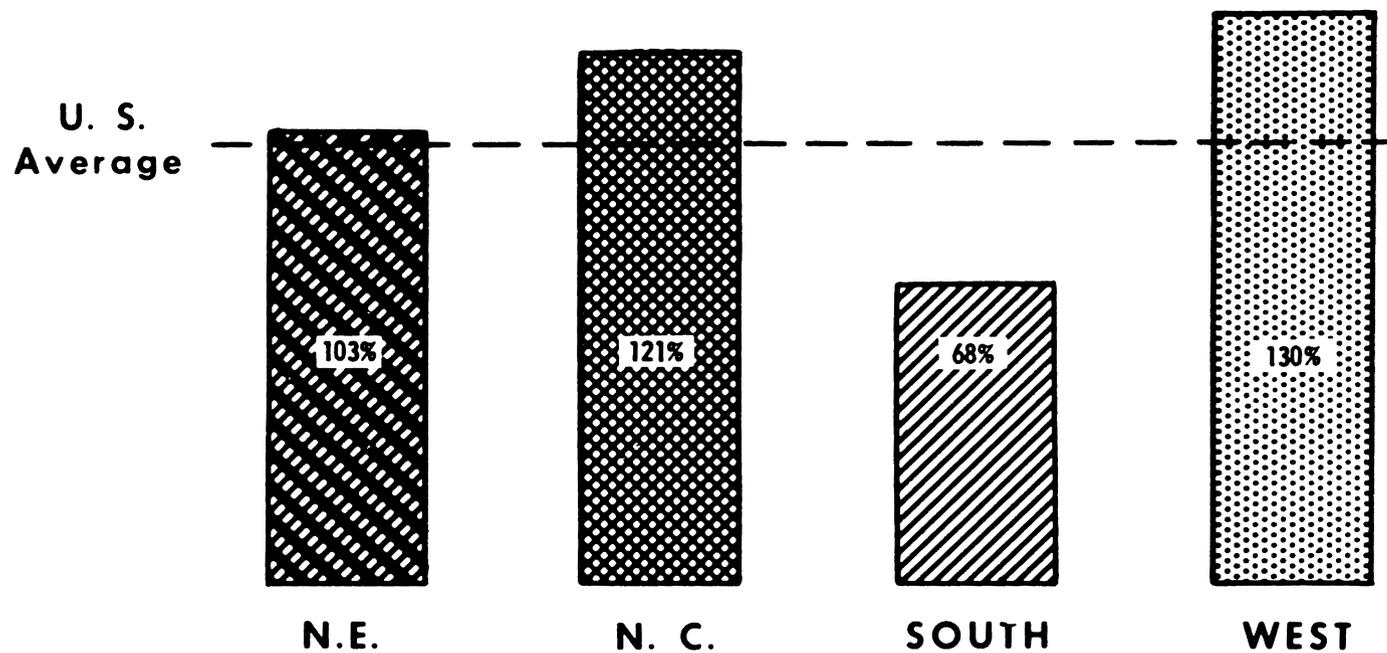
21/ Breimyer, Harold, and Krause, Charlotte, Consumption Patterns for Meat, Bulletin No. 249, A.M.S., U.S.D.A., Washington, D.C., May, 1958, pp. 8, 10.

22/ Butz, Dale E., and Baker, George L., Jr., op. cit., p. 8

23/ Kohls, R. L., Marketing of Agricultural Products, The Macmillan Company, New York, 1961, p. 284.

24/ Meat Consumption Trends and Patterns, op. cit., Section II, pp. 10-22.

REGIONAL DIFFERENCES IN BEEF CONSUMED AT HOME * (Per Person)



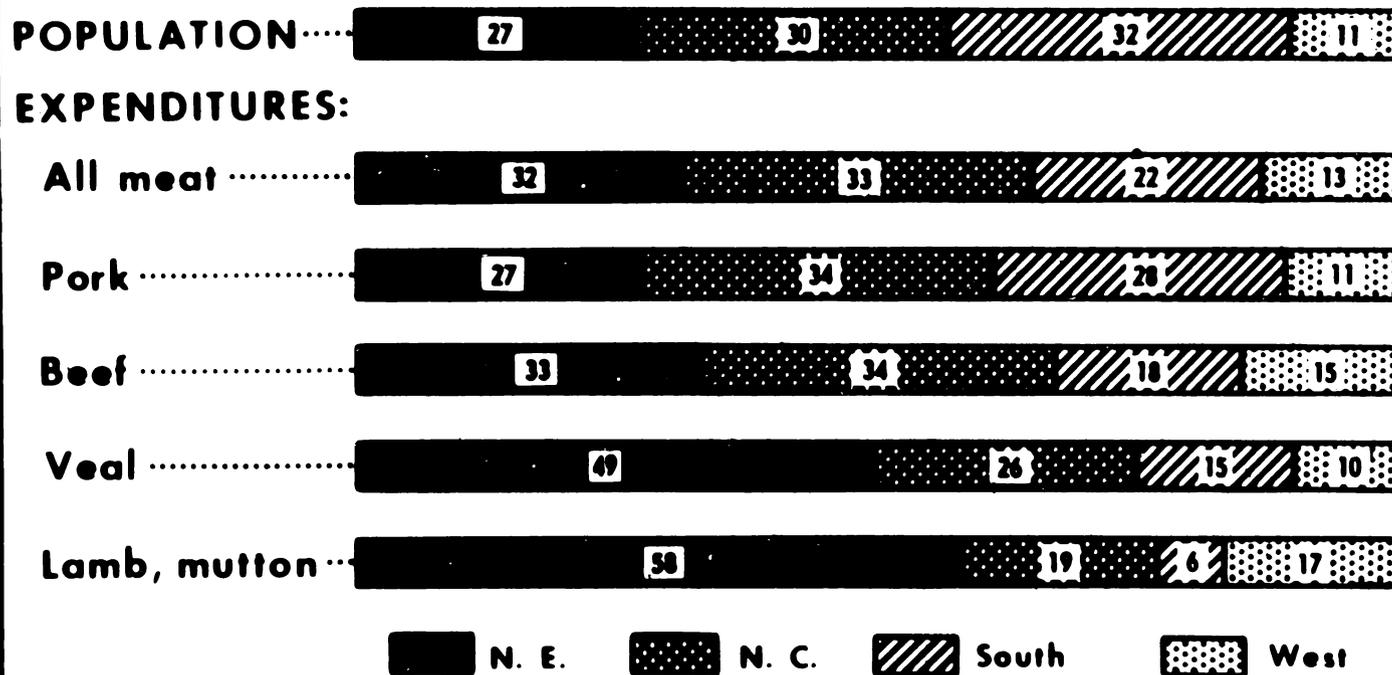
AS PERCENTAGE OF U. S. AVERAGE POUNDAGE, SPRING 1955.

U. S. DEPARTMENT OF AGRICULTURE

NEG. 7687-60 (3) AGRICULTURAL MARKETING SERVICE

Figure 5

REGIONAL SHARES OF HOUSEKEEPING POPULATION AND HOUSEHOLD EXPENDITURES FOR MEAT, SPRING 1955 *



* FIGURES REPRESENT PERCENTAGE OF U. S. TOTAL.

Figure 6

important meat markets. The Northeast had less population than the North Central, and less meat was eaten per capita; but a greater quantity was bought at higher prices than in other regions. The North Central and Northeast had the largest shares of the beef market. If quantity rather than expenditure were used as a measuring criterion, the South would have had a larger share of the market than is shown in Figure 6. This can be attributed to the sale of lower priced cuts in the South. 25/

The future is uncertain; however, Butz and Baker expressed a belief that most of the change in total meat consumption in the future will be the result of increases in population and not changes in per capita consumption. They were also of the opinion that beef consumption will grow at a faster rate than pork consumption. 26/

PROCEDURE

I. Introduction

In this section an attempt is made to describe the general model formulation decision-making process and to indicate the specific decisions made in formulating the model.

II. Variable Selection

The review of literature and knowledge of the specific problem area indicated that the following factors should be considered in a study of beef cattle prices.

A. The supply of fed beef

Despite Plaxico's 27/ feeling that the supply of fed cattle was fairly constant throughout the year, this factor was hypothesized to be of sufficient importance to be included as a variable.

B. The supply of competing products

1. Pork

Pork has generally been considered the closest competing commodity with beef. 28/

2 25/ Ibid.

26/ Butz, Dale E., and Baker, George L., Jr., op. cit., pp. 14-19.

27/ Plaxico, James S., and James, Jackson L., Beef Cattle Prices, Oklahoma A & M College Agricultural Experiment Station, Bulletin No. B-486, Stillwater, Oklahoma, February, 1957, p. 5.

28/ Fox, Karl A., op. cit., p. 81.

2. Non-fed beef

An increase in the relative importance of processed beef discussed earlier suggested the possibility of a high-cross elasticity between non-fed and fed beef. The fluctuations in the supply of non-fed beef were much greater than those for fed beef. With these facts in mind non-fed beef was hypothesized to be very important in determining the price of fed cattle.

3. Poultry and other meats

It was suggested that poultry and/or other non-red meats might compete with fed beef in the market. 29/ This was hypothesized to be of minor importance.

C. Beef consumption

Consumption and production have been essentially equal during any time period. Wallace and Judge 30/ suggested that there may be some inelasticity in the demand for beef due to slow consumer reaction in response to changing prices and/or quantities of beef. Lagged consumption of beef was therefore hypothesized to be related to fed beef prices.

D. Consumer income

Discretionary income was hypothesized to be the best income demand shifter for fed beef. 31/ Discretionary income, an adjusted disposable income, was hypothesized to give the most accurate measure of the income available for the purchase of high quality beef. Other readily available income measures were disposable income and total personal income.

E. Population

Demand was hypothesized to be related to population.

III. General Considerations

The following are certain decisions that were made in model formulation.

29/ Ibid., p. 79.

30/ Wallace, T. D., and Judge, G. G., op. cit., p. 17.

31/ A complete explanation of the concept of discretionary income and the procedure for its calculation is presented by Franklin, W. B., Discretionary Income, Technical Paper No. 6, National Industrial Conference Board, New York 22, New York, 1958.

A. Selection of class and grade

Of the Prime, Choice, and Good slaughter steers and heifers marketed at five selected terminal cattle markets, 32/ 69% were steers and 31% were heifers. 33/ Steers were selected as the class to be studied.

The following composition was found among slaughter steers sold in the top three grades at seven selected markets: 34/ Prime, 6%; Choice, 56%; and Good, 38%. 35/ Choice was selected as the grade most indicative of the fed steer market. 36/

B. Selection of a specific price

The Chicago market has generally been considered the most influential market in affecting Virginia's fed cattle prices. Chicago has been the largest fed cattle market in the United States and the closest large cattle market to Virginia. Chicago is also centrally located nationally. For these reasons the Chicago price was selected.

Marketing margins were assumed to be constant over short time periods. If this assumption is valid, the demand for beef at retail is accurately reflected in the price at the farm and at all other levels in the marketing process. This assumption was in conflict with ideas expressed by Hassler 37/ and Maki 38/. Further investigation to test the validity of this assumption is suggested.

32/ Denver, Kansas City, Sioux City, South St. Joseph, and St. Louis National Stockyards.

33/ Livestock and Meat Statistics: Statistical Bulletin No. 230, July, 1958, and Supplements for 1958, 1959, and 1960 to Statistical Bulletin 230, A.M.S., U.S.D.A., Washington, D.C.

34/ Chicago, Omaha, Denver, Kansas City, Sioux City, South St. Joseph, and St. Louis National Stockyards.

35/ Livestock and Meat Statistics, op. cit.

36/ Note: The selected terminal markets may have been biased in distribution by class and grade but were assumed to be sufficiently accurate for the above decisions.

37/ Hassler, James B., op. cit., p. 3.

38/ Maki, Wilbur R., Forecasting Beef Cattle and Hog Prices by Quarter-Years, Agricultural and Home Economics Experiment Station, Iowa State University, Research Bulletin 473, December, 1959.

C. Selection of a time period

1. To be specifically forecast

The shorter the forecast time periods and the farther in advance these forecasts can be made with reliable accuracy, the more useful the forecast.

Since the only data readily available on intra-year cattle supplies were published quarterly, the first models were quarterly models. Later a method of obtaining monthly estimates was developed. The final models were monthly models.

2. Which the data will cover

The original plan was to cover a ten-year period. This would include all phases of the cattle cycle and would be current enough to apply to present conditions. However, the data were too limited prior to 1955 to be used in this study.

The data used covered the six-year period from January 1, 1955, to January 1, 1961. While the relatively short time period limited the number of observations, it may, nevertheless, have provided more accurate quantitative measures of current short-run relationships than would a longer time period with more observations. If there was a gradual, non-random, structural change not easily expressed as a function of time, data covering a longer time period may give average structural coefficients not consistent with current conditions. 39/

D. Selection of data

Secondary, time series data were used. The only available aggregate data were compiled by various governmental and industrial agencies. An attempt was made to use data that could be readily obtained, thereby giving wider use to the forecasting procedure.

Data on price, supply, and consumption were obtained from various statistical and research bulletins of the Agricultural Marketing Service of the United States Department of Agriculture. Income data came from publications of the United States Department of Commerce and the National Industrial Conference Board. Population data were published in reports of the United States Bureau of Census.

IV. Economic and Econometric Considerations

A. Choice of a economic model

The single equation method was selected to express the economic relationships to be investigated. There were at least two reasons for its selection.

39/ Hassler, James B., op. cit., p. 3.

- (1) The primary objective of this research was to develop a method of forecasting prices rather than structural identification.
- (2) The data available did not seem to be sufficiently accurate and adequately detailed to justify a simultaneous equation model.

The following questions were borrowed from Fox 40/ for use in organizing an investigation of the applicability of the single equation model. 41/

- (1) Is the supply of fed beef predetermined?

For time periods as short or shorter than a quarter the potential supply of fed cattle was considered in existence and in most cases had been on feed for some time. Results from later attempts to forecast this variable supported this belief.

- (2) Is consumption predetermined?

According to Fox over 98% of the year-to-year variation in domestic consumption of beef was associated with corresponding variation in beef production. The coefficient of determination was 85% when expressing beef consumption as a function of the predetermined or exogenous variables used in explaining beef production. It seemed that if annual consumption was largely predetermined the same would also be true for shorter time periods.

- (3) Is consumer income predetermined?

Fox pointed out that the major farm products--pork, beef, and fluid milk--each accounted for only two to three percent of disposable personal income, therefore income was essentially determined by exogenous factors.

- (4) Is the supply of competing commodities predetermined?

Fox stated that pork production in a given year or season was almost wholly predetermined. He also considered beef production during any year to be essentially predetermined. According to him 85% of the variation in beef production was explained by variables existing at or before the beginning of the calendar year and by exogenous factors which operated during the calendar year.

40/ Fox, Karl A., op. cit., pp. 3, 33.

41/ Ibid., pp. 34-42.

The cattle which fell into the non-fed category were stocker and feeder cattle and breeding animals. It seemed that the supply of these animals was determined by exogenous variables such as range conditions or lagged endogenous variables such as the price of feeder cattle. Fox also considered the supply of poultry and some other meats to be largely predetermined.

Having drawn the above conclusions, the single equation model was assumed to approach closely the conditions necessary for accurate estimates of structural coefficients as well as being a useful forecasting procedure.

B. Choice of a statistical estimating procedure

The least squares method was selected as the statistical estimating procedure. The disturbances were assumed to be normally distributed, so the least squares estimates should coincide with maximum likelihood estimates. 42/

C. Adjustments in the data

1. Choice of algebraic variable form

There was little reason to believe that the relationships were multiplicative rather than additive. Both actual observations and percentage changes from one time period to another were used since there did not seem to be enough a priori knowledge for the selection of one over the other.

2. Consideration of time lag

Both lagged and non-lagged relationships were investigated since either might apply.

3. Other adjustments to consider

a. Seasonal adjustment

In the quarterly analysis data were not seasonally adjusted. If the behavior of the variables was found to be different for specific quarters indicating, for instance, a seasonal pattern, observations were to be grouped by quarters for analysis.

b. Population adjustment

All variables were put on a per capita basis to allow for shifts in demand due to population changes.

42/ Ibid., p. 43.

c. Adjustment for changes in the general price level

The general price level was not considered to be a factor since the wholesale price index was relatively stable during the years 1955-1960.

ANALYSIS

I. The Quarterly Model

A. The following single equation model was postulated to explain quarterly fed cattle price variation.

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + E$$

where:

Y = Price of Choice slaughter steers Chicago 43/

X₁ = Beef consumption per capita (t-1 quarter) 44/

X₂ = Per capita supply of non-fed cattle (t)

X₃ = Per capita supply of pork (t)

X₄ = Per capita supply of fed cattle (t)

E = Unexplained error

No non-seasonally adjusted data on consumer income were found. As a result, neither discretionary, nor disposable, nor total personal income could be used as a demand shifter in the above equation.

The supply of fed cattle was assumed to be the same as marketings of fed cattle published quarterly in Cattle and Calves on Feed reports by the Agricultural Marketing Service. Upon request, per capita beef consumption data were furnished by the Economic Research Service of the United States Department of Agriculture. The supply of non-fed cattle was calculated by subtracting fed cattle marketings from total slaughter numbers. Chicago Choice slaughter steer prices, total cattle slaughter, and commercial hog slaughter were obtained from Livestock and Meat Statistics published by the Agricultural Marketing Service.

The supply variables were expressed in terms of numbers marketed or slaughtered rather than weights marketed or

43/ Average quarterly price based on monthly averages for three months.

44/ "t" refers to the current time period; in this case the current quarter.

slaughtered. Weights would have been used had the data been available for more than the large terminal markets. The number of fed cattle sold through these terminal markets was not believed to be sufficiently large to warrant use of weights in the model.

B. The statistical results

$$Y = .6892 - .2254 X_1 - 3.8693 X_2 - .1900 X_3 - 15.7080 X_4$$

$$R^2 = .7154$$

Analysis of Variance

| Source | d.f. | S.S. | M.S. | F |
|--|------|---------|---------|-----------|
| Reg. due to X_1 | 1 | .002682 | .002682 | 10.5176** |
| Red. due to X_2 over X_1 | 1 | .006813 | .006813 | 26.7176** |
| Red. due to X_3 over X_1, X_2 | 1 | .000518 | .000518 | 2.0314 |
| Red. due to X_4 over X_1, X_2, X_3 | 1 | .002179 | .002179 | 8.5451** |
| Regression | 4 | .012191 | .003048 | 11.9529** |
| Error | 19 | .004849 | .000255 | |
| Total | 23 | .017040 | | |

** .01 significance level
* .05 significance level

t-test

$$H_0 : B_1 \stackrel{>}{\neq} 0$$

$$H_0 : B_2 \leq 0$$

$$t_2 = 5.8203**$$

$$H_0 : B_3 \leq 0$$

$$t_3 = .7755$$

$$H_0 : B_4 \leq 0$$

$$t_4 = 3.2952**$$

C. Discussion of the results

The preceding multiple regression equation was used for exploratory purposes. The supply of pork was not closely

associated with the price of Choice steers. This agrees with the results obtained by Stanton. ^{45/}

Since the supply of pork was not significant, it was removed from further consideration unless additional information indicated its importance. Poultry and other non-red meats were thought to be of less importance than pork as a competing commodity, so these meats were also removed from further consideration under the same conditions.

The one-tailed t-test was used since economic theory limits consideration to one direction. The negative coefficient on beef consumption t-1 quarter is opposite the sign expected if it were a demand variable, therefore no t-statistic was calculated for B₁. Because of the production-consumption relationship, later consideration was given this variable as a lagged supply rather than as a demand indicator.

Both the supply of non-fed and of fed cattle were statistically significant in the regression equation and with the t-test. These two variables were each plotted against Choice steer prices in scatter diagrams to see if any pattern peculiar to specific quarters could be found. Observations were limited, but quarterly patterns were indicated.

D. Independent quarterly regressions

The data were grouped by quarters. For example, the six observations on the first quarter were grouped together. This was done for all four quarters for the six years available data. Simple regressions were used with price as the dependent variable and supply as the independent variable to establish associations for each quarter. Alternative supply time lags and variable forms were also investigated.

1. Results

The following are the results of the regressions. In each case the equation was of the form $Y = a + bX$. Y and X are explained with the results of each regression.

a. Non-fed cattle and calves

- (1) Y = Price of Chicago Choice slaughter steers
X = Per capita supply of non-fed cattle

| Quarter | Time period | |
|---------|------------------------|------------------------|
| | t | t-1 |
| 1 | R ² = .5105 | R ² = .5723 |
| 2 | .8216 | .7259 |
| 3 | .6422 | .5875 |
| 4 | .5758 | .6238 |

^{45/} Stanton, B. F., "Seasonal Demand for Beef, Pork, and Broilers," Agricultural Economics Research, A.M.S., U.S.D.A., Washington, D.C., January, 1961.

- (2) Y = Percentage change in price of Chicago Choice slaughter steers
 X = Percentage change in per capita supply of non-fed cattle

| Quarter | Time period | |
|---------|------------------------|------------------------|
| | t | t-1 |
| 1 | R ² = .0324 | R ² = .1994 |
| 2 | .1787 | .1461 |
| 3 | .2385 | .0202 |
| 4 | .1410 | .0003 |

b. Non-fed cattle less calves

- (1) Y = Price of Chicago Choice slaughter steers
 X = Per capita supply of non-fed cattle less calves

| Quarter | Time period | |
|---------|------------------------|------------------------|
| | t | t-1 |
| 1 | R ² = .5444 | R ² = .5578 |
| 2 | .8658 | .7462 |
| 3 | .6733 | .6387 |
| 4 | .5304 | .6157 |

- (2) Y = Percentage change in price of Chicago Choice slaughter steers
 X = Percentage change in per capita supply of non-fed cattle less calves

| Quarter | Time period | |
|---------|------------------------|------------------------|
| | t | t-1 |
| 1 | R ² = .0020 | R ² = .3744 |
| 2 | .1259 | .2428 |
| 3 | .3298 | .0637 |
| 4 | .1499 | .0244 |

c. Fed cattle

- (1) Y = Price of Chicago Choice slaughter steers
 X = Per capita supply of fed cattle

| Quarter | Time period | |
|---------|------------------------|-------|
| | t | t-1 |
| 1 | R ² = .0949 | .0261 |
| 2 | .1336 | .0126 |
| 3 | .3226 | .1608 |
| 4 | .1591 | .4217 |

- (2) Y = Percentage change in price of Chicago Choice slaughter steers
 X = Percentage change in per capita supply of fed cattle

| Quarter | Time period | |
|---------|------------------------|------------------------|
| | t | t-1 |
| 1 | R ² = .5684 | R ² = .9197 |
| 2 | .8852 | .2232 |
| 3 | .8215 | .3044 |
| 4 | .4339 | .1410 |

2. Discussion of the results

The limited observations did not warrant tests of statistical significance. Emphasis should be given to the fact that with the very small number of observations no conclusions could be drawn. Very general comments will be made about the suggested relationships. The b values were observed to be the same in sign as appeared in the original multiple regression equation and were not calculated.

The per capita supply of non-fed cattle during the second and third quarters gave the highest coefficient of determination. There was little difference between the regressions which included calves and those which did not include calves as a part of supply. The coefficients of determination were much lower when percentage changes in the price of Choice steers and percentage changes in the supply of non-fed cattle were used in the regression equations. A proper supply lag could not be established from the analysis.

The percentage changes in the price of Choice steers and supply of fed cattle yielded higher coefficients of determination than when actual figures were used. This was expected since the supply of fed cattle (in the original or absolute form) was relatively constant. The percentage change in the price of fed cattle from the fourth to the first quarter was very closely associated with the percentage change in supply from the third to the fourth quarter over the six years observed. Non-lagged percentage changes in price and supply were closely related during the second and third quarters.

None of the variables independently seemed to be very closely associated with the price of Choice steers during the fourth quarter. The most desirable algebraic variable forms and time lags were not established. In general it seemed, however, that the early supply of non-fed cattle was one of the most important determinants of price.

II. Monthly Simple Regression Models

The results of the quarterly analysis indicated that more exploratory work was needed if a satisfactory forecasting procedure was to be developed.

As was mentioned previously the quarterly model was attempted first since no monthly figures were available to indicate marketings of either fed or non-fed cattle. However, the Cattle and Calves on Feed reports published quarterly by the Agricultural Marketing Service contained expected marketings for each of the three months following each publication. Expected marketings were used to estimate monthly marketings of fed cattle. ^{46/} The monthly supply of non-fed cattle was calculated by subtracting fed cattle marketings from total cattle slaughter numbers.

A measure of monthly consumer income seemed most logical for a demand shifting variable. The only readily available measure of monthly income seemed to be total personal income published by the United States Department of Commerce. ^{47/} It must be remembered that access to the variables was one criterion for variable selection--subject, of course, to its contribution to the regression.

All monthly data used were seasonally adjusted. The 12-month moving average was used to adjust all data except total personal income. Total personal income was seasonally adjusted before released.

Numerous simple regressions were calculated to increase the author's knowledge of the association between each of these variables and price. Both lagged and non-lagged relationships were tested. Both percentage change and actual numbers were used to see which variable form gave the best fit. In each case the model was of the form $Y = a + bX$. Y and X are explained with the results of each regression.

A. Monthly simple regression results

1. Non-fed cattle

- a. Y = Average monthly price of Chicago Choice slaughter steers
- X = Per capita supply of non-fed cattle

| | t | t-1 |
|------------------------------|-------|-------|
| Coefficient of determination | .8479 | .8074 |

^{46/} Expected marketings were based on survey data from cattle feeders in 13 selected states from January 1955 until July 1960. From July 1960 until January 1961 the only expected marketings published were based on usual relationships between survey data and actual marketings in 26 selected states. Although this created a problem, there was no reason to believe that the total monthly marketing distributions would change appreciably with the inclusion of the additional states. The original 13 states accounted for an average of 86% of the cattle marketed in the 26 states.

^{47/} Business Statistics: A Supplement to the Survey of Current Business, Office of Business Economics, U.S. Dept. of Commerce, Washington, D. C.

- b. Y = Percentage change in average monthly price of Chicago Choice slaughter steers
 X = Percentage change in per capita supply of non-fed cattle

| | | |
|------------------------------|----------|------------|
| | <u>t</u> | <u>t-1</u> |
| Coefficient of determination | .2862 | .4425 |

2. Fed cattle

- a. Y = Average monthly price of Chicago Choice slaughter steers
 X = Per capita supply of fed cattle

| | | |
|------------------------------|----------|------------|
| | <u>t</u> | <u>t-1</u> |
| Coefficient of determination | .2543 | .2103 |

- b. Y = Percentage change in average monthly price of Chicago Choice slaughter steers
 X = Percentage change in per capita supply of fed cattle

| | | |
|------------------------------|----------|------------|
| | <u>t</u> | <u>t-1</u> |
| Coefficient of determination | .2862 | .4425 |

3. Total personal income

- a. Y = Average monthly price of Chicago Choice slaughter steers
 X = Per capita total personal income

| | | | | |
|----------------|----------|----------------|--------------------|--------------------|
| Coefficient of | <u>t</u> | <u>t-1 mo.</u> | <u>t-3 mo. av.</u> | <u>t-6 mo. av.</u> |
| determination | .5722 | .6052 | .6236 | .6638 |

B. Discussion of the results of the simple regressions

The results of the simple regression analysis were useful in an exploratory sense. The high coefficients of determination were attributed in part to the seasonal adjustment of the data.

The supply of non-fed cattle appeared to be an extremely important factor in determining the price of Choice steers. The coefficient of determination was greater than in the quarterly analysis (See page 23). The supply of fed cattle was of less importance than the non-fed cattle but remained a factor to be considered.

The percentage change in both supply variables was most closely associated with percentage change in price when they were lagged a quarter. The values obtained using percentage changes of non-fed cattle and Choice steer prices were considerably less than those obtained using actual numbers. The results were about the same for both variable forms in the analysis using fed cattle and Choice steer prices. This is in contrast to the quarterly model where the results of

the fed cattle analysis using percentage changes were considerably higher than those using actual numbers and prices.

The analysis of total personal income and price of Choice steers supports the hypothesis that the buying pattern for high quality beef lags changes in income.

III. Monthly Multiple Regression Models

A three-variable multiple regression model was formulated using the price of Choice slaughter steers at Chicago as the dependent variable with per capita supply of non-fed cattle and per capita total personal income as independent variables ($R^2 = .7945$). The residuals were plotted and found to be closely associated with fed cattle supplies. A multiple regression model using all four variables was postulated.

Although results obtained using different time lags in the independent simple regressions were worthwhile in an exploratory sense, they would not necessarily apply in formulating the multiple regression model. Several multiple regressions using different supply lags for X_1 and X_2 were tried in an attempt to obtain the best fit in the four-variable model. The six-month average total personal income per capita was used as the third independent variable.

It is important to note that all possible combinations of lagged variables have not been used. It is therefore quite possible that the optimum combination of lags was not obtained.

In each case the highest multiple coefficient of determination was used as the criterion for selecting time lags. The author is aware of the limitations of this type of analysis. However, in the absence of a priori knowledge, the coefficient of determination is the best evidence of optimum time lag.

Further analysis of time lags can be considered in future research if there is a feeling that meaningful contributions can be made.

A. The trial models

1. The model

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + E$$

where:

Y = Average monthly price of Chicago Choice slaughter steers

and:

X_1 = Per capita supply of fed cattle (t or t-? mo.)

X_2 = Per capita supply of non-fed cattle (t or t-? mo.)

X_3 = Per capita total personal income (t-6 mo. ave.)

E = Unexplained error

2. The results

| | Time period <u>48/</u> | | | |
|------------------------------|------------------------|-------|-------|-------|
| | t | t-1 | t-2 | t-3 |
| Coefficient of determination | .9770 | .9853 | .9955 | .9879 |

The model with the two-month lag in both supply variables gave the highest coefficient of multiple determination. Further statistical analysis was made of this model.

B. The final model

1. The model

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + E$$

where:

Y = Average price of Chicago Choice slaughter steers

and:

X_1 = Per capita supply of fed cattle (t-2 mo.)

X_2 = Per capita supply of non-fed cattle (t-2 mo.)

X_3 = Per capita total personal income (t-6 mo. av.)

E = Unexplained error

2. The results

a. The coefficients

$$Y = .503935 - 87.2300 X_1 - 20.7760 X_2 + 153.9300 X_3$$

$$R^2 = .9955$$

(1) Explanation

The unit used to express the data on supplies of fed and non-fed cattle was the number of animals slaughtered per capita. Total personal income was expressed in billions of dollars per capita. The regression coefficient B_1 indicates that with a 1 unit change in the number of fed cattle slaughtered per capita the price of Choice slaughter steers at Chicago changed 87.23 units in the opposite direction. B_2 and B_3 can be interpreted similarly.

48/ Time period refers only to the supply variables.

In interpreting the results it must be remembered that the ranges over which these relationships were established were .005795 to .008793 non-fed cattle per capita per month, .004476 to .005161 fed cattle per capita per month, and .00181 to .00227 million dollars per capita per month on a seasonally adjusted annual basis.

The multiple coefficient of determination was .9955. In other words, 99.55% of the variation in the price of Chicago Choice slaughter steers was explained by the regression due to the variables X_1 , X_2 , and X_3 .

b. Analysis of Variance

| Source | d.f. | S.S. | M.S. | F |
|---|------|-----------|-----------|-------------|
| Reg. due to X_1 | 1 | .00599283 | .005993 | 2066.5517** |
| Red. due to X_2 over X_1 | 1 | .02548805 | .025488 | 8788.9655** |
| Red. due to X_3 over X_1 and X_2 | 1 | .00310169 | .003102 | 1069.6552** |
| Regression | 3 | .034583 | .011528 | 3975.1724** |
| Error | 54 | .000157 | .00000290 | |
| Total | 57 | .034740 | | |

** .01 significance level

* .05 significance level

(1) Explanation

The F-test indicated that a significant amount of the variation in the price of Choice slaughter steers at Chicago was explained by the regression due to the per capita supply of fed cattle. The per capita supply of non-fed cattle explained a significant amount over that which was explained by the supply of fed cattle per capita. Total personal income per capita explained a significant amount in addition to that explained by the other two variables. The overall regression of these three variables on price was also significant.

The results from statistical tests in the Analysis of Variance were based on the order in which the variables appeared in the model. The following multiple coefficients of determination give a more complete analysis of the various possible combinations of variables in the model.

- (a) $R^2 = .9955$
- (b) $R^2_{0.123 \text{ 49/}} = .9062$
- (c) $R^2_{0.12} = .7361$
- (d) $R^2_{0.13 \text{ 0.23}} = .7945$

c. The t-test

Various hypotheses were tested using the t-test. The t-statistic was calculated by dividing each B value by the standard error of that B value.

(1) The test

$$\begin{aligned} H_o : B_1 &\leq 0 \\ t_1 &= \frac{-87.2300}{5.6215} = -15.5172^{**} \\ H_o : B_2 &\leq 0 \\ t_2 &= \frac{-20.7760}{1.1791} = -17.6202^{**} \\ H_o : B_3 &\geq 0 \\ t_3 &= \frac{153.9300}{14.8843} = 10.3418^{**} \end{aligned}$$

** .01 significance level
* .05 significance level

(2) Explanation

All of the B values were statistically significant using the one-tailed t-test. 50/

d. The standard partials

The standard partials were calculated to obtain the relative importance of these coefficients. This statistic was calculated by multiplying each B value by the square root of the ratio of the sums of squares of the corresponding variable to the total sums of squares.

49/ In this analysis the subscript zero refers to the dependent variable, one refers to X_1 , two refers to X_2 , and three refers to X_3 .

50/ For explanation see page 21.

$$(1) B_i' = B_i \sqrt{\frac{ssi}{say}}$$
$$B_1' = -87.2300 \sqrt{\frac{.00000235}{.03473994}} = -.7175$$
$$B_2' = -20.7760 \sqrt{\frac{.00007641}{.03473994}} = -.9744$$
$$B_3' = 153.9300 \sqrt{\frac{.00000043}{.03473994}} = .5416$$

(2) Explanation

The per capita supply of non-fed cattle was most important, the per capita supply of fed cattle was next important, and total personal income per capita was least important in explaining the variation in the price of Chicago Choice slaughter steers.

e. Partial correlation analysis

(1) Definitions

- (a) r_{ij} = Simple correlation coefficient which measures the association between two variables.
- (b) $r_{ij.k}$ = Partial correlation coefficient which measures the association between two variables holding the effect of a known third variable constant.
- (c) $r_{ij.kl}$ = Partial correlation coefficient which measures the association between two variables holding the effects of two other known variables constant.

(2) The results

(a) Multicollinearity 51/

- i. $r_{12} = |.7590|$
- ii. $r_{13} = |.7262|$
- iii. $r_{23} = |.8182|$
- iv. $r_{12.3} = |.4170|$
- v. $r_{13.2} = |.2811|$
- vi. $r_{23.1} = |.5966|$

(b) Additional partial correlation analysis 52/

- i. $r_{01} = | .4153 |$
- ii. $r_{02} = | .8729 |$
- iii. $r_{03} = | .8179 |$
- iv. $r_{01.2} = | -.7783 |$
- v. $r_{02.1} = | .9416 |$
- vi. $r_{03.1} = | .8256 |$
- vii. $r_{01.3} = | -.4518 |$
- viii. $r_{03.2} = | .3697 |$
- ix. $r_{02.3} = | .6158 |$
- x. $r_{01.23} = | .9893 |$
- xi. $r_{02.13} = | .9914 |$
- xii. $r_{03.12} = | .9763 |$

(3) Explanation

The values for (a) i through vi measured intercorrelation. The intercorrelation did not appear to be significant enough to affect seriously the reliability of the analysis. The highest intercorrelation occurred between total personal income per capita and the supply of non-fed cattle per capita. There is little reason to believe that there is any significant interdependence between these variables. 53/ The remainder of the partial correlation analysis measured the different relationships between the independent variables and price. This made the analysis more complete in the sense that more is known about the independent contribution of each variable in the model. 54/

52/ Ibid.

53/ See page 18.

54/ For a complete discussion of partial correlation analysis and the interpretation of its results see Snedecor, George W., Statistical Methods, Iowa State College Press, Ames, Iowa, Fifth Edition, 1956, p. 429.

f. Serial correlation

The Durbin-Watson test 55/ was used to test for serial correlation in the residuals. The following statistic was calculated:

$$d = \frac{\sum_{t=2}^T (\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=1}^T \hat{u}_t^2}$$

where \hat{u}_t is the unexplained residual for observation t.

(1) Results

$$d = .3856$$
$$4-d = 3.6144$$

The d value fell below the lower bound in the two-tailed test at the five percent level of significance. One can therefore be 95% confident that there was positive correlation in the residuals. This bias in the residuals violates an assumption of regression analysis; but because of the small amount of unexplained variation no further residual analysis was made.

Some possible explanations for the serial correlation may be suggested. There was a cyclical effect in beef cattle prices and numbers which was not accounted for in the model. Additional research in alternative models with different variables and alternative algebraic variable forms may be justified.

C. Discussion of the results of the final model

The unusually high multiple coefficient of determination was quite unexpected. Had data been available on the supply weights, a more sophisticated model could have been postulated. As has been previously stated all combinations of time lags were not investigated. It would also seem that errors in sampling by those who constructed the secondary data used would give a greater error in the regression analysis than occurred.

The signs of all the partial regression coefficients agreed with a priori reasoning. All three variables were significant with the F-test and the t-test. Non-fed cattle appeared to be by far the most important factor in explaining the variation of

55/ Friedman, Joan, and Foote, Richard J., Computational Methods for Handling Systems of Simultaneous Equations, Agricultural Handbook No. 94, A.M.S., U.S.D.A., Washington, D.C., November, 1955, p. 77.

Choice steer prices. Fed cattle were next in importance followed by total personal income. None of the independent variables were considered to be significantly intercorrelated. There was serial correlation in the residuals. This did not seem critical to the analysis. However, additional work may be needed in alternative models. The ideal would be an accurate model sufficiently detailed to account for this bias.

Before a researcher attempts to refine the models developed in this analysis, careful consideration must be given to how meaningful additional refinement might be. This will be particularly true until more detailed data are available on numbers and weights of cattle by class and grade.

IV. Forecasting

Before the established model could be used in forecasting, a procedure had to be developed for forecasting the independent variables. Some exploratory work was done to develop this procedure.

A. Quarterly forecasting trial models

The only forecast developed for the quarterly model in this thesis was that of the supply of fed cattle per quarter. It was done when the quarterly model was investigated and is included here only as an item of interest.

1. The model

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + E$$

where:

Y = Fed cattle marketed

X₁ = Number of cattle on feed over 900 lbs.

X₂ = Number of cattle on feed 600-900 lbs.

X₃ = Beef steer-corn price ratio (t or t-?)

E = Unexplained error

2. The data

The data on X₁ and X₂ came from Cattle and Calves on Feed reports. The data on X₃ were published in Livestock and Meat Statistics.

3. Explanation of the variables

Nearly all cattle weighing 900 pounds or more at the beginning of the quarter were believed to be marketed by the end of the quarter.

A part of those cattle weighing from 600-900 pounds were hypothesized to be marketed during the same three months. Some economic criterion, it was thought, would affect the number of these cattle marketed during the quarter.

The beef steer-corn price ratio during the quarter was believed to be an economic indicator of how many of the lighter cattle would be pushed to market weight.

Four multiple regression equations were used to establish which monthly or average steer-corn price ratio was most closely associated with supply.

4. The results

The steer-corn price ratio did not contribute significantly in any of the regressions so was deleted.

B. Quarterly forecasting

1. The final model

a. $Y = B_0 + B_1X_1 + B_2X_2 + E$

where:

Y = Fed cattle marketings

X_1 = Number of cattle on feed over 900 lbs.

X_2 = Number of cattle on feed 600-900 lbs.

E = Unexplained error

b. Analysis of Variance

| Source | d.f. | S.S. | M.S. | F |
|---------------------------------------|------|---------|--------|------------|
| Reg. due to X_1 | 1 | 701500 | 701500 | 121.5561** |
| Added red. due to X_2 over X_1 | 1 | 224700 | 224700 | 38.936 ** |
| Regression | 2 | 926200 | 463100 | 80.2461** |
| Error | 21 | 121200 | 5771 | |
| Total | 23 | 1047400 | | |

** .01 significance level

* .05 significance level

c. The coefficients

$$Y = 662 - .8029 X_1 - .2937 X_2$$

$$R^2 = .8843$$

2. Discussion of the model

The signs of both partial regression coefficients agreed with existing economic theory. Both variables and the overall regression were significant in the Analysis of Variance.

The relatively high multiple coefficient of determination in this model further substantiated the earlier assumption that the supply of fed beef is largely predetermined.

C. Monthly forecasting

1. Fed cattle

Since expected marketings were used as actual marketings in the established model, no attempt was made to forecast monthly supplies of fed cattle. The Cattle and Calves on Feed reports, published at the beginning of each quarter, served as a monthly forecast for the following three months.

2. Non-fed cattle

A simple regression model was used to forecast supplies of non-fed cattle. Various time lags were tried with the independent variable to obtain the best fit. All data were seasonally adjusted.

a. The model

$$Y = a + bX$$

where:

Y = Supply of non-fed cattle

X = Price of stocker and feeder steers at Kansas City 56/

b. The results

| Time period | Coefficient of determination |
|-------------|------------------------------|
| t | .9110 |
| t-1 mo. | .9161 |
| t-2 mo. | .9731 |
| t-3 mo. | .9882 |
| t-4 mo. | .9921 |
| t-5 mo. | .9851 |
| t-6 mo. | .9679 |

56/ Weighted average cost per 100 pounds for all weights and grades shipped.

c. The coefficients

Of the lags investigated, the 4-month lag was optimum.

$$Y = .2288 + .4714 X$$

where:

Y = Supply of non-fed cattle

X = Price of stocker and feeder steers at Kansas City (t-4 mo.)

3. Total personal income

The average monthly income over the past six months was forecast as a function of time. The multiple coefficient of determination between income and time was .9512 over the six-year period, 1955-60.

4. Population

Monthly population was forecast monthly using average increases in population from month to month.

Average monthly increases in population were calculated for each month from 1955-60. ^{57/} The monthly average population increases for the six year period were as follows:

| Month | J | F | M | A | M | J | J | A | S | O | N | D |
|-----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Average population increase (000) | 270 | 194 | 212 | 251 | 219 | 246 | 227 | 271 | 297 | 271 | 285 | 244 |

These average monthly increases were added to total population for forecasts of total population for three months in advance.

V. The Residuals

Price estimates were calculated by using original data in the established model. Attention should be paid to the fact that

^{57/} Monthly increases were calculated from total population estimates published by United States Bureau of Census, United States Department of Commerce, Washington, D. C.

the partial regression coefficients in the model were obtained by using these data. A more reliable test of the usefulness of the estimating coefficients could be made if data for other time periods were available. The standard deviation of the regression line was .0018. Interpreted, this meant that .6826 of the observations would be expected to fall within ± 18 cents per hundredweight of the estimated price. The following is a frequency distribution of the absolute residuals. A class interval of 25 cents was used because of the common usage of 25-cent increments (per hundredweight) in livestock pricing. The average seasonally adjusted monthly price of Choice steers at Chicago over the six-year period was \$25.31 per hundredweight. A 25-cent residual would be an error of about one percent.

Number of residuals

| | |
|------------------|----|
| 25 cents or less | 41 |
| 26-50 cents | 13 |
| over 50 cents | 4 |

SUMMARY

The objectives of this study were (1) to determine the important variables affecting prices of fed cattle in the short run, (2) to establish the relationship between important independent variables and prices of fed cattle, and (3) to develop methods for incorporating relationships into meaningful short-run predictions of fed cattle prices.

In order to facilitate wider use of the findings only readily available data were used in a model free from many of the complexities which might restrict its use. Exploratory work was done in developing both quarterly and monthly economic models. The important variables found to affect fed cattle prices were the per capita supply of non-fed cattle, the per capita supply of fed cattle, and per capita total personal income. The lack of a priori knowledge necessitated the investigation of various time lags and alternative algebraic variable forms. Consideration was given to both seasonally adjusted and non-seasonally adjusted data. A model using the three seasonally adjusted variables was postulated to explain the variation in seasonally adjusted monthly fed cattle prices ($R^2 = .9955$). The per capita supplies of both fed and non-fed cattle were lagged two months. Per capita total personal income was averaged over the previous six months. A detailed statistical analysis was made to establish confidence in the validity of the estimating equation.

In order to make seasonally adjusted forecasts from the final estimating equation, the independent variables must be estimated. Work was initiated to develop procedures for forecasting the seasonally adjusted six-month average total personal income per capita, the seasonally adjusted supply of non-fed cattle, and total population by months. Some work was done on forecasting the quarterly supply of fed cattle.

The following is a summary of the monthly model and the forecasting equations. All variables are seasonally adjusted.

The Model

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + E$$

where:

Y = Average price of Chicago Choice slaughter steers

and:

X_1 = Per capita supply of fed cattle (t-2 mo.)

X_2 = Per capita supply of non-fed cattle (t-2 mo.)

X_3 = Per capita total personal income (t-6 mo. av.)

E = Unexplained error

Forecasting

1. Supply of fed cattle--Marketing intentions as published quarterly in Cattle and Calves on Feed are used as forecasts of the supply of fed cattle.
2. Supply of non-fed cattle
 - a. The Model
$$Y = a + bX$$
where:
$$Y = \text{Supply of non-fed cattle}$$
$$X = \text{Price of stocker and feeder steers at Kansas City (t-4 mo.)}$$
3. Total personal income
 - a. The Model
$$Y = a + bX$$
where:
$$Y = \text{Total personal income per capita}$$
$$X = \text{Time}$$
4. Population--Population is forecasted using specific average monthly increases in population.

No actual forecast could be made, but the procedure for forecasting the independent variables in the final model showed promise for future use. Before monthly forecasts can be made, further work must be done either in developing a seasonal index which approximates the twelve-month moving average (The twelve-month moving average was used to seasonally adjust the data used in developing the estimating equation.) or in projecting non-seasonally adjusted data far enough into the future for the twelve-month moving average to be calculated. If seasonally adjusted prices are forecasted, a method must be found to remove the seasonal effect.

The author recognizes the limitations of this work. It is his hope, however, that additional research will take advantage of the opportunities touched here. It is possible that the use of the twelve-month moving average removed fluctuations which were not seasonal in nature. This possibility may be investigated. Work may be done in formulating more complete models of the livestock economy and in expanding the work to cover other grades and classes of livestock. A highly desirable goal would be to forecast monthly prices a year in advance for all grades and classes of livestock.

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