AN ABSTRACT OF THE THESIS OF

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Title: AN ECONOMIC ANALYSIS OF CATTLE FEEDING AND INTERREGIONAL FLOWS OF LIVE AND CARCASS BEEF

Abstract approved: James G. Youde

The U. S. fed beef industry is a complex composed of production, slaughtering, distribution, and consumption activities. The level of each of these activities varies spatially, generating regional imbalances. The purpose of this study is to explain the levels of cattle feeding in different regions and to study fed beef shipments from surplus-producing regions to deficit-producing regions.

The continental U. S. was divided into nine regions. A basic economic model was developed with functional relationships among production, consumption and prices. This model was diagrammed to show causal ordering in a recursive chain. This structure was essentially a set of hypotheses to be tested. The ordinary least-squares method of regression analysis was employed to estimate the coefficients in the relationships. The equations were incorporated to form a simulation model. The model was validated by

comparing estimated values over the 1962-68 period. The overall average deviation between the estimated values of all variable calculated by the model and their historical counterparts was about four percent. Thus the model portrayed a reasonably accurate picture of actual conditions in the fed beef industry.

The model was used to project the number of cattle fed and other variables for 1975. The effect of an increase in feed grain prices was also traced through the model.

Consumption of fed beef in each region was estimated and compared with production of fed beef. It was found that from 1962 to 1966 only the Eastern region was a deficit fed beef-producing region. In 1967, 1968 and 1975 the California-Arizona and Utah-Nevada region also showed deficits. A model was designed to determine the flows of fed beef from surplus to deficit regions, considering transportation costs, slaughter costs, and slaughter capacities in each region.

The basic determinants of shipments among regions were the price differences of wholesale fed beef and live fed cattle. Trade took place between two regions on the basis of a price difference which made it profitable for a surplus region to ship fed beef to a deficit region. Equilibrium was reached when prices of each trading pair of regions were such that they differed exactly by the transportation cost between the regions.

The results of the empirical analysis indicated that the cattle feeding industry is growing and is expected to continue to grow until at least 1975. Colorado, the Southern Plains, the Northern Plains, and the Midwest were found to be the main areas of cattle feeding. The direction and magnitude of fed beef shipments are expected to change between 1968 and 1975. The projected fed beef shipments from surplus-producing regions to deficit-producing regions in 1975 are expected to be about 10 billion pounds. Most fed beef is projected to be shipped in carcass form in the future.

An Economic Analysis of Cattle Feeding and Interregional Flows of Live and Carcass Beef

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I INTRODUCTION

The Problem

The beef cattle feeding industry in the United States has undergone a tremendous expansion since World War II (7, p. 22). As consumer demand for fed beef increased rapidly, it presented the national beef industry with new opportunities for growth. In response, there has been a rapid increase of commercial feedlots in the western and Plains states; shifts in the locations of beef cattle herds and slaughter plants; improved techniques of production, slaughter, and processing; and changes in the structure of marketing industries.

The total number of fed cattle marketed increased from about 13 million head in 1960 to 23 million head in 1968, for an increase of about 75 percent during the 9-year period. Shifts in the location and importance of cattle feeding are evident in most feeding areas of the United States. The North Central region has been and is still the leading cattle feeding region in the nation. The 12 states of this region fed 8 million head of cattle, about 64 percent of the 13 million for the whole United States, in 1960. In 1968, this region fed 14 million cattle of the total 23 million and thus accounted for 62 percent of the total (32).

Cattle feeding activity increased very rapidly in the Southern Plains, especially in Texas. These states made the largest proportional gain in fed cattle production during the period 1960-68. The number of commercial feedlots with a capacity of 1,000 head or more increased very rapidly in the area (7 , p. 34). Cattle fed in Texas increased from 477,000 head in 1960 to 1,970,000 head in 1968, showing an increase of more than 400 percent (32).

The Pacific Northwest showed an increase in cattle feeding, but its relative share in the total declined from 4.25 percent to 4 percent during 1960-68. The state of California fed about 12 percent of the total cattle fed in 1960, but in 1968 it accounted for less than 9 percent of the total. Wyoming, Utah and North Dakota demonstrated a decline in relative as well as absolute numbers of cattle fed during the same period.

Cattle feeding activity is shifting from farm feeding with capacity of less than 1,000 head annually to commercial feedlots with capacity ranging from 1,000 to 100,000 head (7, p. 24). These feedlots are highly specialized and efficient production units. Internal and external economies of size have helped them grow. They utilize up-to-date technology, modern equipment, and trained management.

The cattle slaughtering industry moved from its origin in the East to the large terminal markets in the Midwest and then to the fed beef production areas (7, p. 82). These location changes resulted from improved technology and greater mechanization of slaughter plant operations, along with the economy of shipping beef in carcass form rather than in live form. Development of refrigerated trucks and railroad cars facilitated the transition.

On the demand side, the national per capita consumption of fed beef has increased from 45.5 pounds in 1960 to 71.3 pounds in 1968 for an increase of 56 percent. Per capita consumption varies from region to region. The California-Arizona region was estimated to have the highest per capita consumption of 85.5 pounds in 1968, while the lowest figure was 62 pounds for Texas-Oklahoma-New Mexico area. Also, there have been differential rates of growth of population and per capita income in different areas of the nation. These changes have changed the total level and character of demand for fed beef.

The differential growth of demand for fed beef, along with differential increase in its supply, have affected the activities of various components of fed beef industry. The production, marketing, slaughtering, processing, distribution and consumption of fed beef have been affected. When the levels of all these activities differ among regions, regional imbalances are generated and consequently product shipments among regions become necessary.

Knowledge of supply and demand of fed beef and the resultant interregional product shipments is essential for all firms in the beef cattle industry. It is necessary for feeder cattle producers and feedlot operators to know the demand for fed cattle in order to make decisions as to how many feeder cattle should be produced and fed. The production level of fed cattle affects the decisions of packing plant operators as to what the slaughter capacity of their plants should be in order to slaughter cattle that need to be slaughtered. The location of slaughtering and processing facilities is affected by the location of production and consumption.

Information regarding the factors that affect the regional supplies and the location of livestock production is needed as a guide to shipments among regions and is essential for various governmental agencies and industry groups concerned with the development of the fed beef economy. This study was undertaken with the view of such problems of all concerned firms and is expected to lead to higher levels of efficiency, more orderly systems of distribution, and more accurate pricing arrangements.

Objectives of the Study

The overall objective of this study is to make an economic analysis of the U. S. beef cattle feeding industry by regions, and interregional flows of live and carcass beef. Specific objectives are:

(1) To develop a simulation model to explain and predict the levels of cattle feeding and the important variables which affect the levels of cattle feeding in each region of the United States.

(2) To determine the structure of prices in the feeder cattle, slaughter cattle, and wholesale beef markets.

(3) To examine the impact of projected future changes in selected variables on other variables in the model, and on the model as a whole.

(4) To determine the direction and magnitude of equilibrium shipments of live and carcass beef among regions of the United States.

Previous Research

Several past studies have analyzed regional levels of cattle feeding and interregional flows of live and carcass beef in the United States. Erickson and Havlicek (4) made a study on regional production of cattle and calves for commercial slaughter for the period 1948-61. They used a recursive system of two multiple regression equations estimated by the least squares method to determine cattle production available for slaughter in each of 26 regions. They concluded that cattle supply response to the stocker-feeder price varied greatly among different areas of the United States. The Corn Belt area elasticities, though inelastic, were greater than those of the western and mountain areas. The southern and southeastern regions exhibited the greater supply response to a change in the feeder price. A change in price of corn on the average has a greater relative effect on cattle production in the Corn Belt and other areas where large numbers of cattle are fed than in areas where smaller numbers of cattle are fed. On the national level, their study reveals that the price of feeder cattle lagged one year affects the number and total liveweight of cattle on feed that will be commercially slaughtered during a given year, and the price of corn affects the weight to which animals already in feedlots will be fed, as well as the number that will be placed on feed.

Havlicek, Rizek, and Judge (8) studied interregional flows of slaughter livestock for 1955 and 1960. They used a linear programming transportation model to determine the minimum-cost flows of slaughter livestock between regions. They concluded that major surplus areas of slaughter cattle in 1955 and 1960 were located in the western part of the Corn Belt, and major deficit areas were the eastern part of the United States, California, Ohio, Wisconsin, and Michigan. Moderate changes occurred in the flow patterns between the two years analyzed. They concluded that the changes which occurred were due mainly to regional shifts in the location of production, and slaughter facilities moving closer to areas of production.

Crom (2) developed a simulated interregional model of the livestock-meat economy for data projected to 1975. His model was essentially a transportation model in which total production and total consumption were equal and predetermined. Slaughter capacity was a given restriction, and meat flows were optimized subject to slaughter and transportation costs. Crom concluded that interregional shipments of 7.67 billion pounds of beef (carcass weight) and 7.4 billion pounds of cattle (liveweight) would take place. Thirteen surplus beef producing regions (major surplus areas were Iowa, Minnesota, Nebraska and Colorado) shipped beef to 11 deficit-producing areas (major deficit areas were the Eastern states and California). Price differentials calculated from the solution showed Indiana would have the greatest comparative advantage for shipping beef east, while New Mexico-Arizona and Utah-Idaho-Nevada would have the greatest advantage for supplying the Pacific Coast.

Williams and Dietrich (34) developed an interregional analysis of the fed beef economy for 1960, using a linear programming spatial model. Their study revealed that price differentials among surplus regions and transportation cost differences among these regions to deficit markets frequently were so small that they were readily offset by other factors. Location relative to feed and feeder cattle as reflected in delivered costs might be more important. Located far from all deficit markets Colorado, nevertheless, would be able to ship surplus beef East, West and Southeast. The Kansas-Missouri area, as well as Southern Plains, were located disadvantageously with respect to live and dressed beef shipments to California.

Although these studies are pertinent to the problem on hand, no extensive effort has been made to form a comprehensive model to determine the supply of fed cattle and to estimate the variables associated with it. In Chapter II of this study, the economic structure of the cattle feeding industry has been detailed, and a simulation model has been prepared to analyze the cattle feeding industry empirically. Based upon this model the variables have been projected to 1975. In Chapter III an attempt has been made to prepare a model to study the interregional flows of live cattle and carcass beef from a surplus-producing region to deficit-producing area. Chapter IV contains a summary of the discussions and conclusions of the analysis.

II ECONOMIC STRUCTURE OF THE CATTLE FEEDING INDUSTRY

Theoretical Considerations

According to generally accepted microeconomic theory, the supply of a product in a market area depends upon regional endowments of natural resources, production functions for intermediate and final products, costs of the inputs, and price of the product.

Theoretically, the price of a product and the quantity offered for sale have a positive relationship. Assuming everything else remains constant, an increase in price of the product will encourage producers to produce more. An inverse relationship exists between costs of production and supply of the product. Assuming other things equal, an increase in the cost of variable factors will raise the average cost curve and marginal cost curve up and to the left so that the point of intersection between the price line and the marginal cost curve will be to the left of the original intersection point. Consequently, the producer will produce less if he is a profit maximizer.

Per unit profits are measured as the price of the final product the producer gets in a market minus all costs he incurs in production of the product. In general, every firm is assumed to be operating in such a manner as to maximize its profits or to minimize its losses. A greater profit will give incentive to the firm to produce more.

The time period considered in this study is the short run. In the long run resources are mobile in the cattle feeding industry, but in the short run they are not. The response to a change in product or factor prices is not instantaneous. There is a time lag for adjustments to occur. In the short run factors which affect production of fed cattle can affect only a portion of total cattle fed, since the animals already exist, and only weight variations of the animals from feeding them a little longer to heavier weights or selling them sooner at lighter weights can occur. Thus, supply response to a change in product or factor price requires a period in which producers can makes some changes, making the supply of fed cattle in the short run relatively less responsive to changes in prices. The change in number of cattle fed in feedlots in any one time period, therefore, is dependent upon the price a feedlot operator expects to get from selling his cattle, the relation of this price to input costs which have been incurred on them, and the length of time required to place fed cattle on the market.

Analytical Procedure

Models based on mathematical optimizing methods often fall short of realistically representing the complexities of an economic system. With the advent of automatic data processing and high speed computers, new and powerful analytical tools have been created. One such tool is simulation, a research technique by which it is possible to analyze large and comprehensive models of an economic system. This technique is used to analyze the economic structure of the United States cattle feeding industry in this thesis.

According to Naylor et al. (21, p. 3), simulation is a numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behavior of a business or economic system (or some component thereof) over extended periods of real time. Simulation models can be much more complex and realistic than models using conventional mathematical techniques. Nonlinearities, discontinuities, time delays, and irreversibilities can be built into these models. Through simulation the effects of certain informational, organizational, and environmental changes on the operation of a system can be studied by making proper alterations in the model. Simulation of a complex system, when properly constructed and validated, can yield valuable insights into which variables are most important in a system, and how these variables interact.

One of the desirable features of a simulation model is that it can be recursive. A model is said to be fully recursive if it is possible to sequence one-at-a-time computations of successive values of endogenous variables in such a way that for any time period the value of each endogenous variable may be computed, given only exogenous variables, lagged endogenous variables, and preceding current endogenous variables in the sequence (22, p. 232).

Three types of variables are included in this model--endogenous, predetermined endogenous, and exogenous. Those variables whose values are determined within the system are termed as endogenous variables. The values of these variables are determined by exogenous variables, or predetermined endogenous variables, or a combination of the two. Predetermined endogenous variables or lagged endogenous variables are those whose values are generated by the system in a time period prior to the time period of the model under consideration. The variables whose values are determined outside the system and whose values for the system are considered as given are known as exogenous variables.

Two types of relationships are used in this model--identities and functional relationships. Identities specify an exact relation between the variables, with no random variable. A functional relationship may or may not be exact. It generally has a random error term (1, p. 2).

Fourteen relationships were developed to study the regional economic structure of the United States cattle feeding industry. The economic structure, for the purposes of this study, refers to the relationships among such variables as production, marketing, and consumption in a comprehensive system of interdependent events.

These relationships were incorporated to form a simulation model to explain and predict the level of cattle feeding in nine specified regions, and the variables associated with the levels of cattle feeding.

The United States was partitioned into nine regions, each region consisting of one or more states. Homogeneity of cattle production along with placing emphasis on western states, played an important role in grouping of states into regions. The regions and states composing each region were as follows:

Region 1 - California and Arizona.

Region 2 - Pacific Northwest States (Oregon, Washington, and Idaho).

Region 3 - Montana and Wyoming.

Region 4 - Colorado.

Region 5 - Nevada and Utah.

Region 6 - Northern Plains States (North Dakota, South Dakota, Nebraska, and Kansas).

Region 7 - Southern Plains States (Texas, Oklahoma, and New Mexico).

Region 8 - Cornbelt states (Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio).

Region 9 - Remainder of Continental U. S. (23 states).

Figure 1 shows the regional demarcation of the United States.

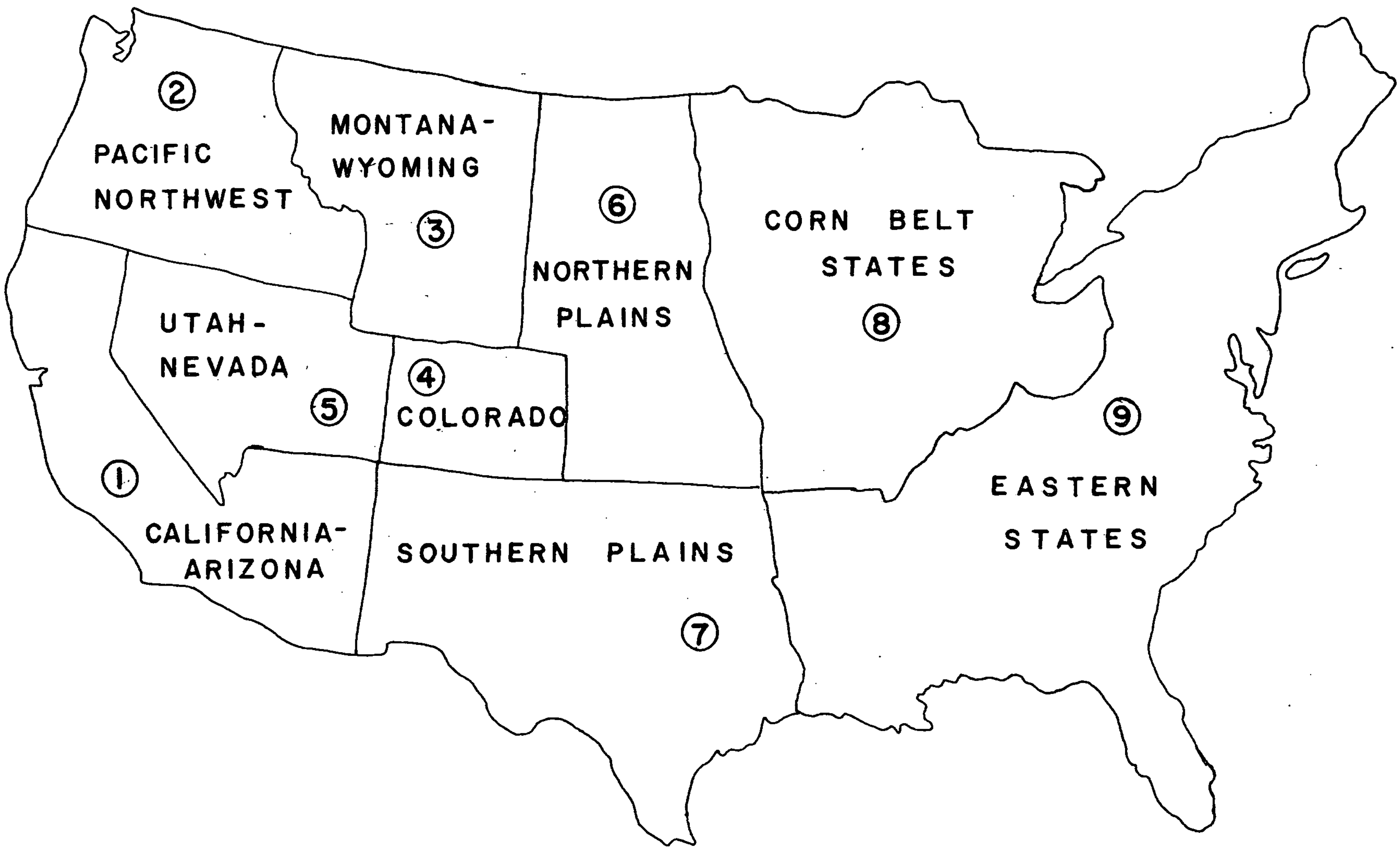

Figure 1. Regional Demarcation of the United States

The Empirical Model

A flow chart was designed to represent the causal ordering of prices and other variables in the cattle feeding industry (see Figure 2). The exogenous variables are shown by rectangles, while the endogenous and lagged endogenous variables are depicted by circles. Causal ordering is shown by the direction of arrows. The superscripts above the variables refer to the area or region under consideration: i refers to the individual region number, N refers to a national value, C refers to a Chicago figure, and K refers to a Kansas City figure. The subscripts below the variables denote time period: initially, t stands for 1961, t+1 for 1962, t-1 for 1960, and t-2 for 1959.

The complete regional simulation model in equation form is shown in Figure 3. The units of measurement and an explanation of the variables are given in Table 1.

Description of the Model

There are no strictly separate compartments for production, marketing, and consumption within the model. Variables of the model interact among each other to estimate the dependent values.

The number of cattle fed in a region during a year was considered to be a function of three variables: profits made by feedlot operator from cattle feeding during the previous time period, supply of

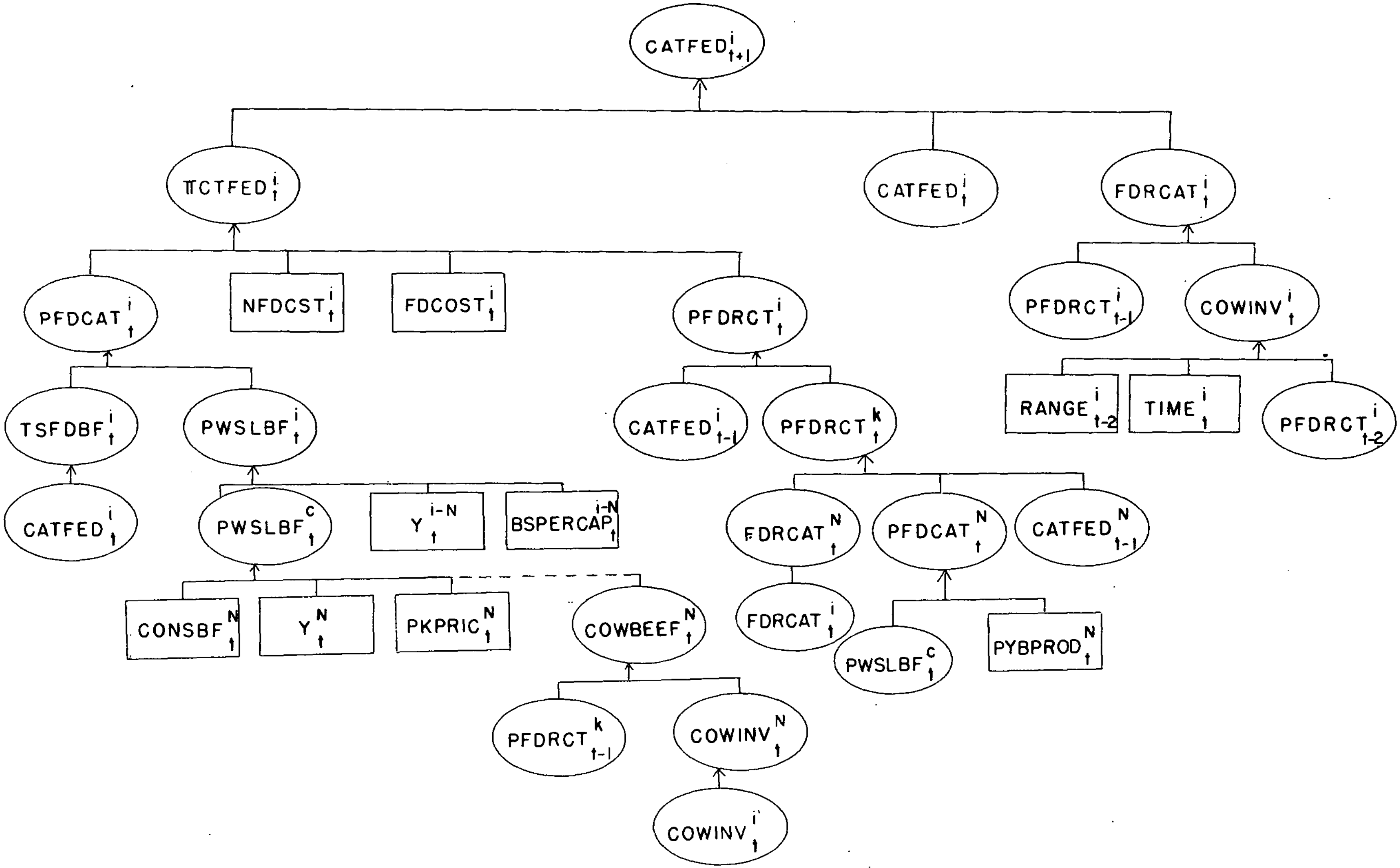

Figure 2. A Regional Simulation Model for the U. S. Beef Cattle Feeding Industry--Flow Chart

(1)	$COWINV_t^i = f_1(RANGE_{t-2}^i, TIME_t^i, PFDRCT_{t-2}^i)$
(2)	$FDRCAT_t^i = f_2(COWINV_t^i, PFDRCT_{t-2}^i)$
(3)	$COWINV_t^N = \sum_{i=1}^{9} COWINV_t^i$
(4)	$COWBEEF_t^N = f_4(COWINV_t^N, PFDRCT_{t-1}^K)$
(5)	$PWSLBF_t^C = f_5(CONSBF_t^N, Y^N_t, PKPRIC_t^N)$
(6)	$PWSLBF_t^i = f_6(PWSLBF_t^C, Y_t^{i-N}, BSPERCAP_t^{i-N})$
(7)	$TSFDBF_t^i = f_7(CATFED_t^i)$
(8)	$PFDCAT_t^i = f_8(TSFDBF_t^i, PWSLBF_t^i)$
(9)	$PFDCAT_t^N = f_9(PWSLBF_t^C, PBYPROD_t^N)$
(10)	$FDRCAT_t^N = \sum_{i=1}^{9} FDRCAT_t^i$
(11)	$PFDRCT_t^K = f_{11}(FDRCAT_t^N, PRDCAT_t^N, CATFED_{t-1}^N)$
(12)	$PFDRCT_t^i = f_{12}(CATFED_{t-1}^i, PFDRCT_t^K)$
(13)	$\Pi CTFED_t^i = f_{13}(PFDCAT_t^i, PFDRCT_t^i, FDCOST_t^i, NFDCST_t^i)$
(14)	$CATFED_{t+1}^i = f_{14}(\Pi CTFED_t^i, FDRCAT_t^i, CATFED_t^i)$

Figure 3. A Regional Stimulation Model for the U. S. Beef Cattle Feeding Industry--Structural Equations

Table 1. Description of Variables.

Variable	Unit of measurement	Description
COWINV	head	Cows, 2 yrs. and older (other than kept for milk) on farms, January 1
RANGE	percent	Range conditions in a region
TIME	number	1959=1, 1960=2, . . .
PFDRCT	dollars	Price per cwt., choice steer, 500-800 pounds
FDRCAT	head	Feeder cattle (80 percent of calves born)
COWBEEF	1,000 pounds	Nonfed beef
PWSLBF	dollars	Price per cwt. of wholesale beef
CATFED	head	Number of fed cattle marketed from feedlots
CONSBF	pounds	Per capita consumption of fed beef
Y	dollars	Disposable income per capita
PKPRIC	dollars	Pork price per cwt.
BSPERCAP	pounds	Beef supply per capita
TSFDBF	1,000 pounds	Total supply of fed beef
PFDCAT	dollars	Price per cwt., choice steer, 900-1,100 pounds
PBYPROD	dollars	Price per cwt. of by-product
Π CTFED	dollars	Feedlot profits from one steer
FDCOST	dollars	Feed costs for 425 pounds of gain in a feedlot
NFDCST	dollars	Nonfeed costs for 425 pounds of gain in a feedlot

feeder cattle in that region during the previous time period, and the number of cattle fed in that region lagged one year.

Feedlot profits per head of cattle fed were calculated as the price of fed cattle a feedlot operator receives minus price paid for feeder cattle minus feed and nonfeed costs of fattening the feeder. It was assumed that a feeder is bought when it weighs 600 pounds and it is fed until it weighs 1,025 pounds. As a result, feed costs and nonfeed cost were calculated for a gain of 425 pounds in feeder weight in a feedlot. Feed costs and nonfeed costs were treated as exogenous variables in this study.

The supply of feeder cattle in a region was a function of cow inventory in the region in the same year and market prices of feeder cattle in the region two years previously. This functional relationship was so constructed because the decisions of the production of feeder cattle are expected to be based on expectations of future prices, which are usually based upon current price levels.

The price of feeder cattle in a region was estimated as a function of the number of cattle fed in the previous time period and the national price of feeder cattle. Feeder cattle prices in the national market, in turn, were determined by the following three variables: (1) the total supply of feeder cattle in the United States (the sum of feeder cattle supplies in the various regions); (2) price of fed cattle in the national market; and (3) the number of cattle fed in the United

States in the previous time period.

The price of fed cattle in a region was determined by the total supply of fed beef in the region and the regional price of wholesale beef. The regional total supply of fed beef was a function of the number of cattle fed in the region. Price of wholesale beef in a region was estimated as a function of the national price of wholesale beef; the difference between regional per capita disposable income and the national per capita disposable income value; and the difference between regional and national beef supply per capita.

The national price of fed cattle was a function of the national price of wholesale beef and the price of by-products. The price of by-products was treated as an exogenous variable. The national price of wholesale beef was estimated as a function of fed beef per capita in the United States; the national per capita disposable income; and the pork price in the nation.

The national supply of cow beef was determined by the national cow inventory, which was the sum of the regional cow inventories, and the national price of feeder cattle[1] in the previous time period. The cow inventory in a region was estimated as a function of the range condition two years previously, a trend variable, and price of feeder cattle in the region two years previously. The range condition was treated as an exogenous variable in this study.

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[1]Kansas City price.

Collection and Processing of Data

Data collected for the study were from various published sources. These data were in raw form and, where necessary, were revised to fit the requirements of the model. The main source of the data was the Statistical Reporting Service of the United States Department of Agriculture. The data sources, and methods of processing the data are discussed below.

Feedlot Costs

The cost structure of each feedlot depends upon numerous variables, including type of feed fed to animals, cost of each feed ingredient, type of feedmill utilized, capital and labor requirements with alternative methods of operation, and cost of land, as determined by alternative use value and tax differences. These feedlot costs can be divided into feed costs and nonfeed costs. Feed costs are those which are concerned with the feed ingredients fed to the animal to fatten it, including grain, supplements, roughage, etc. Nonfeed costs are concerned with all other costs of the feedlot, such as labor wages, taxes, interest, insurance, repairs, depreciation, gasoline, etc.

For purposes of this study, feeder cattle were assumed to be purchased by the feedlot operator when they weighed 600 pounds.

Though the initial weight of the animal varies from region to region and from state to state, the initial weight of 600 pounds was considered to be appropriate in a number of bulletins published by the Agricultural Experiment Stations of various states. Similarly, the weight of the finished cattle was taken to be 1, 025 pounds. Thus, the weight gained by the animal while in the feedlot was assumed to be 425 pounds.

Nonfeed Costs (NFDCST): Nonfeed costs of a feedlot operation include labor costs, management costs, investment costs, and miscellaneous items, such as veterinary expenses, death loss and taxes. The nonfeed costs will vary for each feedlot, depending partially upon the size of the operation.

The items involved in feeding cattle and their costs in a region were obtained from various bulletins of Agricultural Experiment Stations for a particular year. In order to calculate nonfeed costs for the entire period, 1956-67, national indices were obtained separately for four categories: production items, labor wage rates, interest on capital, and taxes payable. The source of such indices was Agricultural Prices, 1970, published by the Statistical Reporting Service of the United States Department of Agriculture. The indices given therein used 1910-14 as the base period. These were converted to the base year 1956 and were used to adjust the nonfeed cost data for other years.

Feed Costs (FDCOST): Feed costs are affected by the system of feeding, size of feedlot, and ingredient prices. Different regions in the study have different sizes of representative feedlots. Costs also vary from region to region due to differences in feed components and the prices which feedlot operators pay for these components.

Feed costs and feed ration ingredients for different states were taken from a Southern region study.[2] The states were grouped together according to regions, and the costs were averaged to obtain a figure for each region. The average was a weighted average, the weights used being the number of cattle fed in the individual state. These costs were on a per head basis for 350 pounds of gain and were converted to a per head basis for 425 pounds of gain by multiplying each region's cost by a conversion factor.

In the Southern region study, feed ingredients were priced at 1965 prices to give 1965 costs. In order to obtain feed costs for other years, prices of the feed ingredients were taken from Agricultural Statistics and Agricultural Prices each year during the entire 1956-1967 period.

Prices of Feeder Cattle (PFDRCT) and Fed Cattle (PFDCAT)

The price of feeder steers, choice grade, 500-800 pounds, was taken as the representative price for feeder cattle. These prices were taken from reports of major livestock markets in each region. Markets used for each region are shown below:

[2] A letter from Wesley G. Smith, Tennessee Valley Authority, along with summary of feed costs per head for beef animals, 1965.

Region	Market(s)
1	Los Angeles (California), Phoenix (Arizona)
2	Portland (Oregon)
3	Billings (Montana)
4	Denver (Colorado)
5	Ogden (Utah)
6	Omaha (Nebraska)
7	Amarillo (Texas), Oklahoma City (Oklahoma), Clovis (New Mexico)
8	St. Paul (Minnesota), Kansas City (Missouri), Indianapolis (Indiana), Sioux City (Iowa)
9	Nashville (Tennessee), Thomasville (Georgia), Baltimore (Maryland)

The prices of choice steers, 900-1100 pounds, were taken to be the prices of fed cattle in each region. These prices were also taken for the markets listed above.

The source of feeder cattle and fed cattle prices was Livestock Detailed Quotations, published by the Livestock Marketing Service of the U. S. Department of Agriculture. These prices are reported monthly, and they were averaged for use as annual prices in the model.

Price of Wholesale Beef (PWSLBF)

Price of wholesale beef at Chicago was taken as representative of the national price. The price used was that reported for choice steers, 600-700 pound carcasses. Source: Agricultural Statistics, 1969. Regional prices used were wholesale dressed steer beef prices, choice grade, 600-700 pounds. These prices were available for five principal markets of the United States. The prices in other regions were taken on the basis of proximity to the region in which these principal markets were situated. Source: Livestock and Meat Statistics, 1958-1970.

Total Supply of Fed Beef (TSFDBF)

For total supply of fed beef in a region, the figures for dressed fed beef were used. The total supply of fed beef in head was obtained from Cattle and Calves on Feed bulletins. Using average dressing yields, the head count was converted to weight in pounds. These data were not available for all years and states. To get the required years and states, an additional conversion was used. The percentage of total, marketings of dressed fed beef accounted for in each year was multiplied by the marketings in each state, and the results were used to represent total supply of fed beef.

Supply of Cow Beef (COWBEEF)

National supply of cow beef was taken as the total number of cattle slaughtered minus the number of fed cattle slaughtered, converted to dressed beef equivalent. Source: Livestock and Meat Statistics, 1958-70.

Cow Inventory (COWINV)

Cow inventory, regional as well as national, was taken as all cows two years and older (other than those kept for milk) on hand on January 1 of a given year. Source: Livestock and Meat Statistics, 1958-70.

Supply of Feeder Cattle (FDRCAT)

Feeder cattle supply was estimated by using 80 percent of total calves born in a given year. This figure of 80 percent was obtained in consultation with Extension livestock specialists at Oregon State University. Source of figures for calves born was Livestock and Meat Statistics, 1958-70.

Number of Cattle Fed (CATFED)

The figures on cattle fed in different regions were taken as cattle marketed from feedlots during the year (by adding the four quarterly figures). The source was Livestock and Meat Statistics. For Region 9, the data for cattle fed were approximated as follows: Cattle fed figures for only seven states--Pennsylvania, Georgia, Florida, Kentucky, Tennessee, Alabama, and Mississippi--are reported in Livestock and Meat Statistics and in quarterly Cattle on Feed reports. The other 16 states in Region 9 supposedly feed a negligible number of cattle. The total number of cattle fed in the above-mentioned seven states was assumed to represent the total for Region 9. However, even the data for all the above seven states were not available before 1964. To estimate the number of cattle fed in this region, the average percentage that all cattle marketed in the missing states were of the total cattle marketed in the remaining states in 1964 and 1965 was used to be representative of the percentage of fed cattle marketed in the missing states during 1960, 1961, 1962, and 1963.

Per Capita Beef Supply (BSPERCAP)

Total cattle slaughter (in pounds dressed weight) in each region was divided by the population of that region to arrive at beef supply per capita before imports and exports. The figures for population were obtained from Statistical Abstract of the United States, Bureau of Census.

Pork Price (PKPRIC)

The national price of pork is wholesale price per hundred pounds of carcass pork at Chicago. Source: Livestock and Meat Statistics, 1958-1970.

By-product Prices (PBYPROD)

It was found that hides account for 34 percent of the value of by-products in beef slaughter (35, p. 201). Therefore, hide prices at Chicago were used as a proxy for national by-product prices. These prices were taken from Livestock and Meat Statistics, 1958-70.

Range Conditions (RANGE)

Range conditions were only available for the western states. This variable was omitted in Regions 8 and 9. The source of range condition information was data from the Crop Reporting Board of the U. S. Department of Agriculture.

Disposable Income (Y)

The figures for national and regional disposable income per capita were obtained from the Statistical Abstract of the United States, 1960-1970.

Per Capita Consumption of Fed Beef (CONSBF)

It was assumed in this study that the amount of fed beef produced in the U. S. equals the amount of fed beef consumed, and there is no foreign trade in fed beef.[3] Fed beef consumed (produced) in the United States was divided by the total population to obtain national per capita consumption of fed beef.

It was further assumed that an index prepared for per capita consumption of all beef, fed and nonfed, in each region, taking the national figure as a base, can be taken as an index for regional per capita consumption of fed beef. This index was given in a study which used different regions than those used in this study (23, p. 13). The index was adjusted according to the regions considered in this study. The same index was used for the entire period considered in this thesis.

The national per capita consumption of fed beef in each year, combined with the regional index, produced the figures for per capita consumption of fed beef in each region of the United States for the period under consideration.

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[3] At certain times small quantities of fed beef are imported from Canada and the United States is currently beginning to ship fed beef to Japan and West Germany. However, these movement of fed beef were very small during the period analyzed by the model.

To check if total demand was equal to total supply in the fed beef sector, per capita consumption in each region was multiplied by population of each respective region, and the results were added to get the quantity of fed beef consumed in the United States. When this quantity was compared to the total fed beef produced, it was found that all deviations between the two figures were less than two percent for each year.

Estimation of Behavioral Relationships

The ordinary least-squares multiple regression technique was used to estimate the coefficients of the functional relationships in the model. The following assumptions were made for the analysis: (1) the functional relationship is linear; (2) the disturbance terms are distributed independently with zero expectation and constant variance; and (3) the variables are measured without error (11, p. 107).

The data used for the estimation of coefficients were generally for the period 1956-67. Due to lack of data for some variables, some coefficients were estimated from the data for a lesser number of years. In choosing among alternative behavioral relationships, the selection was generally made on the basis of coefficients of determination (R^2) and the level of significance of the variable coefficients (t-values). In general, the coefficients were accepted where they were of the right economic sign and were statistically significantly different from zero at the 0.1 level.

The equations were checked for multicollinearity. Mutlicollinearity is said to exist when some or all of the explanatory variables in a relation are so highly correlated one with another that it becomes very difficult, if not impossible, to disentangle their separate influences and obtain a reasonably precise estimate of their relative effects (11, p. 201). Although it is possible to estimate the joint effect of the two variables, it is difficult to identify the effects of each variable individually. However, the estimate of the standard error of the total equation, and thus of the index of multiple determination, R^2, is unaffected (12, p. 227).

A few high intercorrelations were found among variables. In the equation estimating the national prices of feeder cattle, the supply of feeder cattle in the United States and the number of cattle fed were found to be highly intercorrelated. These two variables were positively related and the magnitude of intercorrelation between them was 0.84.

The inclusion of the number of cattle fed, however, increased the coefficient of determination (R^2) of the equation from 0.73 to 0.82. It also enhanced the t-value of the national supply of feeder cattle from -0.383 to -1.252. High intercorrelations were also found between the national price of feeder cattle and the number of cattle fed in individual regions in the fitted equation of the regional price of feeder cattle.

In determining the price of wholesale fed beef in the nation, the intercorrelation was high between the national per capita consumption of fed beef and national per capita disposable income. However, the R^2 value and t-value of per capita consumption of fed beef were enhanced by the inclusion of per capita disposable income in the equation.

The existence of intercorrelation in the above equations suggests that the coefficients of intercorrelated variables must be regarded with caution. This will not affect the interpretation of the explanatory power of the entire equation.

The problem of incorrect specification of the functional relationships deserves comment. Certain relevant variables may be left out from the regression model (often due to inadequacy of data being analyzed). This may seriously bias the individual estimates of the remaining regression coefficients. In some cases the bias can be several times larger than the standard error estimated for the coefficient by ordinary least-squares technique. Thus the coefficients should be regarded with caution.

The final form of the regression equations is presented in Tables 2 to 10. The t-value associated with each coefficient is shown below the coefficient. The degrees of freedom are presented with each regression equation. At the end of each equation an R^2

Table 2. Estimating Equations for Regional Cow Inventories ($COWINV_t^i$)

Equation No.	Region	Regression Constant	Regression Coefficients			R^2	d. f.	Period
			$RANGE_{t-2}^i$	TIME	$PFDRCT_{t-2}^i$			
1	1	948,301.550	5,130.438 (2.459)*	26,107.421 (10.156)*	-8,157.290 (-3.179)*	0.95	6	1958-67
	2	272,386.050	9,912.302 (1.891)	55,413.098 (16.487)*	1,786.307 (0.603)	0.98	6	1958-67
	3	959,732.370	12,737.857 (5.036)*	63,927.726 (23,344)*	-16,627.264 (-6.908)*	0.99	6	1958-67
	4	655,396.930	1,141.073 (0.880)	28,806.252 (23.865)*	-1,347.734 (-0.759)	0.99	6	1958-67
	5	507,458.730	1,429.301 (1.656)	9,791.038 (8.459)*	-4,298.316 (-4.221)*	0.94	6	1958-67
	6	3,780,263.500	13,853.618 (0.909)	226,578.851 (15.023)*	-25,205.404 (-1.453)	0.97	6	1958-67
	7	4,598,010.100	4,973.596 (0.171)	289,261.520 (10.754)*	26,331.490 (0.683)	0.96	6	1958-67
	8	3,714,038.100	--	209,662.386 (28.768)*	-9,509.604 (-1.231)	0.99	7	1958-67
	9	6,935,611.200	--	315,896.767 (22.552)*	-54,096.080 (-4.628)*	0.98	7	1958-67

*t-values significant at the five percent level.

Table 3. Estimating Equations for the Number of Feeder Cattle ($FDRCAT_t^i$), by Regions

Equation No.	Region	Regression Constant	Regression Coefficients: $COWINV_t^i$	Regression Coefficients: $PFDRCT_{t-1}^i$	R^2	d.f.	Period
2	1	751,145.930	0.641 (7.883)*	-363.124 (-1.134)	0.92	7	1957-66
	2	725,234.160	0.518 (11.283)*	-109.154 (-0.294)	0.95	8	1956-66
	3	112,606.140	0.719 (18.348)*	-171.463 (0.483)	0.98	7	1957-66
	4	167,167.120	0.686 (18.172)*	-296.560 (-1.822)	0.97	8	1956-66
	5	105,810.070	0.651 (5.297)*	-123.817 (-0.726)	0.82	8	1956-66
	6	2,246,191.800	0.538 (17.172)*	-2,307.336 (-2.161)*	0.97	7	1957-66
	7	2,000,047.300	0.512 (17.650)*	-1,859.926 (-1.325)	0.97	7	1957-66
	8	11,266,400.000	-0.135 (2.257)*	-76,874.970 (-5.609)*	0.84	8	1956-66
	9	9,626,455.900	0.169 (7.693)*	-71,129.037 (-11.597)*	0.96	8	1956-66

*t-values significant at the five percent level.

Table 4. Estimating Equations for the National Cow Beef ($COWBEEF^N_t$) and Price of Wholesale Beef ($PWSLBF^C_t$)

Equation No.	Regression Equation	R^2	d.f.	Period
4	$COWBEEF^N_t = 4,511,404,100.000 + 341.823\ COWINV^N_t$ (4.384)* $-326,363,099.000\ PFDRCT^K_{t-1}$ (-2.900)*	0.74	8	1957-67
5	$PWSLBF^C_t = 62.554 - 0.5888\ CONSBF^N_t + 0.01304\ Y^N_t$ (-3.293)* (2.604)* $+ 0.05119\ PKPRIC^N_t$ (0.345)	0.77	4	1960-67

*t-values significant at the five percent level.

Table 5. Estimating Equations for the Regional Price of Wholesale Beef ($PWSLBF_t^i$)

Equation No.	Region	Regression Constant	Regression Coefficients $PWSLBF_t^C$	Y_t^{i-N}	$BSPERCAP_t^{i-N}$	R^2	d.f.	Period
6	1	-1.579	1.0681 (9.477)*	-0.00949 (-1.204)	0.14205 (3.103)*	0.92	8	1956-67
	2	8.550	0.8545 (8.150)*	0.00073 (0.076)	-0.18318 (-3.068)*	0.91	8	"
	3	16.844	0.6214 (4.658)*	0.02780 (3.020)*	0.05210 (1.989)*	0.88	8	"
	4	3.484	0.9702 (10.017)*	-0.00231 (-0.768)	-0.01593 (-3.875)*	0.93	8	"
	5	4.273	0.8756 (6.070)*	-0.00364 (-1.020)	-0.02934 (-0.626)	0.84	8	"
	6	-0.008	0.9905 (7.496)*	-0.00388 (-0.894)	-0.00688 (-2.751)*	0.90	8	"
	7	-1.034	1.0734 (9.254)*	0.01455 (4.392)*	0.06357 (2.064)*	0.94	8	"
	8	-17.947	1.1088 (5.075)*	-0.02365 (-1.768)	0.22673 (1.077)	0.86	8	"
	9	7.759	0.9438 (9.133)*	0.00304 (0.315)	0.08347 (2.549)*	0.94	8	"

*t-values significant at the five percent level.

Table 6. Estimating Equations for the Regional Supplies of Fed Beef (TSFDBF$_t^i$)

Equation No.	Region	Regression Constant	Regression Coefficient CATFED$_t^i$	R^2	d. f.	Period
7	1	-76,815.837	0.460047 (22)*	0.98	6	1960-67
	2	-35,632.062	0.489665 (32)*	0.99	6	"
	3	-8,799.632	0.488377 (37)*	0.99	6	"
	4	-15,607.241	0.490321 (63)*	0.99	6	"
	5	-448.371	0.446476 (11)*	0.95	6	"
	6	-60,486.878	0.489851 (65)*	0.99	6	"
	7	-9,687.128	0.453832 (185)*	0.99	6	"
	8	-300,626.430	0.377218 (21)*	0.98	6	"
	9	82,347.120	0.279968 (5.245)*	0.82	6	"

*t-values significant at the five percent level.

Table 7. Estimating Equations for the Regional Price of Fed Cattle ($PFDCAT_t^i$)

Equation No.	Region	Regression Constant	Regression Coefficients: $TSFDBF_t^i$	Regression Coefficients: $PWSLBF_t^i$	R^2	d. f.	Period
8	1	-8.05150	0.000002648 (2.665)*	0.6935 (7.541)*	0.86	9	1956-67
	2	-8.04627	0.000002837 (0.417)	0.78278 (6.105)*	0.81	9	"
	3	-7.28763	0.000033384 (1.295)	0.70296 (5.690)*	0.78	9	"
	4	-4.78666	0.000003244 (2.462)*	0.71186 (10.338)*	0.92	9	"
	5	-4.84953	-0.000003971 (-0.072)	0.73086 (5.101)*	0.75	9	"
	6	-6.00327	0.000000780 (2.246)*	0.74325 (10.468)*	0.92	9	"
	7	-4.69477	0.000001995 (2.189)*	0.70844 (7.003)*	0.84	9	"
	8	-6.67262	0.000001080 (2.318)*	0.71010 (9.366)*	0.90	9	"
	9	-3.48353	0.000005650 (0.269)	0.63913 (4.692)*	0.71	9	"

*t-values significant at the five percent level.

Table 8. Estimating Equations for the National Price of Fed Cattle ($PFDCAT_t^N$) and Feeder Cattle ($PFDRCT_t^K$)

Equation No.	Regression Equation	R^2	d.f.	Period
9	$PFDCAT_t^N = -5.2725 + 0.7007\ PWSLBF_t^C$ (17.357)* $+ 6.1946\ PBYPROD_t^N$ (1.737)	0.98	9	1956-67
11	$PFDRCT_t^K = 30.032 - 0.000001103\ FDRCAT_t^N$ (-1.252) $+ 1.015889 PFDCAT_t^N + 0.000000527\ CATFED_{t-1}^N$ (2.300) (1.203)	0.82	3	1961-67

*t-values significant at the five percent level.

Table 9. Estimating Equations for the Regional Price of Feeder Cattle ($PFDRCT_t^i$)

Equation No.	Region	Regression Constant	Regression Coefficients: $CATFED_{t-1}^i$	Regression Coefficients: $PFDRCT_t^K$	R^2	d.f.	Period
12	1	5.345	-0.0000019 (-6.333)*	0.950 (20.743)*	0.99	4	1961-67
	2	-0.673	-0.0000002 (-0.084)	1.026 (10.428)*	0.96	4	"
	3	1.882	-0.0000130 (-7.27)*	1.044 (5.258)*	0.92	4	"
	4	5.180	-0.0000011 (-0.590)	0.882 (4.929)*	0.86	4	"
	5	0.217	-0.0000104 (-0.925)	1.051 (10.779)*	0.97	4	"
	6	2.866	-0.0000001 (-1.084)	0.976 (20.314)*	0.99	4	"
	7	2.944	-0.0000002 (-0.977)	0.890 (18.977)*	0.98	4	"
	8	7.014	-0.0000001 (-0.412)	0.793 (7.635)*	0.94	4	"
	9	5.006	-0.00000354 (-0.901)	0.823 (6.943)*	0.92	4	"

*t-values significant at the five percent level.

Table 10. Estimating Equations for the Number of Fed Cattle ($CATFED^i_{t+1}$), by Regions.

Equation No.	Region	Regression Constant	Regression Coefficients $\Pi CTFED^i_t$	$FDRCAT^i_t$	$CATFED^i_t$	R^2	d.f.	Period
14	1	-211,846.790	-1,459.037 (-0.255)	0.999 (0.481)	0.516 (1.270)	0.81	4	1960-67
	2	-126,150.120	-904.244 (-1.309)	0.067 (0.372)	1.115 (8.028)*	0.98	4	"
	3	-63,697.548	287.315 (0.401)	0.162 (2.736)*	0.148 (0.516)	0.88	4	"
	4	-1,456,571.200	2,762.636 (1.520)	2.856 (2.544)*	0.486 (1.927)	0.98	4	"
	5	-1,473.977	35.066 (0.029)	0.351 (0.937)	-0.014 (0.025)	0.26	4	"
	6	-1,368,347.300	5,869.036 (0.468)	0.392 (0.493)	0.961 (2.737)*	0.95	4	"
	7	-618,655.750	7,873.219 (1.865)	0.079 (0.359)	1.184 (7.672)*	0.99	4	"
	8	-12,922,725.000	-6,065.641 (-0.699)	1.393 (2.574)*	1.176 (13.633)*	0.98	4	"
	9	-11,190,053.900	-411.433 (-0.439)	0.228 (1.670)	-0.504 (0.748)	0.76	4	"

*t-values significant at the five percent level.

value is given. The period for which data for each equation were used is also shown in the table.

In general, the values of coefficients of determination (R^2) were very high. That means that the independent variables chosen explained a large percentage of the variation in the response or dependent variables. Most coefficients of determination were between 0.90 and 1.00. The t-values associated with the coefficients of equation were generally statistically significant at the 0.10 level. That means that most of the coefficients were statistically significantly different from zero at that level. A brief discussion of the statistical results of each equation is given below.

For the equation estimating regional cow inventories, all R^2 were between 0.94 to 0.99. Range conditions lagged two years and time trend were positively related to cow inventory, while price of feeder cattle two years previously was negatively related to it. These relations were the expected ones on the basis of economic knowledge. There were, however, two exceptions. Price of feeder cattle lagged two years was positively related to cow inventory in Regions 2 and 7.

The number of feeder cattle in a region to be available to feedlots had a positive relationship with cow inventories and a negative relationship with its own price. The negative relationship of the number of feeder cattle and its price can be explained as follows.

When the price of feeder cattle increases, the producers of heifers hold their heifers in the expectation of higher prices next year. The number of feeder cattle to be fed in feedlots, which also includes heifers, therefore decreases. All coefficients of determination for this equation were from 0.82 to 0.98.

In the equation estimating the national supply of cow beef, cow inventory was found to be directly related to cow beef supply, and the national price of feeder cattle was inversely related. The individual tests of significance of coefficients using the students t-distribution show that at the five percent level of significance both coefficients are significant. The fit of the equation to the historical data was found to be satisfactory.

In estimation of the national price of wholesale beef, the signs of coefficients of the national per capita disposable income and pork price were positive while that of per capita consumption was negative. These signs were the expected ones *a priori*. R^2 for the equation was 0.77.

Price of wholesale beef in a region had a positive relationship with the national price of wholesale beef. That is, an increase in the national price of wholesale beef induces an increase in the price of wholesale beef in a region. The signs of coefficients of the difference in per capita national and regional disposable income and the difference in per capita national and regional supply of fed beef were positive in some regions and negative in others. The magnitude of R^2 ranged between 0.84 to 0.94, indicating the fit of the equations to the available data in all regions was reasonably good.

Total supply of fed beef in a region was found to be positively related to the number of cattle fed. This was expected a priori. R^2 for the estimating equation varied from 0.95 to 0.99, except in Region 9 where R^2 was 0.82.

The price of fed cattle in a region was estimated by the total supply of fed beef and the price of wholesale beef in that region and was found that it was positively related to both variables. These signs were expected a priori. The supply of fed beef and prices of fed cattle were expected to have a positive relationship. The demand for fed cattle is a derived demand, wholesale beef being the final product of consumption. When the prices of wholesale beef goes up, the price of fed cattle increases. The magnitude of R^2 ranged from 0.71 to 0.92 for the various regions.

The national price of fed cattle was found to be positively related to the national price of wholesale beef and the national price of by-products. The magnitude of R^2 for the equation was 0.98. The national price of feeder cattle is negatively related to the national supply of feeder cattle and positively related to the national price of fed cattle and cattle fed one year previously. The R^2 was 0.82.

In estimation of the regional prices of feeder cattle, the coefficient of the number of cattle fed in the region was negative, indicating that an increase in the number of cattle fed in the previous year will reduce the price of feeder cattle this year. This is not compatible with what was expected a priori. This may be because the effect of the national price of feeder cattle overshadows the effect of the number of cattle fed in the previous years. The coefficient of the national price of feeder cattle had positive sign. R^2 for this equation ranged from 0.86 to 0.99.

Feedlot profits per head of cattle fed were taken as identically equal to the price of fed cattle a feedlot operator receives minus price paid for 600-pound choice feeder cattle minus feed and non-feed costs of fattening a feeder to a fed cattle market weight of 1,025 pounds.

In estimating the number of cattle fed in various regions, the coefficient of one-year lagged supply of feeder cattle had a positive sign which was expected a priori because an increase in supply of feeder cattle will produce an increase in the number of fed cattle. Feedlot profits, one-year lagged, had positive signs in five regions and negative signs in four regions. On the basis of economic theory the profits are expected to give incentive to the feedlot operators to increase the number of cattle fed. Due to limited availability of data, only eight observations for the period 1960-67 were used. The profits in those eight observations did not show any consistent trend, while the number of cattle fed increased every year. That is how the negative sign for the coefficient of feedlots profits was obtained in four regions. The number of cattle fed in the previous year was positively related to the number of cattle fed this year in seven regions but negatively related in Region 5 and 9, where the actual data on cattle fed fluctuated. The magnitude of R^2 ranged from 0.76 to 0.99, with the exception of Region 5, where its value was 0.26.

Empirical Development of the Model

The estimating equations and identities were ordered to form a simulation model. A computer program in Fortran IV computer language was written to solve the model. The model being recursive, the initial conditions which existed at or prior to 1961 were fed into the computer. That is, the values of lagged endogenous variables at or prior to 1961 were needed to run the model. In addition, the values of the following exogenous variables for the entire period were read into the system: national disposable income per capita, regional disposable income per capita, national beef supply per capita, regional beef supply per capita, national price of by-products, regional pork price, and regional feed and nonfeed costs.

The simulation program was run with initial values of the lagged endogenous variables and the values of exogenous variables. Results obtained from the first iteration were the estimated values of the endogenous variables for 1961, and the level of cattle feeding in various regions for 1962. The second iteration began with these values of the endogenous variables as values of predetermined endogenous variables for the second time period, and the algorithm went through all the equations and identities once again, estimating the values of all endogenous variables for 1962 and the level of cattle feeding for 1963. This process was repeated until the endogenous variables were estimated for 1967 and the level of cattle feeding was estimated for 1968.

The results obtained from the computer simulation model were compared with the actual historical data for the same period to find the forecasting accuracy of the model. Whenever there were signs of error buildup, the model was examined to find the cause of the error and its buildup. If the buildup of the error was of such a magnitude that it produced estimates completely out of the relevant range, an operating limit or rule was introduced in the system according to what would have been expected on the basis of economic logic.

The operating rules are introduced into the model to avoid accumulation of error through time, and to improve estimates. The rules are wrought in such a fashion that they have economic basis, and their purpose is to dampen the deviations between the actual and estimated values. Especially when the model is designed for prediction of a number of variables over an extended time period, the operating rules are important because if there is an error buildup through time, then the long-run predictions would be out of the relevant range. The introduction of operating rules in such situations is an essential part of the model development.

When it was necessary to introduce an operating rule in the model, the model was run again with the operating rule, and the results of all endogenous variables estimated by the system were compared to the historical data to determine whether the introduction of the operating rule had been useful. If the operating rule had been operative, and the results for that variable for which the operating rule was inserted in the system had come closer to the historical data, then its effect on other endogenous variables was checked. In the recursive model, the results obtained for one endogenous variable affect the values of other endogenous variables. If the values of other endogenous variables were disturbed and absolute deviation between their estimated values from the simulation model and their actual values increased substantially from as expected by randomness, then that operating rule was discarded and a new operating rule was introduced.

The introduction of operating rules was continued until all the variables were satisfactorily reproduced. The complete simulation program is presented in Appendix II.

Operating Rules

Five operating rules were introduced in the model, four on the number of cattle fed and one on the national price of feeder cattle. This being a short run model, there is a limit placed by certain factors on the way the number of cattle fed will behave in a region. Some of these factors are slaughter capacity of a region, the capacity of feedlots in a region, the effect of supply of cattle fed on prices in wholesale beef, fed cattle, and feeder cattle markets, the demand for fed beef, and the availability and cost of transportation. These factors can be expected to place some constraints on the rate of growth of cattle feeding in a region.

Some of the estimated figures on the number of cattle fed in Region 7 (Texas, Oklahoma, and New Mexico) were about 20 to 30 percent larger than the actual figures. The deviation increased at a tremendous rate for that variable in the last few years. One of the variables explaining the variation in the number of cattle fed was the number of cattle fed in the previous time period. Thus, in order to control the accumulation of error in the estimates, restrictions were placed on that variable in that region. The number of cattle fed in Region 7 was restricted to a maximum of 15 percent increase per year. That is, if the number of cattle fed in a certain year was estimated to increase by more than 15 percent from that in the previous year, then the number of cattle fed in that year was increased by

15 percent from that in the previous year. If the increase in the number of cattle fed in that region was less than 15 percent, then the restriction was inoperative.

The limit of 15 percent increase was considered to be appropriate because with that restriction the estimated values of that variable were closer to the actual historical data, and also the estimated values of other variables were reproduced with a smaller deviation. The restriction was found operative in 1965, 1966, 1967 and 1968.

Operating restrictions were also introduced on the number of cattle fed in Regions 2 (Pacific Northwest), 6 (North Plains states), and 8 (Corn Belt states). In the Pacific Northwest the estimates of the number of cattle fed were depressed in comparison with the actual historical values. Therefore, the first estimated value, that is, of 1962, was multiplied by 1.10. Since the estimation of the value of cattle fed in a certain year depended upon the value in the preceding year, the years following 1962 were reproduced with higher accuracy. Similarly, the number of cattle fed in the North Plains states in 1962 were multiplied by 0.90 to dampen its very rapid increase in that year.

The estimated number of cattle fed in the Midewest were much lower than the actual values. A figure of yearly increase of 0.05 was considered to be appropriate to put the estimated figure in line with the actual figures. Therefore, the minimum yearly increase of 0.05 was introduced for the first four years (1962-65). This operating rule was operative only in 1963 and 1964.

The estimated values of price of feeder cattle in the national market and regional markets were too high as compared with historical figures. Too high prices of feeder cattle in a region would give incentive to feeder cattle producers to increase their herds. This will increase the number of cattle fed because the number of feeder cattle and cattle fed are positively related. The number of cattle fed next year, in turn, depends upon the number fed this year. This relationship is also positive. Thus, a cycle may continue which may cause the values of other variables to go out of line.

One of the variables in the estimating equation of the regional price of feeder cattle was the price of feeder cattle in the national market. Therefore, the national price of feeder cattle was reduced by $2.00 through a reduction in the intercept value. This operating rule brought the estimated prices of the feeder cattle closer to their historical counterparts.

Validation of the Model

Whether or not the simulation model is a valid representation of the cattle feeding industry depends upon how closely the simulated values of the variable of the model correspond to their historical counterparts. The model is validated if the historical values were reproduced with an acceptable accuracy. In general, the values of the variables which this simulation model generated fell within the acceptable limits from the observed values. The historical and estimated values of all endogenous variables are given in Appendix 1, Tables 1 to 8. The percent deviations--average, highest, and lowest--between simulated values and actual values of all endogenous variables are shown in Table 11. The deviations of individual variables are discussed below.

The average deviation of the simulated values of the number of cattle fed for the entire period, 1962-68, from the observed values was six percent. The lowest deviation was about two percent in Region 8 and the highest was about 16 percent. The average deviation for the Pacific Northwest region was seven percent.

The estimated values of the feeder cattle supply in any region for the period diverged less than three percent from the historical values. The divergence was less than one percent in Region 8, and slightly more than one percent in the Pacific Northwest.

The simulated values of cow inventories were very close to the actual values. The average deviation between the two was about one percent, with the lowest percent deviation of 0.60 occurring in Region 4. The maximum percent deviation for this variable was two percent in the Southern Plains. In the Pacific Northwest region, the deviation was 1.75 percent.

The regional prices of feeder cattle, fed cattle, and wholesale

Table 11. Percent Deviations Between Simulated Values and Actual Values of all Endogenous Variables--Average, Highest, and Lowest

Variable	Avg. % deviation	Highest % deviation		Lowest % deviation	
		Region	% Dev.	Region	% Dev.
CATFED	6.06	7	16.12	8	2.26
FDRCAT	2.83	6	6.54	8	0.76
COWINV	1.27	7	2.09	4	0.60
TSFDBF	5.50	7	15.29	1	1.99
PFDRCT	3.97	9	7.11	1	2.43
PFDCAT	2.65	5	5.32	2	1.55
PWSLBF	2.19	5	3.59	1	1.43
$PWSLBF^{C}$	1.45	-	--	-	--
$PFDRCT^{K}$	7.84	-	--	-	--
$PFDCAT^{C}$	1.73	-	--	-	--
$COWBEEF^{N}$	10.26	-	--	-	--

beef were fairly reproduced. The average deviations ranged from two percent to less than four percent. Average deviations for the Pacific Northwest region for three price variables were 3.65, 1.55, and 2.28 percent, respectively.

The deviation in the total supply of fed beef was closely related to the deviation in the number of cattle fed in feedlots. The average deviation for this variable was 5.5 percent, and that in the Pacific Northwest region was 5.13 percent.

The simulated value of the national prices of wholesale beef, feeder cattle, and fed cattle diverged from their historical counterparts by 1.45, 7.84 and 1.73 percent, respectively. The average deviation in supply of cow beef in the nation was slightly more than ten percent.

Forecasting Properties of the Model

One of the main characteristics of the simulation model developed above is that if the values of exogenous variables of the model are known for any given period--past, present or future--the values of endogenous variables can be simulated by the model for the comparable period. Only the initial values of lagged variables and the values of exogenous variables are needed to operate it over any specified time period. The impact of various changes in the values of exogenous variables, changes in the initial conditions, or changes in the structure of one or more equations can be handled through the model. For example, the model can be used to trace the impact of a change in price structure on the other variables determined in the system.

This model is of a recursive nature and can be used to project values of endogenous variables in future time periods. It can be initiated in any year and projected to any year by feeding in the appropriate data on initial conditions and exogenous variables. When future predictions are desired, the values of exogenous variables need to be estimated in order to operate the model. Most of such estimated values can be obtained by techniques like time series simple regression analysis, especially when there appears to be some trend shown by data of the past period. The data on income, population, and per capita consumption of fed beef are a few examples of such variables. The values of some variables whose historical values fluctuate around a pivotal value could be estimated by taking their mean value into consideration. The range condition variable is an example of this type of relation.

The parameters of the model were estimated from historical data. They portray the economic activity during the historical period used for their estimation under the existing economic structure of the cattle feeding industry. If the structure of the industry changes, that is, if there are changes in the existing institutions or governmental policies, a new set of coefficients to represent the behavioral relationships is needed. The model cannot predict these changes, but it can trace the effect of such changes on the variables determined by the system if the changes are incorporated into the model.

Projections to 1975

Projections in 1975 were made through the model for all endogenous variables. For this analysis, values for all exogenous variables were estimated up to 1975. The ordinary least-squares technique was used to estimate the national per capita consumption of beef, national and regional per capita disposable income, beef supply per capita in the U. S. and all nine regions, and feedlot costs in each region. Prices of by-products were considered as constant because the changes in that variable throughout the 1956-68 period were very small. The range conditions in all regions and the national price of pork were taken at their mean values because their values in the past years indicated that they fluctuated around mean values.

The values of the exogenous variables and the initial conditions were fed into the computer, and the projected values were obtained up to 1975. The values of the endogenous variable in 1968 and 1975, along with the percent changes for the period 1968-75, are shown in Table 12.

Table 12. The Estimated Values of Endogenous Variables, 1968 and 1975, and Percent Changes during 1968-75.

Variable	Period	Region 1	2	3	4	5	6	7	8	9	National
CATFED (1,000 head)	1968	2,907	809	236	1,476	172	6,066	2,071	8,525	684	22,946
	1975	3,191	1,269	261	2,208	181	10,291	5,510	11,246	709	34,871
	% change 1968-75	9.74	56.89	10.41	49.57	5.68	69.64	166.0	32.09	3.69	51.96
	Yearly % change	1.39	8.12	1.48	7.08	0.81	9.94	23.7	4.58	0.52	7.42
FDRCAT (1,000 head)	1968	1,659	1,581	1,685	844	503	5,662	6,317	8,484	9,457	36,192
	1975	1,755	1,785	1,956	978	534	6,450	7,396	8,023	9,521	38,402
	% change 1968-75	5.79	12.95	16.03	15.91	6.12	13.91	17.07	-5.44	0.67	6.10
	Yearly % change	0.82	1.85	2.29	2.27	0.87	1.98	2.43	-0.77	0.09	0.87
COWINV (1,000 head)	1968	1,431	1,657	2,194	998	616	6,465	8,523	5,564	8,853	36,301
	1975	1,583	2,053	2,571	1,196	664	7,948	10,644	6,999	10,862	44,525
	% change 1968-75	10.63	23.90	17.18	19.75	7.84	22.93	24.88	25.80	22.69	22.65
	Yearly % change	1.51	3.41	2.45	2.82	1.12	2.89	3.55	3.68	3.24	3.23

Table 12. Continued

Variable	Period	Region 1	2	3	4	5	6	7	8	9	National
TSFDBF (1,000 pounds)	1968	1,260,995	360,647	106,869	708,393	76,410	2,911,326	930,410	3,516,697	273,989	10,145,736
	1975	1,391,403	586,100	118,918	1,067,343	80,782	4,980,931	2,490,991	4,430,122	280,543	15,427,130
	% change 1968-75	11.03	62.51	11.27	52.39	5.72	71.08	167.73	25.97	2.39	53.56
	Yearly % change	1.57	8.93	1.61	7.48	0.81	10.15	23.96	3.71	0.34	7.65
PFDCAT (dollars)	1968	26.24	26.05	21.37	27.04	27.18	27.04	26.49	27.79	25.59	27.02
	1975	26.83	26.07	19.76	27.93	28.50	28.81	28.71	27.78	25.38	27.69
	% change 1968-75	2.2	0	-7.5	3.3	4.7	6.6	8.3	0	-0.7	2.47
	Yearly % change	0.31	0	-1.07	0.47	0.67	0.94	1.18	0	-0.1	0.35
PFDRCT (dollars)	1968	25.46	26.76	26.96	27.42	26.69	28.56	26.51	27.52	24.73	26.89
	1975	28.82	30.91	30.91	30.21	30.93	32.17	29.59	30.54	28.03	31.01
	% change 1968-75	13.30	15.7	14.0	10.2	16.1	12.0	11.0	10.9	13.3	15.32
	Yearly % change	1.90	2.20	2.00	1.45	2.30	1.71	1.57	1.55	1.90	2.18

Table 12. Continued

Variable	Period	Region 1	2	3	4	5	6	7	8	9	National
PWSLBF (dollars)	1968	44. 64	42. 25	35. 70	41. 48	43. 41	41. 41	41. 40	43. 18	43. 07	45. 17
	1975	44. 99	41. 46	32. 83	41. 10	45. 20	41. 61	40. 13	41. 78	42. 68	46. 12
	% change 1968-75	0. 7	-1. 8	-8. 0	-0. 9	4. 1	0. 48	-3. 0	-3. 24	-0. 90	2. 10
	Yearly % change	0. 1	-0. 26	-1. 14	-0. 12	0. 58	0. 07	-0. 42	-0. 46	-0. 12	0. 30
COWBEEF (1, 000 pounds)	1968										8, 623, 057
	1975										9, 891, 412
	% change 1968-75										14. 70
	Yearly % change										2. 10

According to the projected estimates, substantially greater numbers of cattle will be fed in United States feedlots in 1975 than in 1968. The total number of fed cattle was estimated to be about 23 million head in 1968, while the number projected for 1975 was about 35 million. This means that about 50 percent more cattle will be fed in 1975 than in 1968 in the United States. Though the estimated number of cattle fed showed an increase in all nine regions separately, the increase was not equally divided among all regions. The Pacific Northwest region showed an increase of about 57 percent in the number of cattle fed duirng 1968-75. That is, eight percent more cattle are estimated to be fed in Pacific Northwest feedlots annually during that period. The California-Arizona region is projected to increase its fed cattle production by less than ten percent in the 1968-75 period, that is, an annual increase of slightly over one percent is expected to take place in that region.

The lowest increase in the number of cattle fed was found in the eastern states. These states were estimated to have fed 684,000 head of cattle in 1968 and were projected to feed 709,000 head in 1975. Thus, an increase of 3.69 percent in the number of cattle fed was estimated during 1968-75 period, or an increase of 0.52 percent per year.

The Utah-Nevada region would increase the number of cattle fed by 0.81 per annum during this period. Its total number of cattle fed was estimated to increase from 172,000 head to 181,000 head during the 1968-75 period.

The maximum increase in the number of cattle fed was estimated in the Texas-Oklahoma-New Mexico region. This region recorded an expansion from 2,071,000 head in 1968 to 5,510,000 head in 1975, which is an increase of about 23 percent annually.

The North Central area comprised of 12 states was estimated to be the leading area in the number of cattle fed in 1975. It increased its fed cattle by 48 percent during 1968-75. Of the 35 million head about 22 million head will be fed in these states in 1975. Thus, about 62 percent of the total number of cattle fed in the United States are estimated to be fed in these states.

Colorado is expected to increase its fed cattle at the rate of seven percent annually during the period 1968-75, feeding over two million head in 1975. The Montana-Wyoming region is found to have an increase of about 1.40 percent annually during the period.

The supply of feeder cattle in the United States increased from about 36 million head in 1968 to more than 38 million head in 1975, for an increase of six percent during the period.

The increase in supply of feeder cattle in the Pacific Northwest was about 13 percent during 1968-75, whereas the number of cattle fed increased by about 57 percent during the same period. This may be due to the fact that in the earlier years the number of cattle fed in Pacific Northwest feedlots was substantially less than the number of feeder cattle available there. This uneven increase between the two variables would bring this difference to a lesser extent in 1975.

The supply of feeder cattle was estimated to increase by about two percent annually in the Northern Plains states, and to decrease by 0.77 percent annually in the Corn Belt area. Thus, the increase for the North Central states during 1968-75 is expected to be only about two percent.

The simulated value of cow inventory in the United States was 23 percent higher in 1975 than in 1968. The value of this variable increased in every region. The Pacific Northwest was estimated to increase its cow inventory from 1.6 million head in 1968 to two million head in 1975, for an increase of 3.41 percent annually.

The national supply of nonfed beef increased from 8.6 billion pounds in 1967 to about 9.9 billion pounds in 1975, showing an increase of about 15 percent during 1968-75, or about two percent annually.

The projected values of the national prices of feeder cattle, fed cattle, and wholesale beef markets recorded an increase of 2.1, 2.5, and 15.3 percent, respectively, during 1968-75. The projected increase in regional feeder cattle prices ranged from 1.45 percent to 2.3 percent annually, the Pacific Northwest prices increasing by about two percent annually. The regional fed cattle prices decreased in two regions, Montana-Wyoming and the Eastern states. Montana-Wyoming recorded a decrease of about one percent annually and

Eastern states about 0.1 percent annually during 1968-75. The Pacific Northwest did not show any change in the price of fed cattle during that period.

The projected values of regional prices of wholesale beef in 1975 deviated slightly from the values estimated by the model for 1968. The only value which was significantly different from that in 1968 was of Montana-Wyoming region where the price of wholesale beef had shown a decline of eight percent during the period or decline of about one percent per year. This is in correspondence with the decrease of price of fed cattle in the same region.

Impact of Changes in Feed Grain Prices

The simulated model of the beef cattle feeding industry was used to analyze the effect of an increase in feed grain prices on the number of cattle fed in different regions, and the variables associated with it. Feed grains were divided into two categoreis--corn and all other feed grains. Corn prices were raised by 20 percent over the usual estimates for 1970-75, and the prices of all other feed grains were raised by 15 percent for the period 1970-75. These figures were used because in Fall, 1970, corn leaf blight occurred in the United States increasing corn prices by more than 20 percent.

This increase in feed grain prices increased the regional feed costs for the period 1970-75. The values of all other exogenous variables were the same as used in the projections of the endogenous variables for 1975. Only the value of feed costs were changed for the period 1970-75.

Since feed cost is one of the variables in calculating profitability of cattle feeding, an increase in feed costs decreases the profitability of feedlot operators. The number of cattle fed, among other things, is a function of profits of feeding cattle in feedlots lagged one year. Therefore, a change in profits in 1970 affected the number of cattle fed in 1971. If the effect of the change in cattle fed is traced through the flow chart (Figure 2), it can be seen that a change in the number of cattle fed in 1971 would affect prices of fed cattle and the total supply of fed beef in 1971, the national and regional price of feeder cattle in 1972, the supply of feeder cattle and nonfed beef in 1973, and cow inventories in 1974. This is due to lagged reactions in the beef cattle feeding industry. The changes in the projections for 1975 for all endogenous variables with the feed grain price increase are shown in Table 13.

The number of cattle fed in the United States were predicted to decline by about 324,000 head in 1975 with the increase in feed grain prices. This constitutes a decline of about one percent in the earlier projections made for 1975. The estimated number of cattle fed showed an increase in four of the nine regions. These four regions were California-Arizona, Pacific Northwest, Midwest,

Table 13. Changes in Projections for 1975 of the Endogenous Variables with Feed Grain Price Increase.

Variable	Region	Without feed grain increase Y_1	With feed grain increase Y_2	Difference $Y_2 - Y_1$	Percent difference $\frac{Y_2 - Y_1}{Y_1} \times 100$
		Head	Head	Head	Percent
CATFED	1	3,191,455	3,219,159	27,704	0.86
	2	1,269,710	1,293,214	23,504	1.85
	3	261,516	259,597	-1,919	-0.73
	4	2,208,656	2,140,870	-67,786	-3.06
	5	131,938	181,696	-242	-0.13
	6	10,291,740	9,971,039	-320,701	-3.11
	7	5,510,049	5,510,140	0	0
	8	11,246,970	11,262,190	15,220	0.13
	9	709,841	710,425	584	0.08
Total U. S.		34,871,966	34,548,330	-323,636	-0.92
FDRCAT	1	1,755,892	1,756,286	394	0.02
	2	1,786,733	1,785,706	-27	0
	3	1,956,265	1,956,360	95	0
	4	978,869	978,832	-37	0
	5	534,869	534,954	85	0.01
	6	6,450,147	6,450,409	262	0
	7	7,396,590	7,396,284	-306	0
	8	8,023,235	8,026,545	3,310	0.04
	9	9,521,363	9,524,244	2,881	0.03
Total U. S.		38,402,963	38,409,620	6,657	0.02
COWINV	1	1,583,374	1,583,943	569	0.03
	2	2,053,625	2,053,567	-58	0
	3	2,571,368	2,571,498	130	0
	4	1,196,017	1,195,979	-38	0
	5	664,790	664,915	125	0.02
	6	7,948,653	7,949,069	416	0
	7	10,644,560	10,643,850	-710	0
	8	6,999,895	7,000,218	323	0
	9	10,862,910	10,864,550	1,640	0.01
Total U. S.		44,525,192	44,527,589	2,397	0

(Continued)

Table 13. Continued

Variable	Region	Without feed grain increase Y_1	With feed grain increase Y_2	Difference $Y_2 - Y_1$	Percent difference $\frac{Y_2 - Y_1}{Y_1} \times 100$
		Pounds	Pounds	Pounds	Percent
TSFDBF	1	1,391,403,000	1,404,149,000	12,746,000	0.90
	2	586,100,000	597,609,000	11,509,000	1.96
	3	118,918,000	117,982,000	-936,000	-0.78
	4	1,067,343,000	1,034,106,000	-33,237,000	-3.11
	5	80,782,000	80,674,000	-108,000	-0.13
	6	4,980,931,000	4,823,837,000	-157,094,000	-3.15
	7	2,490,991,000	2,490,991,000	0	0
	8	4,430,122,000	4,548,927,000	118,805,000	2.68
	9	280,543,000	281,243,000	700,000	0.25
Total U. S.		15,427,130,000	15,379,518,000	-47,612,000	-0.31
		Dollars	Dollars	Dollars	Percent
PFDRCT	1	28.82	28.74	-.08	-0.27
	2	30.91	30.88	-.03	-0.09
	3	30.91	30.90	-.01	-0.03
	4	30.21	30.25	.04	0.12
	5	30.93	30.90	-.03	-0.09
	6	32.17	32.16	-.01	-0.03
	7	29.59	29.56	-.03	-0.09
	8	30.54	30.50	-.04	-0.12
	9	28.03	28.00	-.03	-0.10
	N	31.01	30.98	-.03	-0.09
PFDCAT	1	26.83	26.87	.04	0.15
	2	26.07	26.10	.03	0.10
	3	19.76	19.72	-.04	-0.20
	4	27.93	27.82	-.11	-0.04
	5	28.50	28.50	0	0
	6	28.81	28.68	-.13	-0.45
	7	28.71	28.71	0	0
	8	27.78	27.91	.13	0.46
	9	25.38	25.38	0	0
	N	27.69	27.69	0	0
		Pounds	Pounds	Pounds	Percent
COWBEEF	N	9,891,413,000	9,903,578,000	12,165,000	0.12

and Eastern states. The Pacific Northwest states showed an increase of about 24,000 head. The maximum decline in the estimated number of cattle fed occurred in the Northern Plains states. The cattle fed in these states decreased by 320,000 head in response to an increase in feed grain prices. The total supply of fed beef which is directly related to the number of fed cattle decreased with increase in feed grain prices. It showed the same direction of change in the individual regions as that shown by the number of cattle fed.

The regional and national prices in the feeder cattle market declined from the projected ones with the increase in feed grain prices. The only exception was Colorado, where prices increased by four cents per hundredweight over the projections for 1975. Prices in the fed cattle market increased in three regions, did not show any change in three regions, and declined in three regions from the projected values for 1975.

The supply of feeder cattle decreased slightly in the Pacific Northwest, Colorado, and the Southern Plains in response to the feed grain price increase, while it increased in the other six regions. Cow inventories also showed the same trend as the supply of feeder cattle.

The national supply of nonfed beef increased slightly in response to a relative decline in the number of fed cattle in the United States in 1975. This increase was expected on the basis of economic theory, because cow beef is considered to be a good substitute for fed beef, cross elasticity between the two being 1..292, when percentage change in the quantity of nonfed beef is considered in response to the price of fed beef (15, p. 178).

III INTERREGIONAL SHIPMENTS OF FED BEEF

The total demand for a product in a region is the horizontal summation of individual consumer's demand curves in that region. That is, at every price the quantities taken of that product by an individual consumer are added for all consumers in the region to derive a regional demand curve.

The consumer's demand for a product depends upon (1) the price of the produce, (2) consumer's tastes and preferences, (3) the consumer's income, (4) prices of related commodities, and (5) the range of goods available to consumer. The demand curve is generally drawn as a relationship between price and quantity of the product demanded. All other factors are assumed constant. Usually, as the price of the product increases, the quantity demanded decreases. Therefore, the individual's demand curve is drawn downward sloping to the right. When any of the other factors change, the demand curve changes. For example, if the individual's income increases then at the same price the individual will buy more of that product. When summing the individual demand curves to obtain total demand for a region or a nation, population also becomes an important factor.

Due to an increase in consumer income per capita and increases in population after World War II, the demand for fed beef has expanded. Consumers' tastes and preferences have also played an important role in this expansion of demand. This growth has not been the same in every region. In some regions, where urbanization is relatively higher and new industries have been developed, the population has increased very rapidly. Therefore, the regional distribution of fed beef consumption and the level and character of demand have changed tremendously during the past 25 years.

On the supply side, technological innovation outside as well as within the livestock-meat industry has increased the overall supply of fed beef in the United States. Some regions were located favorably with respect to resources and were well adapted to adjust to new methods and practices. Regional differences in supplies or in prices of factors of production also resulted in differences in the regional rate of acceptance of technological innovation. The rate of specialization and integration also varied among different regions. Therefore, supplies of cattle and beef increased more in some regions, which were favored by economic environments, than in others.

This differential growth in demand and supply of fed beef in various regions contributed to important changes in physical and economic relationships among regions, necessitating interregional adjustments.

In the first section of this chapter, a model for determining interregional shipments of fed beef has been developed. The second section describes the collection and processing of data for estimating the cost of transportation of live and carcass fed beef among regions, cattle slaughtering capacity, and slaughter costs. In the third section, the coefficients of behavioral equations used in the model have been estimated. Finally, the results of empirical analysis have been discussed.

Framework of Analysis

An attempt has been made here to construct a model which can explain the shipments of fed beef among regions. The model as presented is still in a crude, developmental stage. While solution of the model may not exactly depict the actual industry situation, the methodology used is expected to be of value in viewing some locational aspects of the fed beef industry.

Perfect competition has been assumed in the model; trade between regions takes place on the basis of economic incentives. Also, fed beef is viewed as a homogeneous commodity; that is, there are no differences of quality of fed beef among regions.

Theoretical Considerations

The basic determinants of the amounts of interregional trade, as discussed in this study, are prices of live fed cattle and carcass beef. Trade takes place from a surplus-producing region to a deficit-producing region on the condition that there is a price differential which makes it profitable for a surplus region to ship to a deficit region. A surplus region is considered to be one in which the number of cattle fed, transformed into carcass weight, exceeds the fed beef consumption of the region. The consumption in a region was calculated by multiplying per capita consumption of fed beef by population of the region. A deficit region is considered to be one in which the number of cattle fed, transformed into carcass weight, fell short of the consumption of fed beef in that region. Trade continued until the price level in the importing region[4] did not exceed the price level of the exporting region by more than the cost of transportation between the two regions. That is, the price level in the importing region should be equal to or greater than the price level of the exporting region plus the cost of transportation between the two. This is the condition of an equilibrium in the two regions. When all pairs of exporting and importing regions, considered simultaneously, have reached the condition described above, an equilibrium in national fed beef trade is said to have been reached.

A hypothetical two-region case may be presented graphically (13, p. 334). A demand and supply curve for a product are given for two regions, E and I (Figure 4). Cost of transportation for

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[4] Importing and exporting do not refer to foreign trade but to interregional shipments in the United States.

shipping product from one region to the other is also known. The intersection of the demand and supply curves determines the equilibrium prices in Regions E and I separately, the price in Region I being higher than that in Region E.

Region E ships the product to Region I as long as the price differential exceeds the cost of transportation between the two regions. This trade shifts the supply curve of exporting Region E to the left, from S_E to S_E', indicating a decrease in supply of the product for that region and increasing the price. The supply curve of the importing Region I shifts to the right (left in the inverted diagram) from S_I to S_I' indicating an increase in supply for that region, decreasing the price. The equilibrium price level after the shipments have taken place will be O_IP_e for the importing region and O_EP_e for the exporting region. If the prices are not O_IP_e and O_EP_e, trade will continue to take place. With every injection of supply (in one iteration), the prices in both regions will move toward an equilibrium position.

The amount of adjustment needed depends upon the slopes of the demand curves. The more elastic the demand curves, the greater the quantity of the product which must be shipped to reach a new equilibrium price level. In the final equilibrium, price in the importing region equals price in the exporting region, plus the cost of transportation between the regions, that is, $O_IP_e = O_EP_e + T_{EI}$. This two-region case is extended to a multi-region case in the model discussed below.

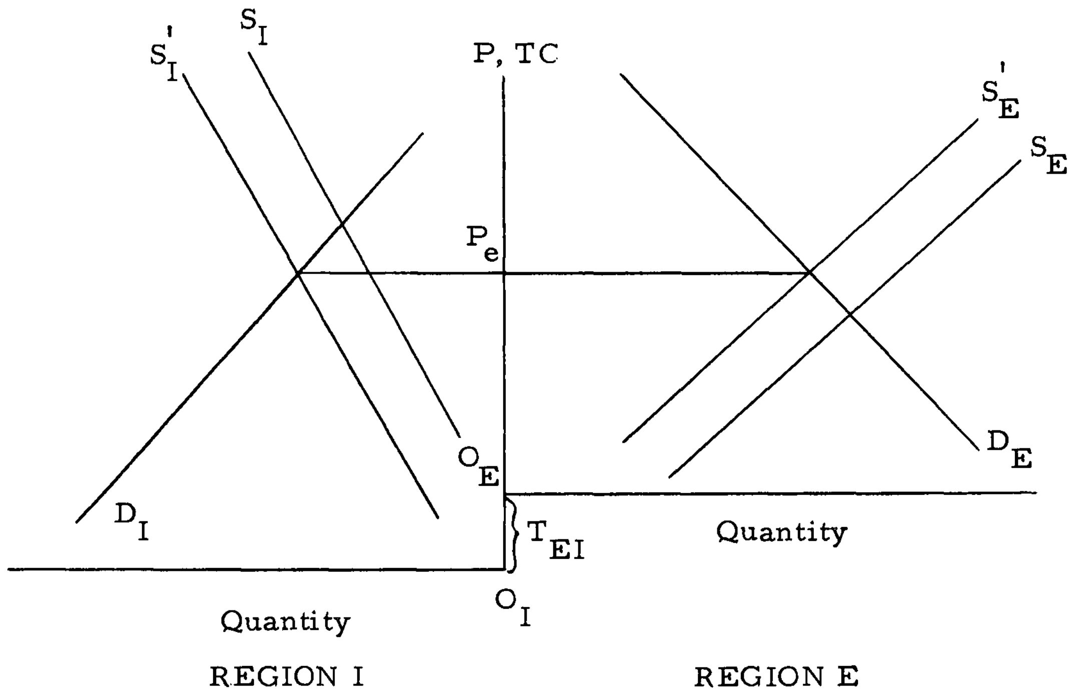

Figure 4. Hypothetical Two-region Model Illustrating the Determination of Equilibrium Market Prices and Shipment Patterns with Given Supply and Demand Curves.

The Model

A description of the model for interregional shipments of live and carcass beef is given in this section. The same nine regions are used as in the previous chapter where regional levels of cattle feeding are discussed (see Figure 1).

The price differentials among regions were the basic determinants of the interregional shipments. The regional price of wholesale beef was considered as a function of the price of wholesale beef in the nation, the difference between the per capita supply of fed beef in the nation and in that region, and the difference between national and regional per capita disposable income. The national price of wholesale beef depended upon per capita consumption of fed beef in the United States, the national per capita disposable income, and the national pork price (see Figure 3).

The wholesale prices of fed beef were calculated for each region. These prices were compared between regions, and the differences in prices packers can get selling in their own region relative to that in other regions were calculated. The cost of transporting carcass beef from one region to another was then deducted from these differences to calculate the net price advantage of shipping carcass beef between regions. The maximum price advantage was then picked up from these values.

The basic method of calculating the maximum price advantage of shipping live cattle among regions was the same as that described above for carcass beef shipments. The total number of fed cattle presently available in a region relative to slaughter capacity in the region was calculated. The dollar value that could be obtained for fed cattle slaughtered in a region was calculated by subtracting transportation costs of shipping beef in carcass form within the region and slaughter costs per hundredweight in a region from the price of wholesale fed beef in the region. These two variables determined the price of fed cattle in a region. The difference in price per hundred pounds that producers can get selling fed cattle in their own region relative to that in other regions was obtained, and subsequently the price advantage was calculated by deducting the transportation costs of shipping live cattle between the regions. The maximum price advantage was then identified.

The two maximum price advantages, one in the case of shipments of carcass beef and the other for live cattle shipments, were compared. Beef in carcass form was shipped if the price advantage of shipping carcass beef was greater than that of shipping beef in live form. Live cattle were shipped if the price advantage of shipping live cattle was greater than that in shipping carcass beef.

The amount of beef to be shipped in one iteration was calculated by an arbitrary number. A number was selected which, when multiplied by the amount of maximum price advantage, would indicate the quantity of live or carcass beef to ship in one iteration. This selection of an arbitrary number was made for carcass beef, and then the number was divided by 615, the average dressed carcass weight of a fed steer, to represent the number of live cattle to be shipped. The arbitrary number was so selected that it would be large enough to get convergence to a solution in a reasonable number of iterations, and small enough so that small surplus-producing regions would ship beef.

Any potential shipments, calculated on the basis of the price advantage, from exporting regions to importing regions were required to meet certain restrictions before they were considered to have taken place. This was done in order to make the solution economically feasible. The surplus regions were not allowed to be net importers of live and carcass beef, and the deficit regions were not allowed to be net exporters. The net importers were considered to be ones whose imports exceeded exports, and the net exporters were the ones whose exports exceeded imports. Some surplus regions found it advantageous to sell other surplus regions who, in turn, could sell it to a deficit region advantageously. This was allowed for within the restrictions, provided the surplus region was not the net importer of fed beef in live or carcass form.

The slaughter capacity of a region was one of the limitations imposed on the number of cattle a region could slaughter. A deficit-producing region was not allowed to import fed cattle in live form in excess of the slaughter capacity minus the number of cattle slaughtered in that region. If the import of fed cattle from other regions exceeded the remaining slaughter capacity after consideration had been given to their own cattle, then this restriction indicated that the last flow of imports of live cattle to that region was void. If slaughter capacity of a region was less than the consumption of fed beef, then that region could not be a net exporter of carcass beef, even though that region was surplus in fed cattle.

If any of the above restrictions applied to the shipments calculated on the basis of maximum price advantage, then that shipment was considered null and void. The maximum price advantages of shipping live or carcass beef were again compared, and the next most advantageous difference was identified for shipments. This was multiplied by the same arbitrary number to obtain the amount to be shipped, which was then checked to meet the restrictions described above. This process was repeated until a shipment was calculated which was economically feasible.

The export of beef was subtracted from the beef available in the exporting region, and the import of beef was added to that available in importing region. This marked the beginning of the second iteration, with new values of amounts of beef available for both importing and exporting regions, and the same initial values for all other regions.

The next iteration started with the inshipments and outshipments of live or carcass beef which were found feasible in the first iteration. These shipments were divided by the population of the region concerned to get inshipments and outshipments on a per capita basis. The amount by which prices in a region will change due to to shipments depended upon the slope of the per capita demand curve in the region.

It was assumed that the slope of the national per capita demand curve for beef was fairly representative of the regional per capita demand curve for fed beef in all regions. That is, the nature of the behavioral patterns of the consumers in the United States was the same in all parts of the country.

The slope of the national demand curve for beef was obtained from a study as -0.01967 (26, p. 29). This may be interpreted as follows. If per capita consumption of fed beef in the United States changes by one pound, the price of wholesale beef, in dollars per hundredweight, will change by two cents in the opposite direction of the change in consumption.

The change in per capita supply of fed beef in a region, due to shipments was multiplied by this slope to find the change in the price of fed beef. The price change was negative in the importing region; therefore, it was subtracted from the original price in that region. The price change was positive in the exporting region; therefore, it was added to that region. These price changes in the importing and exporting regions were not of the same magnitude because of population differences.

The price differences among regions were again calculated, the maximum price advantages were obtained and compared, and shipments were calculated as above. Iterations continued until no price advantage of shipping from one region to another remained. The final results required that positive price differences exactly equalled or were less than the cost of transportation between the two regions that entered the trade.

The process discussed above is represented by the flow chart in Figure 5. The symbols used in the flow chart are explained in Table 14. The computer program written in Fortran IV language is given in Appendix III.

Data Collection and Processing

Transportation Costs (TRCSTC, TRCSTL)

Actual costs of transportation of live and carcass beef, whether by rail or by truck, are not available in a published form. The making of freight rates is a complicated process, involving consideration of such things as value of the commodity, frequency and volume of shipments, density of commodity or weight per cubic foot, competition from other modes of transportation, and susceptibility to damage, in addition to the distance of shipment involved. By correlating each specific factor involved, a new transportation cost matrix can be obtained.[5]

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[5] A letter from R. W. Hall, Assistant Traffic Manager, Consolidated Freightways, Portland, Oregon, to the author, written August 17, 1967.

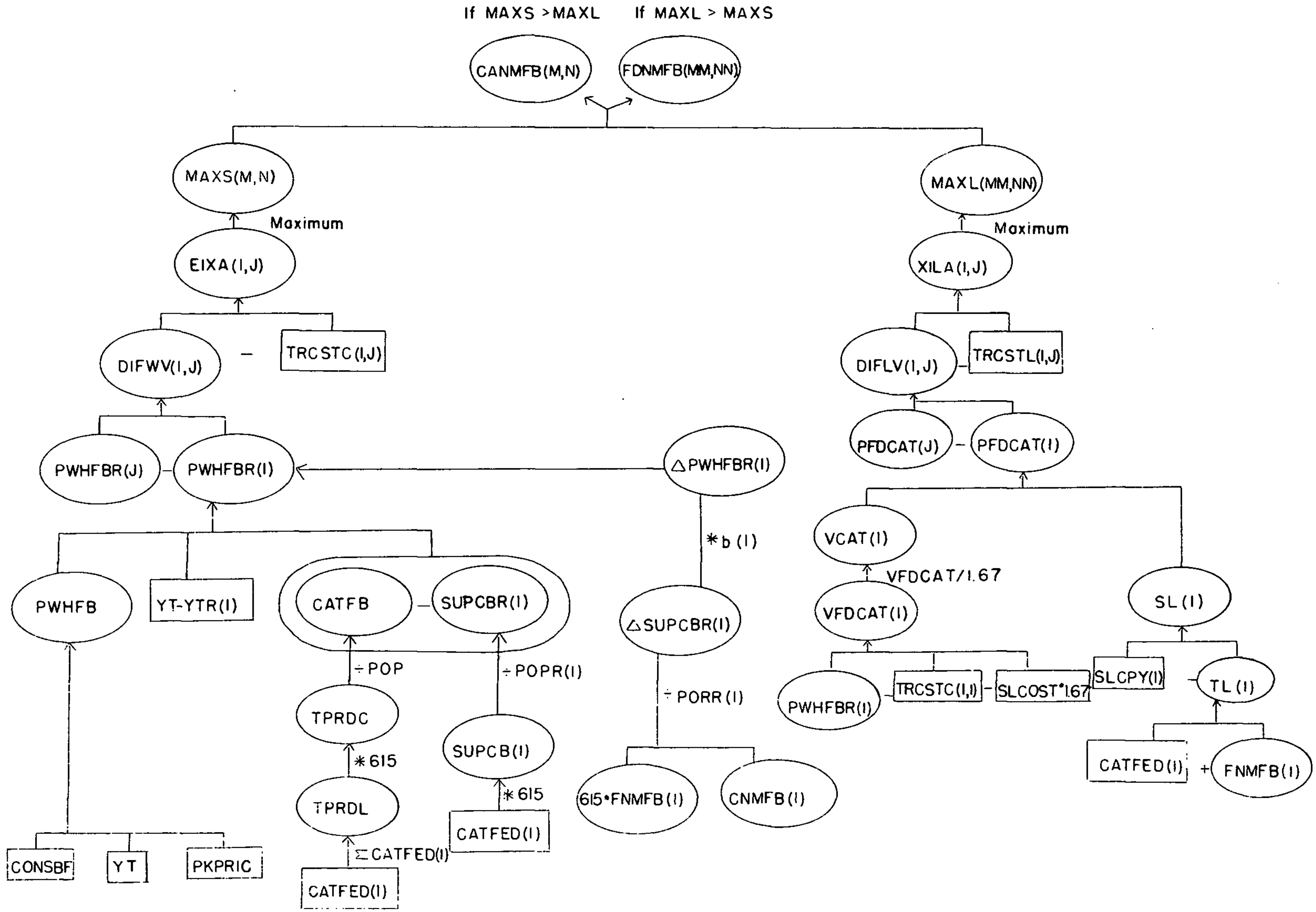

Figure 5. A Model for Interregional Shipments of Live and Carcass Beef

Table 14. Description of Variables

M stands for the region which exports carcass beef.
N stands for the region which imports carcass beef.
MM stands for the region which exports live beef.
NN stands for the region which imports live beef.

TPRDL	= U. S. production fed cattle, live weight.
I	= Subscript for region and/or origin region.
J	= Subscript for region and/or destination region.
TPRDC	= U. S. production fed beef, carcass weight.
CATFB	= Carcass weight of fed beef available per capita in nation.
POP	= U. S. population
SUPCB (I)	= Supply fed carcass beef in region.
CATFED (I)	= Cattle fed that year for slaughter in region.
FNMFB (I)	= Imports-exports of cattle for that region.
CNMFB (I)	= Imports-exports of carcass beef for that region.
PWHFB	= Carcass price of fed beef for nation.
PWHFBR (I)	= Carcass price of fed beef for that region
SUPCBR (I)	= Supply of fed carcass beef per capita in region.
POPR (I)	= Population of region.
YTR (I)	= Income per capita (after taxes) in region.
YT	= Income per capita (after taxes) in nation.
VDFCAT (I)	= Value that could be obtained for fed cattle slaughtered in each region.
TRCSTC (I, J)	= Cost of transporting carcass beef from Region I to Region J.

Table 14. Continued.

SLCOST (I)	= Slaughter cost per 100# liveweight in region.
DIFWV (I, J)	= Difference in price slaughterers can get selling in their own Region I, relative to Region J.
EIXA (I, J)	= Price advantage of shipping carcass beef from I to J (or real large negative number to show not pay).
VCAT (I)	= Value that could be obtained for fed cattle slaughtered in each region, changed to live weight basis.
TL (I)	= Total live animals presently available in region.
SL (I)	= Amount of TL relative to Sl. Capacity in region may be + or - (-when TL exceeds SLCPY).
SLCPY (I)	= Slaughter capacity of region (live weight).
DIFLV (I, J)	= Difference in price producer can get selling in their own Region I, relative to Region J.
XILA (I, J)	= Price advantage of shipping live cattle from I to J (or real large negative number to show not pay).
TRCSTL (I, J)	= Cost of transporting live beef from Region I to Region J.
MAXS (M, N)	= Maximum price differential (EIXA) between regions for carcass beef.
MAXL(MM,NN)	= Maximum price differential (XILA) between regions for live beef.
CANMFB (I, J)	= Import of carcass beef into Region J from Region I.
FDNMFB (I, J)	= Import of live fed cattle into Region J from Region I.
b (I)	= Slope of regional demand curve for fed beef.

Most fed beef in live and carcass form is shipped by truck rather than by rail (4, p. 81). For the purpose of this study it is assumed that all fed beef is shipped by truck. Thus, truck rates were used extensively as applicable rates.

The rates used in this study were based upon the minimum load required by trucking companies. Assuming everything else constant the truck transportation function was developed with transportation cost in dollars per hundredweight as the dependent variable and mileage between the points of shipment as the independent variable. These functions were based on current tariffs--most for 1967, 1968 and 1969--and on rates rather than out-of-pocket costs. The following formulas were used to estimate the transportation costs in this study.[6]

Carcass Beef

$$Y = 0.8508 + 0.00109\ X$$

$$R^2 = 0.7450$$

Live Cattle

$$Y = 0.1061 + 0.00191\ X + 0.00455\ \sqrt{X}$$

$$R^2 = 0.9271$$

Where Y = transportation cost in dollars per hundredweight,

and X = mileage between the two points of shipment.

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[6]A letter from R. A. Dietrich, Assistant Professor, Texas A&M University addressed to James G. Youde, written June 3, 1970.

The points of outshipments and inshipments in the various regions were selected from the important market centers in each region. These points are given below.

Region	Center of shipment
1	Fresno (California)
2	Portland (Oregon)
3	Billings (Montana)
4	Denver (Colorado)
5	Salt Lake City (Utah)
6	Omaha (Nebraska)
7	Fort Worth (Texas)
8	Chicago (Illinois)
9	Nashville (Tennessee)

In reality, transportation rates sometimes vary with differences in the direction of shipments. The freight rate is not necessarily the same from Portland to Denver as it is from Denver to Portland. For the purposes of this study, however, the transportation rates were not assumed to depend upon the direction of shipments, but only on the distance the load is hauled.

Crom (2) developed a matrix of the rates of transportation of beef in live and carcass form among regions for 1975. When the prediction of the direction and magnitude of shipments were made for 1975 in this study, these rates were used.

Slaughter Capacity (SLCPY)

For the purposes of this study, slaughter capacity of a region was defined as the maximum amount of live cattle which could be slaughtered in federally inspected plants and other commercial slaughter houses in the region. The monthly figures are reported in Livestock and Meat Statistics. The month of maximum cattle slaughter was selected out of the 12 months for each region and the number of cattle slaughtered in that month was recorded. This figure was multiplied by 12 to obtain an annual figure. The number obtained was regarded as the estimated annual slaughter capacity for a region. The process was repeated for all years under consideration.

Slaughter Costs (SLCOST)

The costs involved in slaughtering cattle in a given region are important considerations in deciding whether fed beef will be shipped in live or carcass form from surplus-producing regions. That is, slaughter costs in an exporting region help determine whether cattle will be slaughtered in that region prior to shipment.

Most fed beef is shipped in carcass form because many slaughter houses have shifted to the areas of production. Most of these slaughter houses are very large, highly automated, and highly specialized. The costs of slaughtering per hundred pounds carcass in these commercial slaughter houses differ by a very small amount.[7]

In a study made by Williams and Dietrich (34, p. 44), the authors assumed that regional differences in cost of slaughtering were explained by regional differences in wage rates and average output per plant. Taking the Northern Plains as their base region, they indicated that the cost differentials associated with volume or scale of plant were lowest in the North Central region and Colorado, where the average size of plant is large, and highest in the South, where the average plant is small. In contrast, the differentials associated with average wage rate differences were lowest in the South and highest in the North Central region, Colorado, and California. The two sources of cost differences tended to offset one another. They concluded that the contribution of slaughter cost differentials were so small that in models incorporating the estimated slaughter cost differentials, optimum distribution patterns were not affected significantly.

It was assumed in this study that the slaughter costs per hundred pounds carcass are the same for all commercial slaughter houses. These costs were taken from a study for 1960 and were inflated to cover the entire period (17, p. 9).

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[7] From discussions of members of technical committee for project WM-48, San Francisco, June 15-16, 1970.

Estimation of Behavioral Relationships

The same estimating equations as were used in the previous chapter were employed to estimate the national and regional price of wholesale beef. The ordinary least-squares method of multiple regression analysis was used to estimate the functional coefficients of the nine equations used for estimating price of fed cattle. In all equations, data for the 1960-67 period were utilized. This limitation was imposed by the availability of data for the number of cattle fed in feedlots, which were not available before 1960.

The equations, with the t-values below each coefficient, are shown in Table 15. The period of analysis, degrees of freedom, and the coefficient of determination (R^2) are listed opposite each equation. The value that could be obtained for fed cattle slaughtered in each region was positively related to the price of fed cattle. This was expected a priori because that variable was derived from the price of wholesale fed beef, which is expected to have a positive relation with the price of fed cattle. The amount of total slaughter capacity relative to total number of cattle fed was positively related to the price of fed cattle in six regions, but negatively related in three regions. The coefficients of determination (R^2) ranged between 0.74 to 0.96. No high intercorrelation was found in the independent variables of the equations in any region.

Table 15. Estimating Equations for Regional Price of Fed Cattle (PFDCAT(I))

Region	Regression Constant	Regression Coefficients		R^2	d.f.	Period
		VCAT(I)	SL(I)			
1	3.423	0.7831 (5.415)*	0.0000,02207 (1.487)	0.85	5	1960-67
2	2.279	1.0433 (6.569)*	-0.000003238 (-1.198)	0.93	5	"
3	0.169	1.0414 (6.786)*	0.000003264 (1.133)	0.90	5	"
4	0.235	1.0458 (7.519)*	0.000002307 (0.716)	0.91	5	"
5	-3.973	1.1092 (7.663)*	0.000018289 (3.182)*	0.92	5	"
6	-0.503	1.1008 (7.798)*	0.000000241 (0.193)	0.93	5	"
7	9.540	0.7478 (2.613)*	-0.000001217 (-0.758)	0.78	5	"
8	-8.225	1.2505 (10.384)*	0.000000694 (2.342)*	0.96	5	"
9	14.860	0.6003 (2.851)*	-0.000000816 (-0.828)	0.74	5	"

*t-values significant at the five percent level.

The estimated prices of wholesale fed beef in the California-Arizona region and the Eastern states were so low that they did not give price incentives to surplus regions to ship fed beef to these deficit-producing regions. The Eastern region consists of 23 states. Due to lack of data on prices of wholesale fed beef, only prices in New York and Philadelphia represented the whole region. When the price in these two markets decreased, the prices in whole region declined. Similarly price of wholesale fed beef in California-Arizona region did not take Arizona into account. Due to the interregional model being very sensitive to prices of wholesale fed beef, the prices in these two regions were estimated as follows.

It was assumed that prices of wholesale fed beef in both regions bear the same ratios to the estimated national price of wholesale fed beef as that in 1962. That is, ratios of the prices of wholesale beef in the California-Arizona region and the Eastern states with the estimated national price were computed for 1962. The estimated national prices of wholesale fed beef in 1967, 1968 and 1975 were multiplied by these ratios to obtain estimates of prices in the two regions in the respective years.

Results of Empirical Analysis

A comparison of production and consumption of fed beef in each region indicated that from 1962 to 1966 only the Eastern region of the

United States was a deficit-producing area. Although some states in other regions were deficit producers of fed beef, when these states were aggregated into regions, many areas did not show a deficit. California-Arizona and Utah-Nevada were also deficit-producing areas in 1967 and 1968. The production-consumption balances in each region for 1962 to 1968 are shown in Appendix I, Tables 9 to 15.

The Pacific Northwest area consists of Oregon, Washington, and Idaho. Although Oregon and Washington are deficit producers of fed beef, the inclusion of Idaho in the region makes the region a surplus one. Oregon's deficit has increased consistently throughout the 1962-68 period. In 1962, the dressed fed beef produced in Oregon was about 91 million pounds, while the total consumption of fed beef during the same year was estimated at slightly more than 103 million pounds. Thus, Oregon had a deficit of about 12 million pounds in 1962. In the same year, Washington showed a deficit of about 9 million pounds of fed beef. The Pacific Northwest in that year had a surplus of 74 million pounds. In 1968 Oregon and Washington had a deficit of 56 and 69 million pounds of fed beef, respectively, but the Pacific Northwest showed a surplus of 69 million pounds.

Due to only one deficit fed beef region before 1967, there was no competition for the supplies of surplus regions. The results of empirical analysis for optimum pattern of interregional shipments are, therefore, discussed for 1967 and 1968. The optimum projected interregional shipments were also obtained for 1975 and are discuseed in this section.

1967 Shipments

The results of the model indicated that in 1967, five regions supplied fed beef to the Eastern states. These five regions were Montana-Wyoming, Colorado, the Northern Plains, the Southern Plains, and the Corn Belt area. The total shipments to the Eastern region were about 2.5 billion pounds of fed beef, out of which the Corn Belt area provided 1.3 billion pounds. The initial price of wholesale beef in the Eastern states was $44.08 per hundred pounds. After the shipments to that region, the price decreased to $43.57. That is, the drop in price of wholesale beef was $0.51 per hundred pounds. Since price of fed cattle, among other things, is a function of price of wholesale beef, the price of fed cattle was also affected. The relationship between the two prices is positive in every region. Therefore, the direction of the impact of change on the price of fed cattle is the same, that is, a decrease in the price of wholesale beef will entail a decrease in the price of fed cattle. A fall of about $0.18 was recorded in the price of fed cattle in the Eastern region once an equilibrium was reached for 1967.

The deficit of fed beef in the California-Arizona region was very small. Colorado supplied about 6 million pounds of fed beef to that region, and 600, 000 pounds were supplied by the Northern Plains region, which made consumption of fed beef there equal to supply. Colorado shipped about 14 million pounds to the Utah-Nevada region. The price of wholesale beef and fed cattle dropped in that region from $43.65 and $27.61 to $43.45 and $27.48, respectively.

As a result of the model, about 2.5 billion pounds of fed beef entered the trade in 1967. Colorado and the Northern Plains still had a surplus of about 500 million and 2.3 billion pounds, respectively. The Eastern region had a remaining deficit of about 2.9 billion pounds of fed beef. The equilibrium price of wholesale beef in the Eastern region was $43.57 per hundredweight, and the prices in Colorado and the Northern Plains was $41.45 and $41.89, respectively. Thus, the price differential between Colorado and the Eastern region was $2.12 in favor of Colorado and that between the Northern Plains and the Eastern region was $1.68 in favor of the Northern Plains. The cost of transporting a hundred pounds of fed beef between the two pairs was exactly $2.12 and $1.68, respectively. Therefore, there was no price advantage for shipments to take place from surplus fed beef regions to the Eastern region. The Pacific Northwest, which had a surplus of 60 million pounds of fed beef, was at a disadvantageous position locationally with respect to the Eastern states because the transportation costs of shipping fed beef from that region to the Eastern states was $3.48, and the price difference between the prices of wholesale beef in the two regions was only $2.67 per hundred pounds.

This implies that if any shipments of fed beef were to take place from Colorado and the Northern Plains to the Eastern region, the demand curves for fed beef in all three regions should have zero slopes at equilibrium prices. That is, at the equilibrium price, as obtained from the model, the three demand curves would be perfectly elastic. This means that the remaining surplus could be shipped from Colorado and the Northern Plains to the Eastern states only when the prices of wholesale beef do not increase in the shipping region above the level given by the results of the model, and the price does not fall in the recipient region below the equilibrium level there. This would maintain the equilibrium because the price of wholesale beef per hundred pounds in the deficit region would not exceed the price in the surplus region by more than the cost of shipping a hundred pounds of fed beef from surplus to deficit regions.

This suggests that there may be a kink in the demand curves for fed beef in the three regions: Colorado, the Northern Plains, and the Eastern region. It can be visualized by a diagram. Figure 6 shows the possible types of demand curves for deficit and surplus producers of fed beef. The demand curve for fed beef in surplus regions may look like D_A and that in deficit region may look like D_B.

Supply curves for fed beef are shown as S_A and S_B, respectively. After the equilibrium price, P_e, has been reached in surplus regions, any decrease in supply would not have any effect. The price would not increase above P_e. Similarly, after the equilibrium price, P_e', has been reached in deficit fed beef producing region, any increase in supply of fed beef would not decrease the price further. That is, in the surplus regions, P_e, is the upper limit of the price of wholesale fed beef and in the deficit region P_e' is the lower limit.

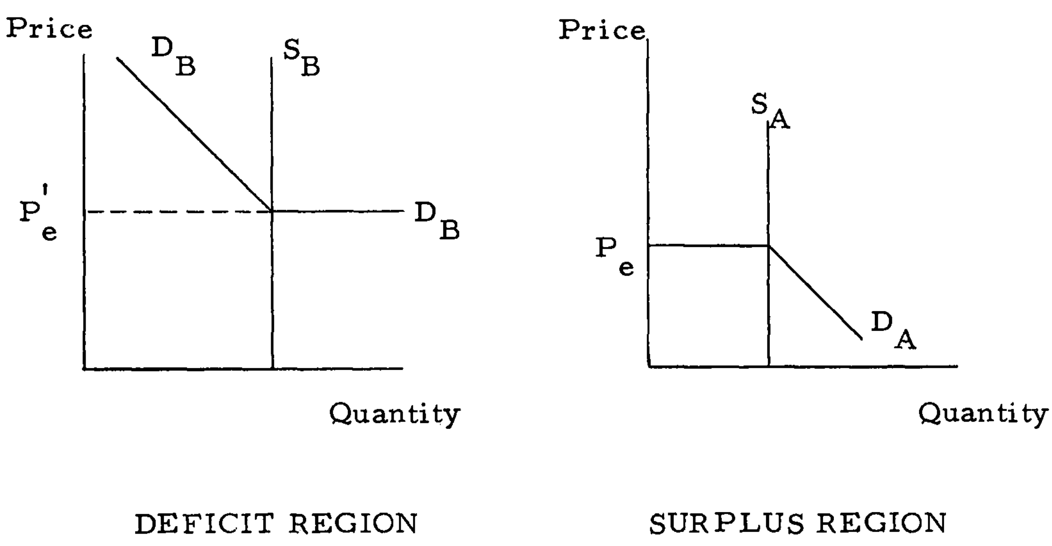

Figure 6. Demand Curves for Surplus and Deficit Fed Beef Producing Regions.

Table 16 shows interregional shipments of live and carcass fed beef during 1967 as given by the model and Table 17 shows the final equilibrium shipments. The map of directions and magnitudes of shipping pattern is shown in Figure 7.

1968 Shipments

During 1968, the California-Arizona region had a deficit of 82 million pounds of fed beef. The estimated price in that region was $46.45 per hundredweight. On the basis of price advantages, the model showed that three regions shipped fed beef to that region. These three regions were the Pacific Northwest, Montana-Wyoming, and Colorado. The Pacific Northwest region shipped about 13 million pounds of fed beef to California and the Montana-Wyoming region shipped about 42 million pounds. Colorado supplied 26 million pounds to that region. Thus, the consumption of fed beef in the California-Arizona region was equal to supply of fed beef. Price of wholesale beef in that region decreased by about 8 cents and price of fed cattle by 4 cents per hundred pounds.

The Utah-Nevada region was supplied fed beef from the Pacific Northwest and Colorado. The total deficit in that region was 16 million pounds of fed beef, out of which Colorado provided about 10 million pounds and the Pacific Northwest shipped the rest. The starting prices of wholesale beef and fed cattle in the Utah-Nevada

Table 16. Interregional Shipments of Live and Carcass Fed Beef, 1967 (thousand pounds dressed weight)

	Destination									
Origin	1	2	3	4	5	6	7	8	9	Total
1										
2										
3	-	-	-	-	-	-	-	-	62, 218	62, 218
4	5, 749	-	-	-	14, 668	-	-	-	153, 203	173, 620
5										
6	595	-	-	-	-	-	-	-	434, 010	434, 605
7	-	-	-	-	-	-	-	-	518, 793	518, 793
8	-	-	-	-	-	-	-	-	1, 316, 655	1, 316, 655
9										
Total	6, 344				14, 668				2, 484, 879	2, 505, 891

Table 17. Optimum Interregional Shipments of Live and Carcass Fed Beef, 1967 (thousand pounds dressed weight)

Origin	Destination 1	2	3	4	5	6	7	8	9	Total
1										
2										
3	-	-	-	-	-	-	-	-	62, 218	62, 218
4	5, 749	-	-	-	14, 668	-	-	-	649, 796	670, 213
5										
6	595	-	-	-	-	-	-	-	2, 786, 355	2, 786, 950
7	-	-	-	-	-	-	-	-	518, 793	518, 793
8	-	-	-	-	-	-	-	-	1, 316, 655	1, 316, 655
9										
Total	6, 344				14, 668				5, 333, 222	5, 354, 234

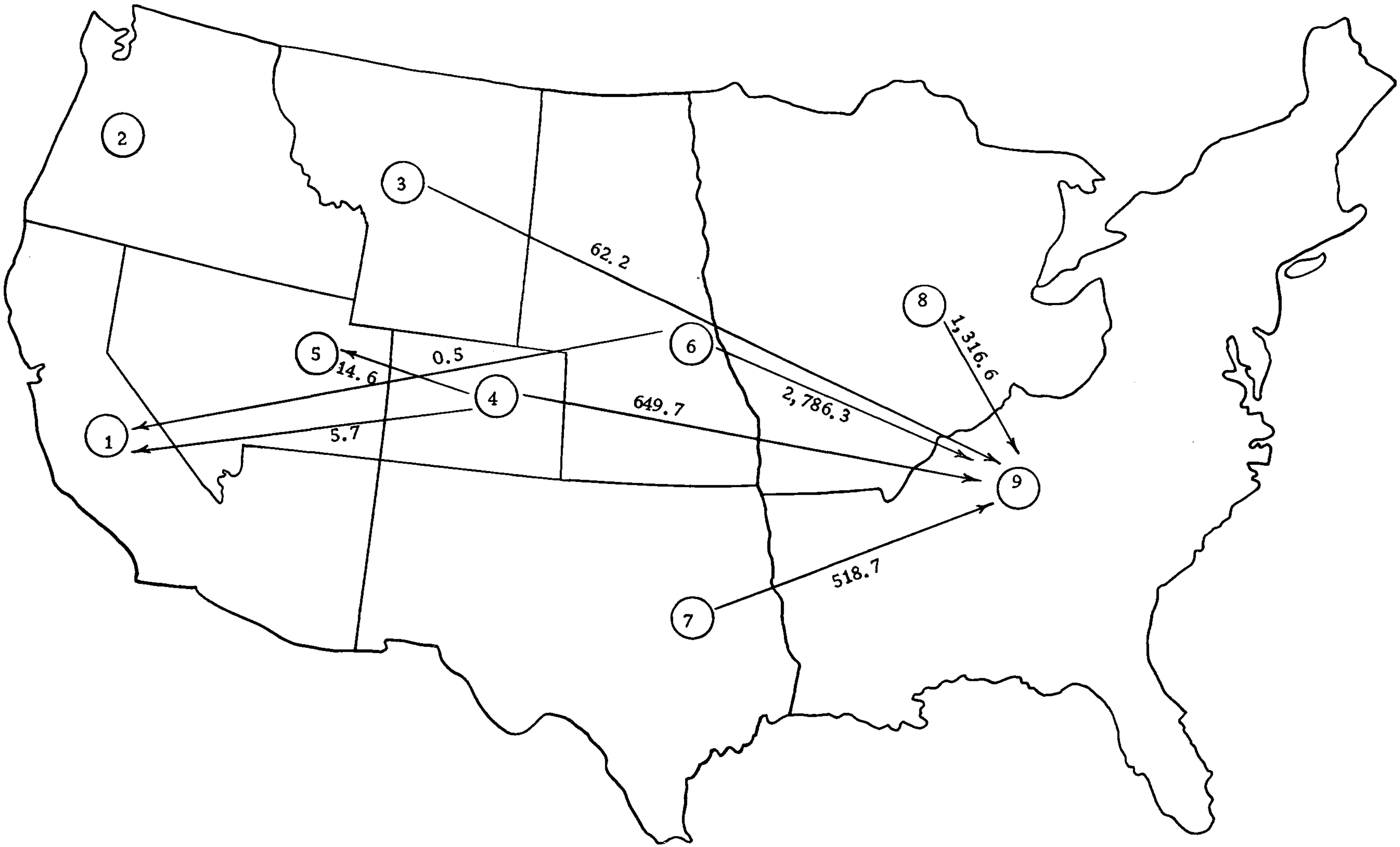

Figure 7. Optimum Shipments of Live and Carcass Fed Beef, 1967 (million pounds dressed weight)

region were $45.17 and $27.82 per hundred pounds, respectively. The prices decreased to $44.96 and $27.68 after the shipments had taken place.

All surplus producing regions, with the exception of the Pacific Northwest, shipped fed beef in carcass form to the Eastern states. The results of the model indicated that about 2.7 billion pounds of fed beef was shipped from five surplus regions to the Eastern states. The Southern Plains and the Corn Belt region shipped surplus fed beef in the amounts of about 764 million pounds and 1.3 billion pounds, respectively, to the Eastern region. The amounts of fed beef shipped to the East from Colorado and the Northern Plains were 117 million pounds and 506 million pounds. Colorado and the Northern Plains still had a surplus of 569 million pounds and 2.5 billion pounds of fed beef, respectively, but they had no price advantage in shipping their remaining surplus to the Eastern region. The final price of wholesale beef in the Eastern region was $45.07, while the prices in Colorado and the Northern Plains were $42.95 and $43.39, respectively. That means the differences of prices of wholesale beef in Colorado and the Northern Plains with respect to the Eastern region was $2.12 and $1.68, respectively. The transportation costs for shipping fed beef from Colorado and the Northern Plains to the Eastern region were exactly $2.12 and $1.68 per hundredweight, respectively. Therefore, there was no price advantage in shipping fed beef from these two

Table 18. Interregional Shipments of Live and Carcass Fed Beef, 1968 (thousand pounds dressed weight)

Origin	Destination 1	2	3	4	5	6	7	8	9	Total
1										
2	12,937	-	-	-	5,266	-	-	-	-	18,203
3	42,350	-	-	-	-	-	-	-	18,002	60,352
4	26,131	-	-	-	10,145	-	-	-	117,041	153,317
5										
6	-	-	-	-	-	-	-	-	506,166	506,317
7	-	-	-	-	-	-	-	-	764,237	764,237
8	-	-	-	-	-	-	-	-	1,301,208	1,301,208
9										
Total	81,418				15,411				2,706,654	2,803,634

Table 19. Optimum Interregional Shipments of Live and Carcass Fed Beef, 1968 (thousand pounds dressed weight)

Origin	Destination 1	2	3	4	5	6	7	8	9	Total
1										
2	12,937	-	-	-	5,266	-	-	-	-	18,203
3	42,350	-	-	-	-	-	-	-	18,002	60,352
4	26,131	-	-	-	10,145	-	-	-	686,155	722,431
5										
6	-	-	-	-	-	-	-	-	3,030,521	3,030,521
7	-	-	-	-	-	-	-	-	764,237	764,237
8	-	-	-	-	-	-	-	-	1,301,208	1,301,208
9										
Total	81,418				15,411				5,800,123	5,896,952

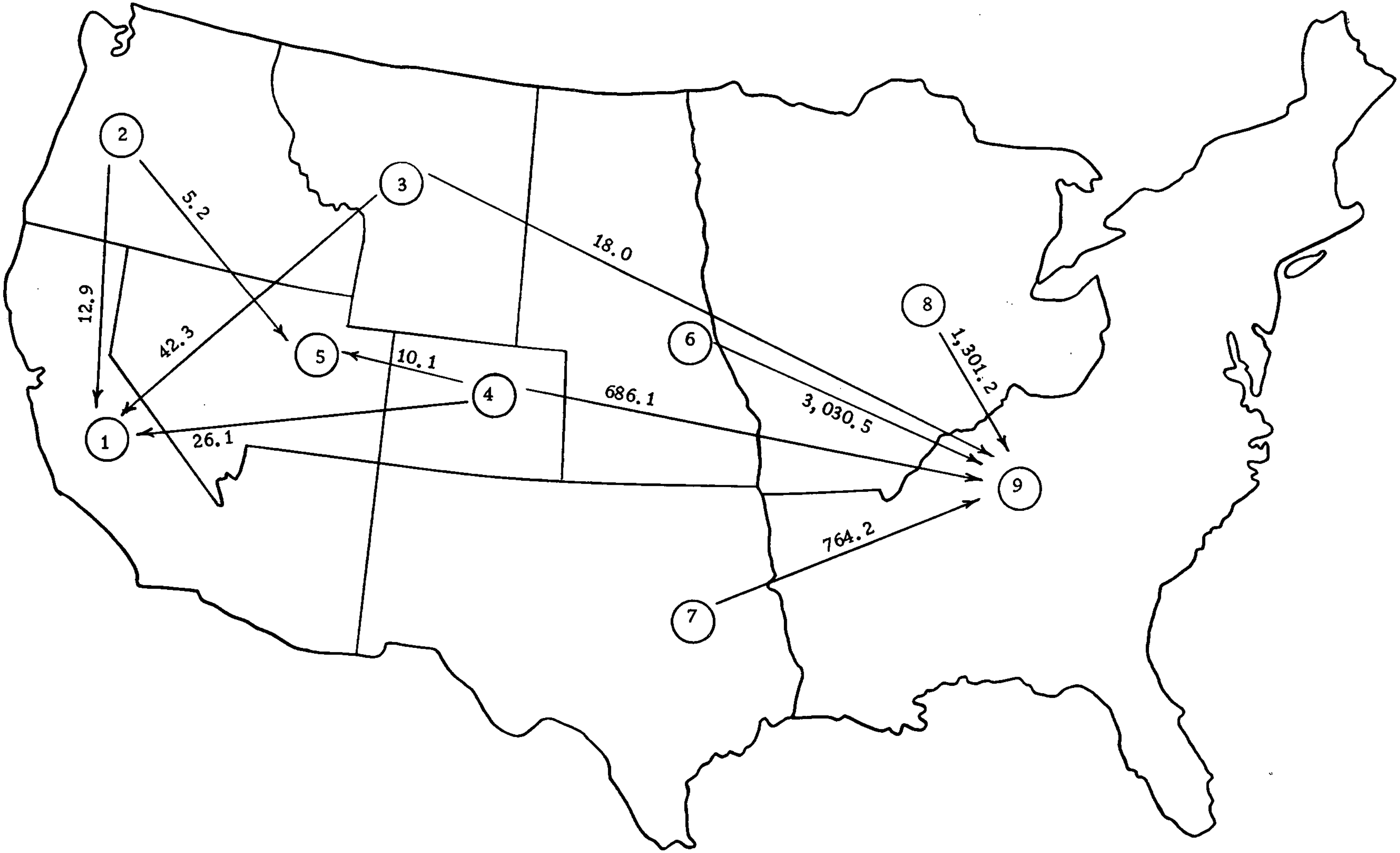

Figure 8. Optimum Shipments of Live and Carcass Fed Beef, 1968 (million pounds dressed weight)

surplus regions to the East.

If the demand curves in the three regions were considered to be perfectly elastic, as discussed above, at the equilibrium prices, the shipments would take place from Colorado and the Northern Plains to the Eastern region. The prices of wholesale beef in the deficit region and surplus regions would differ exactly by the transportation cost.

The model results and final equilibrium results for 1968 are given in Tables 18 and 19, respectively, and the directions and magnitudes of the shipments are given in Figure 8.

Projected 1975 Shipments

When projecting shipments in 1975, the same three regions were found to be deficit: California-Arizona, Utah-Nevada and the Eastern states. The results of the model indicated that four regions would ship fed beef to the California-Arizona region. The Pacific Northwest, the Corn Belt area and Colorado would ship 47 million, 25 million and 466 million pounds of fed beef, respectively, to that region. The Southern Plains region would supply about 292 million pounds to the California-Arizona region. The price of wholesale beef in that region would decrease from $47.43 to $46.78 per hundredweight, and the price of live fed cattle would decline from $27.54 to $27.17 per hundredweight, as a result of these interregional shipments.

The Southern Plains and Montana-Wyoming regions would ship about 13,000 and 69,000 head of fed cattle to Utah and Nevada. The Pacific Northwest would ship both live cattle and dressed fed beef to that region. Total shipment of 67 million pounds dressed weight of fed beef will be received by Utah and Nevada from the three sources. The prices of wholesale fed beef and fed cattle would decrease from $46.12 and $26.97 to $45.36 and $26.53, respectively, in the Utah-Nevada region.

Three regions were estimated to ship fed beef to the deficit producing Eastern states. These three regions are: the Northern Plains, the Southern Plains, and the Corn Belt region. A total of about 3.6 billion pounds of fed beef would be shipped to the Eastern region. The Southern Plains would have the largest share of the shipments, shipping about 1.7 billion pounds of fed beef in 1975. The Eastern states also would receive about 1.1 billion pounds from the Midwest and 800 million pounds from the Northern Plains. The prices of wholesale beef and fed cattle in the Eastern region are expected to decrease from $46.58 and $26.22 to $45.89 and $25.84 per hundredweight, respectively, as a result of these shipments.

The results of the model indicated that about 4.5 billion pounds of fed beef would enter interregional trade channels in 1975. It was found that there was still a surplus of fed beef in two regions: Colorado and the Northern Plains. These regions had surpluses of about 650 million pounds and 5 billion pounds of fed beef, respectively. The California-Arizona region and the Eastern states had deficits of 255 million pounds and 5.3 billion pounds of fed beef, respectively. There was no price incentive for further shipment to occur from these surplus regions to the deficit regions. The differences in carcass beef prices in Colorado and the Northern Plains with respect to the California-Arizona area were \$1.61 and \$1.96 per hundredweight, respectively. The cost of transportation of fed carcass beef from these regions to the California-Arizona region was estimated to be \$1.61 and \$2.70, respectively. This means that the Northern Plains would be in a disadvantageous position for shipping fed beef to the California-Arizona region. If the demand curve for fed beef in Colorado has a slope of zero--that is, if it is infinitely elastic--at the equilibrium price of wholesale fed beef in that region and the demand curve for fed beef in the California-Arizona region is also infinitely elastic at the price of \$46.78 (equilibrium price in that region) per hundredweight of carcass fed beef, then the surplus fed beef would be shipped from Colorado to the California-Arizona region. This shipment would not affect the price of wholesale beef or fed cattle in any of the two trading regions.

Similarly, price differences were calculated between the two surplus regions and the Eastern states. After deducting transportation costs between the two potential trading partners, it was found that

Colorado had a disadvantage in shipping its surplus fed beef to the Eastern states. The price of wholesale beef in Colorado was projected at $45.17, which was only $0.72 less than the price in the deficit Eastern region, and cost of transportation between the two regions was estimated to be $2.07 per hundredweight. However, the price of wholesale beef in the Northern Plains was $44.82; the prices in two regions differ by $1.07. The transportation cost of shipping a hundred pounds of fed beef from the Northern Plains to the Eastern states was projected to be $1.07 in 1975. This means that the price difference exactly equals the cost of transportation between the two regions and there is no price advantage or disadvantage. The demand curves for fed beef in the Northern Plains and the Eastern states have to be infinitely elastic at the equilibrium prices of $44.82 and $45.89, respectively, per hundred pounds of carcass fed beef for trade to take place. As a result, 5 billion pounds of fed beef from the Northern Plains would move to the Eastern states.

The total amount of fed beef to enter interregional trade in 1975 was projected to be 10 billion pounds, most of which will be shipped to the Eastern states.

The results of the model and final optimal shipments are shown in Tables 20 and 21. The direction and magnitude of optimal shipments are shown in Figure 9.

Table 20. Interregional Shipments of Live and Carcass Fed Beef, 1975 (thousand pounds dressed weight)

	Destination									
Origin	1	2	3	4	5	6	7	8	9	Total
1										
2	46,544	-	-	-	16,772	-	-	-	-	63,316
3	-	-	-	-	42,591	-	-	-	-	42,591
4	466,058	-	-	-	-	-	-	-	-	466,058
5										
6	-	-	-	-	-	-	-	-	835,365	835,365
7	291,673	-	-	-	7,859	-	-	-	1,716,142	2,015,674
8	24,837	-	-	-	-	-	-	-	1,076,568	1,101,405
9										
Total	829,112				67,222				3,628,075	4,524,409

Table 21. Optimum Interregional Shipments of Live and Carcass Fed Beef, 1975 (thousand pounds dressed weight)

	Destination									
Origin	1	2	3	4	5	6	7	8	9	Total
1										
2	46,544	-	-	-	16,772	-	-	-	-	63,316
3	-	-	-	-	42,591	-	-	-	-	42,591
4	721,688	-	-	-	-	-	-	-	-	721,688
5										
6	-	-	-	-	-	-	-	-	5,769,138	5,769,138
7	291,673	-	-	-	7,859	-	-	-	1,716,142	2,015,674
8	24,837	-	-	-	-	-	-	-	1,076,568	1,101,405
9										
Total	1,084,742				67,222				8,561,848	9,713,812

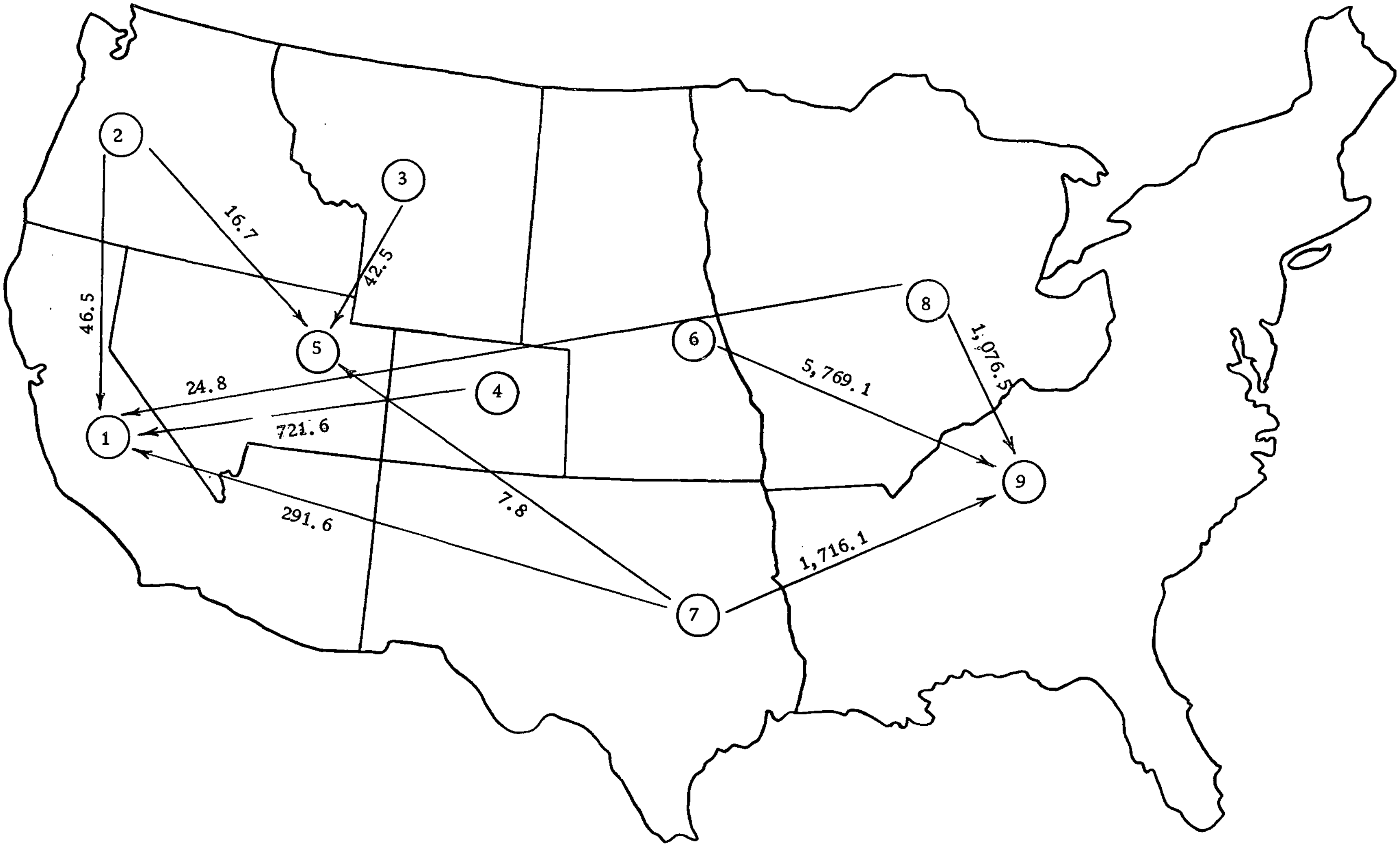

Figure 9. Optimum Shipments of Live and Carcass Fed Beef, 1975 (million pounds dressed weight)

From the results of the empirical analysis, it is clear that many changes are expected to take place between 1968 and 1975. First, in 1968 the California-Arizona region showed a smaller deficit in its production-consumption balance of fed beef. Hence, the surplus production in Colorado was shipped to the Eastern states. In 1975, Colorado is expected to be the main supplier of fed beef to the California-Arizona region. Second, the Southern Plains region shipped 764 million pounds of fed beef to the Eastern states in 1968, but in 1975 it is projected to supply fed beef to all three deficit regions, the amount supplied being more than two billion pounds. Third, the total quantity of fed beef entering interregional trade is expected to increase about 70 percent from 1968 to 1975. Fourth, the Pacific Northwest is projected to increase supplies of fed beef to the California-Arizona region from 13 million pounds in 1968 to 46 million pounds in 1975.

The results of model indicate that most shipments of fed beef from surplus-producing regions to deficit-producing regions will be in carcass form. This implies that the slaughter houses will be located near the areas of production rather than consumption.

IV SUMMARY AND CONCLUSIONS

Demand for fed beef in the United States has increased rapidly since World War II, presenting the fed beef industry with opportunities for expansion. The improved techniques of production, processing and transportation have provided additional incentives for increasing the number of cattle fed in feedlots. The supply of and the demand for fed beef depend upon different factors, and have been different for various regions. When there are differential levels and rates of growth of supply and demand, there arises a need for interregional trade between regions. This research was undertaken to study the levels of cattle feeding in different regions and to build a model to show the interregional flows of live and carcass beef.

A basic economic structure of the fed beef economy was determined. The critical variables and relationships that make up the fed beef economy were identified. The ordinary least-squares method of multiple regression analysis was used to estimate the coefficients of functional relationships. These relationships and three identities were arranged into cause-effect sequence and were incorporated to form a simulation model of the fed beef economy. The main purpose of forming the simulation model was to explain and project the levels of cattle feeding, the number of feeder cattle, cow inventory, and prices of feeder cattle, fed cattle, and wholesale beef when these variables interact in the model.

The model was validated by comparing the estimated values of endogenous variables with their historical counterparts over the 1962-68 period. The results were adjusted, where necessary, to yield a better explanation of the historical phenomenon. This adjustment was accomplished by putting limits on the values of variable according to what was expected on the basis of economic logic. The average deviations between the estimated values from the final model and historical values of the endogenous variables were between 1 and 6 percent. Thus, the model portrayed a reasonably accurate picture of the fed beef economy for the 1962-68 period.

The model was used to project the number of cattle fed and all other endogenous variables for 1975. Due to the recursive nature of the model, only the values of exogenous variables for the entire period were needed. The exogenous variables were per capita consumption of fed beef in the United States and the individual regions, the national and regional per capita disposable income, regional feedlot costs, pork price, price of by-products, and range conditions. The range conditions, pork prices, and price of by-products for each region were taken at their mean values, and the values of the remaining exogenous variables were estimated by the method of simple least-squares regression.

It was projected that the number of cattle fed in the United States in 1975 would be about 35 million head, indicating an increase of about 50 percent over 1968 numbers. The number of fed cattle also showed an increase in all nine regions individually. Fifty-seven percent more cattle are projected to be fed in the Pacific Northwest in 1975 than in 1968; that is, a yearly increase of 8 percent is expected to take place. The number of cattle fed in Colorado is projected to increase by 7 percent per year during the period 1968-75. Hence, it would feed over 2 million head in 1975. The California-Arizona, Montana-Wyoming and Utah-Nevada regions annually will feed 1.40, 1.40, and 0.81 percent more cattle respectively during this period. The North Central area is expected to feed 22 million head out of the total of 35 million head in 1975. The Southern Plains is projected to increase the number of fed cattle at the rate of 23 percent annually, while the Eastern states' number is expected to grow by only 0.52 percent per year.

The prices of feeder cattle and fed cattle, in general, are projected to increase in 1975 over those in 1968. The price of wholesale beef would increase in California-Arizona, Utah-Nevada, and the Northern Plains regions, while it would decrease in the other six regions during the period.

The regional cow inventories and supply of feeder cattle also showed an increase, in general.

The impact of an increase in feedgrain prices on the number of cattle fed and other endogenous variables was traced through the model. Corn prices were increased 20 percent and the price of other feedgrains by 15 percent for the 1970-75 period over the usual estimated prices. It was found that the number of cattle fed in the United States would decrease slightly compared with the original estimates for 1975. National cow beef supply would increase slightly in response to the decrease in the number of cattle fed. The estimates of prices of fed cattle would increase in California-Arizona, the Pacific Northwest, and the Corn Belt states with the increase in feed grain prices, while in other regions they are expected to remain constant or decrease slightly. The regional prices of feeder cattle would decrease from the original estimates, with the only exception in Colorado where feeder cattle prices are expected to increase by 4 cents per hundredweight.

A model was designed to determine the flows of live and carcass fed beef among regions. Fed beef was shipped from a surplus-producing region to a deficit-producing region until the difference between prices of wholesale fed beef, or prices of fed cattle, in the two regions equalled the cost of transporting fed beef between the two regions. That is, trade took place between the two regions on the basis of a price differential which made it profitable for a surplus region to ship fed beef to a deficit region.

Consumption of fed beef in each region was calculated by multiplying per capita consumption of fed beef in the region by the population of the region, and production was estimated by converting the estimated number of fed cattle to dressed beef. A comparison between production and consumption of fed beef in each region showed that during the 1962 to 1966 period only the Eastern region was a deficit-producing region. Though Oregon and Washington were deficit states throughout the period, the Pacific Northwest as a region was not a deficit-producing one. In 1967 and 1968, two more regions were also found to be deficit-producers. These were California-Arizona and Utah-Nevada. The California-Arizona region had a deficit of 6.3 million pounds of fed beef in 1967 and 82.4 million pounds in 1968; while the Utah-Nevada region had a deficit of 14.7 million pounds in 1967 and 16 million pounds in 1968. The deficit in the Eastern states in these two years was 5.4 billion and 5.8 billion pounds, respectively.

The results of the model showed that in 1967 Colorado shipped fed beef to both California-Arizona and Utah-Nevada region. The Eastern states received fed beef from the Montana-Wyoming region, Colorado, the Southern Plains, the Northern Plains, and the Corn Belt area.

In 1968, fed beef was shipped to the California-Arizona region from the Pacific Northwest, the Montana-Wyoming area, and Colorado. The main supplier to the Utah-Nevada region was Colorado. The Eastern states received fed beef mainly from

Colorado, the North Central area, and the Southern Plains. Hence, Colorado supplied fed beef to all deficit regions in 1968.

The model was used to project shipments in 1975. The estimates of production and consumption of fed beef showed that the same three regions would be deficit in 1975 as were in 1967 and 1968. However, there were some notable changes in shipping patterns. The Eastern region will be supplied fed beef by the Northern Plains, the Southern Plains and the Corn Belt region. Colorado, which was one of the main suppliers to this region in 1967 and 1968, would not ship fed beef to the East. This change was probably brought about by an estimate of heavy deficit of fed beef in the California-Arizona region. Colorado was projected to supply about 720 million pounds of fed beef to the California-Arizona region. The latter would also receive 291 million pounds of fed beef from the Southern Plains, and about 47 million pounds from the Pacific Northwest in 1975. The Utah-Nevada region would be supplied live cattle from the Montana-Wyoming region and the Southern Plains. The Pacific Northwest would ship both live fed cattle and dressed beef to that region. The total fed beef which is expected to enter interregional trade in 1975 was projected to be about 10 billion pounds.

The results of this study imply that the production and consumption of fed beef would continue to grow in the United States. With the expansion of fed cattle industry, feeder cattle producers would have an incentive to increase their production. This is especially true of the Northern and Southern Plains where cattle feeding activity has increased tremendously. The Pacific Northwest would also increase its production of feeder cattle in response to the expansion in the number of cattle fed. Increase in feeder cattle production would stimulate cow-calf operations in the United States.

As the cattle feeding industry grows the need for construction of additional slaughter plants would arise. It is evident from the results of this study that most beef would be shipped among regions in dressed form. The processing facilities would be needed near the areas of production. This would necessitate an increase in the number of refrigerated units in the transportation industry.

Reductions in medium- and long-distance transportation rates for shipping fed beef in live and carcass form would result in a change in direction and magnitude of interregional shipments. Governmental agencies, federal and state, would need to take exempt carriers backhaul factors into consideration in regulation of transportation rates.

Further studies are needed in many sub-areas under the heading of interregional flows of fed beef. Unless improvement is made in collection and processing of basic data, studies of this type may be of limited use. For example, without the accuracy of slaughter cost data, it would be very difficult to determine whether cattle will be slaughtered in the region of production before it is shipped to other regions, or whether slaughtering will take place at the place of destination. This is one area where additional work is needed to increase the reliability of results.

No reliable regional data are available on consumption of fed beef. The only data for which some accuracy can be claimed are for consumption of all beef. Only rough estimates are available on consumption of fed beef. This factor needs to be studied further.

Other important areas where further work is needed are transportation costs among regions, economies of feedlot utilization and scale in various regions, and the collection of more accurate data on prices of livestock and feed products in various regions.

The potential contribution which this type of study can make to the fed beef industry, on both a national and a regional scale, justifies the effort to collect more reliable data. This requires a national effort, and close cooperation of public agencies with all sectors of the fed beef industry.

BIBLIOGRAPHY

1. Crom, Richard J. A dynamic price-output model of the beef and pork sectors. Washington, D.C., 1970. 105 p. (U.S. Dept. of Agriculture, Economic Research Service, Technical Bulletin No. 1426).

2. ________________ Simulated interregional models of the livestock-meat economy. Washington, D.C., 1967. 66 p. (U.S. Dept. of Agriculture, Agricultural Economic Report no. 117).

3. Dietrich, R. A. The Texas-Oklahoma cattle feeding industry: structure and operational characteristics. College Station, 1968. 48 p. (Texas. Agricultural Experiment Station. Bulletin B1079)

4. Erickson, Donald B. and Joseph Havlicek, Jr. Regional production of cattle and calves for commercial slaughter. Lafayette, 1966. 32 p. (Purdue University. Agricultural Experiment Station. Research Bulletin no. 813)

5. Gee, C. K. Seasonal cattle feedlots in Colorado. Fort Collins, 1969. 34 p. (Colorado. Experiment Station. Bulletin no. 5405)

6. Gum, R. and J. Wildermuth. Cost-return comparisons for finishing yearling steers. Progressive Agriculture in Arizona 20:20-21. 1968.

7. Gustafson, Ronald A. and Roy N. Van Arsdall. Cattle feeding in the United States. Washington, D.C., 1970. 93 p. (U.S. Dept. of Agriculture, Agricultural Economics Report 88)

8. Havlicek, J., R. L. Rizek, and G. G. Judge. Spatial structure of the livestock economy: II. Brookings, 1964. 56 p. (South Dakota. Agricultural Experiment Station. Bulletin 521)

9. Hunter, E. C. and J. P. Madden. Economies of size for specialized beef feedlots in Colorado. Washington, D.C., 1966. 49 p. (U.S. Dept. of Agriculture, Agricultural Economic Report no. 91)

10. Johnson, R. D. and A. R. Eckert. Cattle feeding costs in Nebraska by system of feeding and size of operation. Lincoln, 1968. 45 p. (Nebraska. Agricultural Experiment Station. SB 496)

11. Johnston, J. Econometric methods. New York, McGraw Hill, 1963. 300 p.

12. Kim, Han Joo. An analysis of investment in the United States beef cattle industry. Doctoral dissertation. Corvallis, Oregon State University, 1970. 317 numbered leaves.

13. King, G. A. and L. F. Schrader. Regional location of cattle feeding. A spatial equilibrium analysis. Hilgardia 34:331-415. 1963.

14. Korzan, G. E. Economics of beef cattle feeding in Oregon. Corvallis, 1968, 10 p. (Oregon. Agricultural Experiment Station. Special Report 250)

15. Langemeier, Larry and R. G. Thompson. Demand, supply, and price relationships for the beef sector, post World War-II period. Journal of Farm Economics 49:178. 1967.

16. Logan, Samuel H. Economics of scale in cattle feeding. Report prepared for the National Commission on Food Marketing. Davis, California. 1965.

17. ________________ Economies of scale in cattle slaughtering plants. Report prepared for the National Commission on Food Marketing. Davis, California. 1965.

18. Maki, Wilbur R. and Richard J. Crom. Evaluation of alternative market organization in a simulated livestock-meat economy. Ames, 1965. p. 579-623. (Iowa State University. Research Bulletin 541)

19. McCoy, J. H. and C. C. Hausman. Economies of scale in commercial cattle feedlots of Kansas--an analysis of nonfeed costs. Manhattan, 1967. 47 p. (Kansas. Agricultural Experiment Station. Tech. Bulletin 151)

20. McDermott, E. C. and J. R. Davidson. The feasibility of cooperative cattle feeding and slaughtering in Montana. Bozeman, 1965. 82 p. (Montana. Agricultural Experiment Station. Bulletin no. 597)

21. Naylor, T. H. et al. Computer simulation techniques. New York, John Wiley and Sons, 1966. 352 p.

22. Orcutt, G. H. Simulation of economic systems. American Economic Review 50:893-907. 1960.

23. Raumik, Robert, Joseph C. Purcell and K. E. Ford. Spatial and temporal aspects of the demand for food in the United States: II. Beef. Experiment, 1969. 42 p. (University of Georgia. College of Agriculture Experiment Stations. Research Bulletin 63)

24. Richards, J. A. and G. E. Korzan. Beef cattle feedlots in Oregon--A feasibility study. Corvallis, 1964. 44 p. (Oregon. Agricultural Experiment Station. Special Report 170)

25. Rizek, R. L., G. G. Judge and J. Havlicek. Spatial structure of the livestock economy. Brookings, 1964. 32 p. (South Dakota State University. Agricultural Experiment Station. Bulletin 520)

26. Sohn, Hong Keun. A spatial equilibrium model of the beef industry in the United States. Doctoral dissertation. Honolulu, University of Hawaii, 1970. 258 numbered leaves.

27. Taylor, M. H., et al. Expansion opportunities in Utah's livextock feeding-meat packing industry in Utah. Logan. 1970, 35 p. (Utah. Extension Service. Bulletin UES-Economics 10)

28. _______________ Feasibility of expanding the livestock feeding and meat packing industry in Utah. Logan. 1970, 197 p. (Utah. Extension Service. Bulletin UES-Economics 9)

29. U. S. Dept. of Agriculture. Agricultural Marketing Service. Livestock detailed quotations. Washington, D. C., 1956-1967.

30. _______________ Statistical Reporting Service. Agricultural statistics. Washington, D. C., 1958-1970.

31. _______________ Statistical Reporting Service. Cattle and calves on feed. Washington, D. C., 1956-1970.

32. _______________ Statistical Reporting Service. Livestock and meat statistics. Washington, D. C., 1958-1970.

33. U. S. Dept. of Commerce. Bureau of the Census. Statistical abstract of the United States. Washington, D. C., 1958-1970.

34. Williams, Willard F. and Raymond A. Dietrich. An interregional analysis of the fed beef economy. Washington, D. C., 1966. 58 p. (U. S. Dept. of Agriculture. Agricultural Economic Report 88).

35. Ziegler, P. Thomas. The meat we eat. Danville, Illinois, Interstate Printers, 1966. 547 p.

APPENDICES

APPENDIX I

APPENDIX TABLE 1   The Comparison of Actual and Predicted Values of the Number of Cattle Fed 1962-68, by Region

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
1	1962	2,412	2,421	-9	-.37
	1963	2,507	2,558	-51	-2.03
	1964	2,661	2,692	9	.33
	1965	2,532	2,741	-209	-8.25
	1966	2,833	2,797	36	1.27
	1967	2,707	2,858	-151	-5.57
	1968	2,777	2,907	-130	-4.68
	AVE.				3.21
2	1962	627	676	-49	-7.81
	1963	636	689	-53	-8.33
	1964	688	712	-24	-3.48
	1965	746	728	19	2.54
	1966	784	748	36	4.59
	1967	861	776	85	9.87
	1968	925	809	116	12.54
	AVE.				7.02
3	1962	172	171	1	.58
	1963	162	184	-22	-13.58
	1964	187	189	-2	-1.07
	1965	204	205	-1	-.39
	1966	233	221	12	5.15
	1967	227	230	-3	-1.32
	1968	226	236	-10	-4.42
	AVE.				3.78

APPENDIX TABLE 1, Continued, Page 2:

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
4	1962	815	859	-44	-5.39
	1963	900	968	-68	-7.55
	1964	951	1,065	-114	-11.98
	1965	1,144	1,145	-1	-.08
	1966	1,268	1,259	9	.71
	1967	1,330	1,339	-9	-.67
	1968	1,431	1,476	-45	-3.14
	AVE.				4.21
5	1962	142	151	-9	-6.33
	1963	148	155	-7	-4.73
	1964	171	159	12	7.01
	1965	175	163	12	6.85
	1966	191	167	24	12.56
	1967	150	171	-21	-14.00
	1968	160	172	-12	-7.50
	AVE.				8.42
6	1962	2,986	3,053	-67	-2.24
	1963	3,304	3,525	-221	-6.68
	1964	3,934	3,999	-65	-1.65
	1965	4,031	4,447	-416	-10.32
	1966	4,663	4,995	-332	-7.11
	1967	5,135	5,492	-357	-6.95
	1968	5,562	6,066	-504	-9.06
	AVE.				6.28

APPENDIX TABLE 1, Continued, Page 3:

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
7	1962	1,071	1,111	-40	-3.73
	1963	1,259	1,071	188	14.93
	1964	1,407	1,184	223	15.84
	1965	1,567	1,362	205	13.08
	1966	1,958	1,566	392	20.02
	1967	2,306	1,801	505	21.89
	1968	2,705	2,071	634	23.40
	AVE.				16.12
8	1962	5,809	6,022	-213	-3.66
	1963	6,121	6,323	-202	-3.30
	1964	6,450	6,640	-190	-2.95
	1965	7,244	7,058	186	2.56
	1966	7,697	7,656	41	.53
	1967	8,279	8,144	135	1.63
	1968	8,628	8,525	103	1.19
	AVE.				2.26
9	1962	614	610	4	.65
	1963	583	637	-54	-9.26
	1964	627	642	-15	-2.39
	1965	675	681	-6	-.88
	1966	698	700	-2	-.28
	1967	672	677	-5	-.74
	1968	631	684	-53	-8.39
	AVE.				3.22
				OVERALL AVERAGE	6.06

APPENDIX TABLE 2 The Comparison of Actual and Predicted Values of the Number of Feeder Cattle 1961-67, by Region

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
1	1961	1,458	1,494	-36	-2.46
	1962	1,490	1,533	-43	-2.88
	1963	1,491	1,544	-53	-3.55
	1964	1,568	1,577	-9	-.57
	1965	1,576	1,609	-33	-2.09
	1966	1,577	1,626	-49	-3.10
	1967	1,602	1,647	-45	-2.80
	AVE.				2.49
2	1961	1,354	1,382	-28	-2.06
	1962	1,401	1,408	-7	-.49
	1963	1,434	1,427	7	.49
	1964	1,490	1,473	17	1.14
	1965	1,521	1,512	9	.59
	1966	1,499	1,519	-20	-1.33
	1967	1,496	1,551	-55	-3.67
	AVE.				1.39
3	1961	1,290	1,290	0	0
	1962	1,304	1,351	-47	-3.60
	1963	1,383	1,386	-3	-.21
	1964	1,456	1,494	-38	-2.60
	1965	1,566	1,582	-16	-1.02
	1966	1,612	1,628	-16	-.99
	1967	1,624	1,649	-25	-1.53
	AVE.				1.42

APPENDIX TABLE 2 Continued, Page 2

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
4	1961	653	703	-50	-7.65
	1962	678	725	-47	-6.93
	1963	714	747	-33	-4.62
	1964	733	766	-33	-4.50
	1965	746	782	-36	-4.82
	1966	776	802	-26	-3.35
	1967	788	825	-37	-4.69
	AVE.				5.22
5	1961	427	439	-12	-2.81
	1962	443	452	-9	-2.03
	1963	442	463	-21	-4.75
	1964	460	475	-15	-3.26
	1965	488	487	1	.20
	1966	486	498	-12	-2.43
	1967	488	500	-12	-2.45
	AVE.				2.56
6	1961	4,422	4,741	-319	-7.21
	1962	5,676	4,923	-753	-13.26
	1963	4,757	5,027	-270	-5.67
	1964	5,062	5,191	-129	-2.54
	1965	5,154	5,331	-177	-3.43
	1966	5,092	5,447	-355	-6.97
	1967	5,202	5,553	-351	-6.74
	AVE.				6.54

APPENDIX TABLE 2 Continued, Page 3

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
7	1961	4,978	5,347	-369	-7.41
	1962	5,228	5,445	-217	-4.15
	1963	5,431	5,589	-158	-2.90
	1964	5,690	5,734	-44	-.77
	1965	5,746	5,850	-104	-1.77
	1966	5,767	5,966	-199	-3.45
	1967	5,909	6,159	-250	-4.23
	AVE.				3.52
8	1961	8,622	8,681	-59	-.68
	1962	8,697	8,695	2	.02
	1963	8,713	8,650	63	.72
	1964	8,881	8,732	149	1.67
	1965	8,802	8,820	-18	-.20
	1966	8,543	8,630	-87	-1.01
	1967	8,461	8,550	-89	-1.05
	AVE.				.76
9	1961	8,759	8,880	-121	-1.38
	1962	8,951	9,124	-173	-1.93
	1963	9,042	9,186	-144	-1.59
	1964	9,086	9,358	-272	-2.99
	1965	9,483	9,544	-61	-.64
	1966	9,406	9,457	-51	-.54
	1967	9,286	9,446	-160	-1.72
	AVE.				1.54
				OVERALL AVERAGE	2.83

APPENDIX TABLE 3 The Comparison of Actual and Predicted Values of the Cow Inventories 1961-67, by Region

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
1	1961	1,188	1,173	15	1.26
	1962	1,224	1,234	-10	-.81
	1963	1,227	1,251	-24	-1.95
	1964	1,318	1,302	16	1.21
	1965	1,363	1,351	12	.88
	1966	1,365	1,378	-13	-.95
	1967	1,425	1,410	15	1.05
	AVE.				1.15
2	1961	1,240	1,273	-33	-2.66
	1962	1,310	1,323	-13	-.99
	1963	1,385	1,361	24	1.73
	1964	1,469	1,449	20	1.36
	1965	1,539	1,524	15	.97
	1966	1,567	1,537	30	1.91
	1967	1,558	1,600	-42	-2.69
	AVE.				1.75
3	1961	1,676	1,644	32	1.90
	1962	1,692	1,728	-36	-2.12
	1963	1,788	1,788	0	0
	1964	1,902	1,926	-24	-1.26
	1965	2,016	2,049	-33	-1.63
	1966	2,147	2,114	33	1.53
	1967	2,153	2,143	10	.46
	AVE.				1.27

APPENDIX TABLE 3 Continued, Page 2

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
4	1961	795	793	2	.25
	1962	815	824	-9	-1.10
	1963	867	856	11	1.26
	1964	887	883	4	.45
	1965	911	906	5	.54
	1966	936	936	0	0
	1967	964	970	-6	-.62
	AVE.				.60
5	1961	528	516	12	2.27
	1962	541	536	5	.92
	1963	537	553	-16	-2.97
	1964	562	572	-10	-1.77
	1965	592	589	3	.50
	1966	615	608	7	1.13
	1967	615	610	5	.81
	AVE.				1.48
6	1961	4,744	4,752	-8	-.16
	1962	4,980	5,089	-109	-2.18
	1963	5,282	5,284	-2	-.03
	1964	5,716	5,581	135	2.36
	1965	5,982	5,834	148	2.47
	1966	6,093	6,060	33	.54
	1967	6,118	6,261	-143	-2.33
	AVE.				1.43

APPENDIX TABLE 3 Continued, Page 3

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Head	1,000 Head	1,000 Head	Percent
7	1961	6,495	6,628	-133	-2.04
	1962	6,787	6,818	-31	-.45
	1963	7,329	7,100	229	3.12
	1964	7,705	7,377	323	4.19
	1965	7,648	7,597	51	.66
	1966	7,839	7,832	7	.08
	1967	7,889	8,213	-324	-4.10
	AVE.				2.09
8	1961	4,061	4,073	-12	-.29
	1962	4,228	4,300	-84	-1.98
	1963	4,456	4,516	-60	-1.34
	1964	4,714	4,723	-9	-.19
	1965	4,962	4,947	15	.30
	1966	5,260	5,171	89	1.69
	1967	5,329	5,361	-32	-.60
	AVE.				.91
9	1961	6,301	6,264	37	.58
	1962	6,728	6,824	-96	-1.42
	1963	7,209	7,253	-44	-.61
	1964	7,512	7,562	-50	-.66
	1965	7,912	7,968	-56	-.70
	1966	8,314	8,374	-60	-.72
	1967	8,520	8,571	51	.59
	AVE.				.75
				OVERALL AVERAGE	1.27

APPENDIX TABLE 4 The Comparison of Actual and Predicted Values of the Total Fed Beef Supply 1961-67, by Regions

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Lbs.	1,000 Lbs.	1,000 Lbs.	Percent
1	1961	943,928	942,188	1,740	.18
	1962	1,037.352	1,037,038	314	.03
	1963	1,073,306	1,100,195	-26,889	-2.50
	1964	1,133,823	1,143,670	-9,847	-.86
	1965	1,251,889	1,184,244	67,645	5.40
	1966	1,233,911	1,210,021	23,890	1.93
	1967	1,201,669	1,238,175	-36,506	-3.03
	AVE.				1.99
2	1961	262,867	263,553	-686	-.26
	1962	271,638	295,456	-23,818	-8.76
	1963	282,009	302,069	-20,060	-7.11
	1964	304,702	313,425	-8,723	-2.86
	1965	325,289	321,003	4,286	1.31
	1966	349,074	331,009	18,065	5.17
	1967	385,225	344,829	40,396	10.48
	AVE.				5.13
3	1961	82,258	82,526	-268	-.32
	1962	74,504	74,821	-317	-.42
	1963	71,531	81,210	-9,679	-13.53
	1964	81,613	83,764	-2,151	-2.63
	1965	90,602	91,530	- 928	-1.02
	1966	105,692	99,508	6,184	5.85
	1967	101,538	103,676	-2,138	-2.10
	AVE.				3.69

APPENDIX TABLE 4   Continued, Page 2

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Lbs.	1,000 Lbs.	1,000 Lbs.	Percent
4	1961	375,028	373,707	1,321	0.35
	1962	377,801	405,952	-28,151	-7.45
	1963	430,488	459,096	-28,608	-6.64
	1964	456,251	506,630	-50,379	-11.04
	1965	541,157	546,247	-5,090	-.94
	1966	603,466	602,161	1,305	.21
	1967	633,771	641,406	-7,635	-1.20
	AVE.				3.97
5	1961	65,592	64,737	855	1.30
	1962	63,956	66,984	-3,028	-4.73
	1963	67,471	68,996	-1,525	-2.26
	1964	75,779	70,647	5,132	6.77
	1965	77,979	72,747	5,232	6.70
	1966	85,432	74,427	11,005	12.88
	1967	62,867	76,051	-13,184	-20.971
	AVE.				7.94
6	1961	1,399,505	1,402,208	-2,703	-.09
	1962	1,388,753	1,435,082	-46,329	-3.33
	1963	1,555,033	1,666,644	-111,611	-7.17
	1964	1,892,546	1,898,866	-6,320	-.33
	1965	1,900,173	2,118,105	-217,932	-11.46
	1966	2,200,117	2,386,442	-186,325	-8.46
	1967	2,458,297	2,629,838	-171,541	-6.97
	AVE.				5.41

APPENDIX TABLE 4 Continued, Page 3

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		1,000 Lbs.	1,000 Lbs.	1,000 Lbs.	Percent
7	1961	358,077	357,916	161	.04
	1962	475,321	494,842	-19,521	-4.10
	1963	564,445	476,469	87,976	15.58
	1964	631,672	527,816	103,856	16.44
	1965	705,335	608,442	96,893	15.92
	1966	891,972	701,161	190,811	27.21
	1967	1,032,247	807,788	224,459	27.78
	AVE.				15.29
8	1961	2,498,574	2,509,238	-10,664	.42
	1962	2,433,653	2,572,522	-138,869	-5.70
	1963	2,512,956	2,686,116	-173,160	-6.89
	1964	2,736,204	2,805,391	-69,187	-2.52
	1965	2,993,143	2,963,169	29,974	1.00
	1966	3,206,415	3,188,791	17,624	.54
	1967	3,453,864	3,372,861	81,003	2.34
	AVE.				2.77
9	1961	235,138	237,169	-2,031	-.86
	1962	245,952	253,405	-7,453	-3.03
	1963	238,849	260,779	-21,930	-9.18
	1964	251,101	262,192	-11,091	-4.41
	1965	268,551	273,228	-4,677	-1.74
	1966	285,597	278,546	7,051	2.46
	1967	276,250	272,054	4,196	1.51
	AVE.				3.31
				OVERALL AVERAGE	5.5

APPENDIX TABLE 5 The Comparison of Actual and Predicted Values of the Price of Feeder Cattle Per Hundred Pounds 1961-67, by Region

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
1	1961	24.52	24.73	-.21	-.85
	1962	25.28	24.69	.59	2.38
	1963	23.50	22.60	.90	3.82
	1964	20.06	20.53	-.47	-2.34
	1965	21.72	22.90	-.18	-.82
	1966	24.90	23.62	1.28	5.14
	1967	24.73	24.18	.55	2.22
	AVE.				2.43
2	1961	24.20	24.38	-.18	-.74
	1962	25.29	24.64	.65	2.49
	1963	24.11	22.80	1.31	5.43
	1964	19.84	20.84	-1.00	-5.04
	1965	22.71	23.58	-.87	-3.83
	1966	25.81	24.54	1.27	4.92
	1967	26.08	25.26	.82	3.14
	AVE.				3.65
3	1961	24.60	24.93	.33	-1.34
	1962	26.59	25.33	1.26	4.73
	1963	25.25	23.68	1.57	6.21
	1964	20.60	21.52	-.92	-4.46
	1965	23.55	24.25	-.70	-2.97
	1966	26.05	25.02	1.03	3.95
	1967	25.98	25.54	.44	1.69
	AVE.				3.62

APPENDIX TABLE 5 Continued, Page 2

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
4	1961	25.97	26.00	-.03	-.11
	1962	26.87	26.17	.70	2.60
	1963	25.31	24.53	.78	3.08
	1964	21.49	22.73	-1.24	-5.77
	1965	25.17	24.98	.19	.75
	1966	26.50	25.72	.78	2.94
	1967	27.03	26.22	.81	2.99
	AVE.				2.60
5	1961	24.24	24.31	-.07	-.28
	1962	25.70	24.76	.94	3.65
	1963	24.04	22.83	1.21	5.03
	1964	19.75	20.78	-1.03	-5.21
	1965	22.81	23.55	-.74	-3.24
	1966	25.98	24.49	1.49	5.73
	1967	25.24	25.19	.05	.19
	AVE.				3.33
6	1961	26.06	26.56	-.50	-1.91
	1962	27.54	26.76	.78	2.83
	1963	25.96	25.02	.94	3.62
	1964	22.42	23.11	-.69	-3.07
	1965	24.35	25.68	-1.33	-5.46
	1966	28.13	26.55	1.58	5.61
	1967	27.46	27.18	.28	1.01
	AVE.				3.35

APPENDIX TABLE 5 Continued, Page 3

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
7	1961	24.38	24.63	-.25	-1.02
	1962	25.40	24.85	.45	1.77
	1963	24.45	23.24	1.21	4.94
	1964	20.67	21.51	-.89	-4.06
	1965	23.04	23.87	-.83	-3.60
	1966	26.01	24.67	1.34	5.15
	1967	25.63	25.60	.03	.11
	AVE.				2.95
8	1961	24.93	25.89	-.96	-3.85
	1962	26.93	26.09	.84	3.11
	1963	25.69	24.66	1.03	4.00
	1964	22.34	23.12	-.73	-3.26
	1965	24.69	25.21	-.52	-2.10
	1966	27.13	25.91	1.22	4.49
	1967	26.59	26.41	.18	.67
	AVE.				3.06
9	1961	25.00	23.31	1.69	6.76
	1962	25.11	23.45	1.66	6.61
	1963	24.94	21.78	3.16	12.67
	1964	21.05	20.12	.93	4.41
	1965	22.81	22.30	.51	2.23
	1966	25.67	22.93	2.74	10.67
	1967	25.06	23.45	1.61	6.42
	AVE.				7.11
				OVERALL AVERAGE	3.57

APPENDIX TABLE 6 The Comparison of Actual and Predicted Values of the Price of Fed Cattle Per Hundred Pounds 1961-67, by Region

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
1	1961	24.05	24.88	-.83	-3.45
	1962	26.29	25.67	.62	2.35
	1963	23.75	24.10	-.35	-1.47
	1964	23.12	22.31	-.81	-3.41
	1965	24.63	25.34	-.71	-2.80
	1966	25.98	25.40	.58	2.23
	1967	25.07	25.75	-.68	-2.71
	AVE.				2.63
2	1961	24.34	24.84	-.50	-2.05
	1962	26.74	25.37	1.37	5.12
	1963	24.11	24.10	.01	.04
	1964	21.88	22.16	-.28	-1.27
	1965	23.91	23.92	-.01	-.04
	1966	24.91	24.48	.43	1.72
	1967	25.10	24.94	.16	.63
	AVE.				1.55
3	1961	23.13	22.53	.60	2.59
	1962	25.26	24.29	.97	3.84
	1963	22.62	22.64	-.02	-.08
	1964	21.04	20.81	.23	1.09
	1965	23.37	22.78	.59	2.52
	1966	24.48	23.19	1.29	5.26
	1967	24.26	24.18	.08	.32
	AVE.				2.24

APPENDIX TABLE 6 Continued, Page 2

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
4	1961	24.21	24.71	-.50	-2.06
	1962	26.86	25.51	1.35	5.02
	1963	23.36	24.22	-.86	-3.68
	1964	22.53	22.79	-.26	-1.15
	1965	25.14	25.12	.02	.07
	1966	25.60	24.91	.69	2.69
	1967	25.00	25.59	-.59	-2.36
	AVE.				2.43
5	1961	23.57	24.30	-.73	-3.09
	1962	25.56	24.92	.64	2.50
	1963	22.93	23.37	-.44	-11.95
	1964	21.31	23.52	-2.21	-10.37
	1965	23.86	24.73	-.87	-3.64
	1966	25.24	24.96	.28	1.10
	1967	25.00	26.16	-1.16	-4.64
	AVE.				5.32
6	1961	24.43	25.41	-.98	-4.01
	1962	26.52	25.57	.95	3.58
	1963	23.58	24.32	-.74	-3.13
	1964	22.41	22.57	-.16	-.71
	1965	24.99	25.32	-.33	-1.32
	1966	25.71	25.14	.57	2.21
	1967	25.29	25.91	-.62	-2.45
	AVE.				2.48

APPENDIX TABLE 6 Continued, Page 3

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
7	1961	24.86	24.52	.34	1.36
	1962	25.86	24.67	1.19	4.60
	1963	23.32	22.61	.71	3.04
	1964	21.90	22.15	-.25	-1.14
	1965	24.48	24.92	-.44	-1.79
	1966	25.58	24.73	.85	3.32
	1967	25.22	25.18	.09	.15
	AVE.				2.34
8	1961	24.54	25.29	-.75	-3.05
	1962	27.13	25.42	1.71	6.30
	1963	23.85	24.27	-.42	-1.76
	1964	22.69	23.64	-.95	-4.18
	1965	25.32	25.33	-.01	-.03
	1966	25.80	25.27	.53	2.05
	1967	25.43	26.41	-.98	-3.85
	AVE.				3.03
9	1961	25.28	25.42	-.14	-.55
	1962	25.35	25.99	-.64	-2.52
	1963	23.96	24.30	-.34	-1.41
	1964	23.12	22.68	.44	1.90
	1965	25.16	24.90	.26	1.03
	1966	25.54	24.68	.86	3.36
	1967	25.51	24.97	.54	2.11
	AVE.				1.84
				OVERALL AVERAGE	2.65

APPENDIX TABLE 7 The Comparison of Actual and Predicted Values of the Price of Wholesale Fed Beef Per Hundred Pounds 1961,67, by Region

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
1	1961	42.34	43.89	-1.55	-3.66
	1962	46.06	44.67	1.39	3.01
	1963	41.53	42.17	-.64	-1.54
	1964	39.58	39.42	.16	.40
	1965	43.30	43.63	-.33	-.76
	1966	43.62	43.61	.01	.02
	1967	44.29	44.01	.28	.63
	AVE.				1.43
2	1961	39.44	41.05	-1.61	-4.08
	1962	43.13	41.62	1.51	3.50
	1963	38.28	39.97	-1.69	-4.41
	1964	36.89	37.46	-.57	-1.54
	1965	40.31	39.67	.64	1.58
	1966	40.49	40.36	.13	.32
	1967	41.14	40.90	.24	.58
	AVE.				2.28
3	1961	38.34	38.50	-.16	-.41
	1962	42.06	41.37	.69	1.64
	1963	37.18	38.72	-1.54	-4.14
	1964	35.90	35.99	-.09	-.25
	1965	39.36	38.42	.94	2.38
	1966	39.62	38.63	.99	2.49
	1967	40.29	39.84	.45	1.11
	AVE.				1.77

APPENDIX TABLE 7 Continued, Page 2

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
4	1961	38.34	39.74	-1.40	-3.65
	1962	42.06	40.72	1.34	3.18
	1963	37.18	38.66	-1.48	-3.98
	1964	35.90	36.44	-.54	-1.50
	1965	39.36	39.52	-.16	-.40
	1966	39.62	38.98	.64	1.61
	1967	40.29	39.76	.53	1.31
	AVE.				2.23
5	1961	38.34	39.54	-1.20	-3.12
	1962	42.06	40.36	1.70	4.04
	1963	37.18	38.24	-1.06	-2.85
	1964	35.90	38.44	-2.54	-7.07
	1965	39.36	40.08	-.72	-1.82
	1966	39.62	40.39	-.77	-1.94
	1967	40.29	42.02	-1.73	-4.29
	AVE.				3.59
6	1961	38.66	40.79	-2.13	-5.50
	1962	42.54	40.98	1.56	3.66
	1963	37.65	39.05	-1.40	-3.71
	1964	36.15	36.45	-.30	-.82
	1965	39.65	39.92	-.27	-.68
	1966	39.99	39.41	.58	1.45
	1967	40.62	40.19	.43	1.05
	AVE.				2.41

APPENDIX TABLE 7 Continued, Page 3

Region	Year	Actual Value	Predicted Value	Deviation	Percent Deviation
		Dollars	Dollars	Dollars	Percent
7	1961	38.34	40.24	-1.90	-4.95
	1962	42.06	40.06	2.00	4.75
	1963	37.18	37.20	-.02	-.05
	1964	35.90	36.41	-.51	-1.42
	1965	39.36	40.10	-.74	-1.88
	1966	39.62	39.56	.06	.15
	1967	40.29	39.90	.39	.96
	AVE.				2.02
8	1961	39.44	41.20	-1.76	-4.46
	1962	43.13	41.36	.23	.53
	1963	38.28	39.49	-1.21	-3.16
	1964	36.89	38.43	-1.54	-4.17
	1965	40.31	40.57	-.26	-.64
	1966	40.49	40.13	.36	.88
	1967	41.14	41.47	.33	.80
	AVE.				2.09
9	1961	41.15	43.12	-1.97	-4.78
	1962	45.05	43.88	1.17	2.59
	1963	40.04	41.17	-1.13	-2.83
	1964	38.40	38.62	-.22	-.57
	1965	41.85	41.99	-.14	-.33
	1966	42.00	41.61	.39	.93
	1967	42.64	42.12	.52	1.21
	AVE.				1.89
				OVERALL AVERAGE	2.19

APPENDIX TABLE 8 The Comparison of Actual and Predicted Values of the National Variables 1961-67, by Region

C O W B E E F

Year	Actual Value	Predicted Value	Deviation	Percent Deviation
	1,000 Pounds	1,000 Pounds	1,000 Pounds	Percent
1961	5,735,880	6,053,467	-317,587	-5.53
1962	5,648,100	6,308,708	-660,608	-11.69
1963	5,519,360	6,658,244	-1,138,884	-20.63
1964	6,915,600	7,727,051	-811,451	-11.73
1965	8,957,034	8,822,438	134,596	1.50
1966	9,591,357	8,375,461	1,215,896	12.67
1967	9,200,400	8,455,909	744,491	8.09
AVE.				10.26

P W S L B F

Year	Actual Vaule	Predicted Value	Deviation	Percent Deviation
	Dollars	Dollars	Dollars	Percent
1961	41.14	42.70	-1.56	-3.79
1962	44.84	43.43	1.41	3.14
1963	40.83	41.15	-.32	-.78
1964	39.48	39.03	.45	1.13
1965	42.61	42.72	-.11	-.25
1966	43.04	42.83	.21	.48
1967	43.37	43.65	-.28	-.64
AVE.				1.45

APPENDIX TABLE 8 Continued, Page 2

P F D R C T

Year	Actual Value	Predicted Value	Deviation	Percent Deviation
	Dollars	Dollars	Dollars	Percent
1961	26.06	24.53	1.53	5.87
1962	27.54	24.79	2.75	9.98
1963	25.96	23.01	2.95	11.36
1964	22.42	21.11	1.31	5.84
1965	24.35	23.78	.57	2.34
1966	28.13	24.72	3.41	12.12
1967	27.46	25.42	2.04	7.42
AVE.				7.84

P F D C A T

Year	Actual Value	Predicted Value	Deviation	Percent Deviation
	Dollars	Dollars	Dollars	Percent
1961	24.54	25.46	-.92	-3.74
1962	27.13	26.01	1.12	4.12
1963	23.89	24.18	-.29	-1.21
1964	22.69	22.61	.08	.35
1965	25.32	25.44	-.12	-.47
1966	25.80	25.75	.05	.19
1967	25.43	25.96	-.53	-2.08
AVE.				1.73

APPENDIX TABLE 9 Production - Consumption Balances for Fed Beef, 1962, by Region

	Region	1 Per Capita Consumption	2 Population	3 Total Consumption	4 Cattle Fed	5 Total Production Carcuss Weight	(Col. 5 - Col. 3) Balance Production	 -- Consumption
		Pounds	Number	Pounds	Head	Pounds	Pounds	Head
	California	58.45	16,990,000	993,065,000	1,844,000	1,134,060,000	140,995,000	229,000
	Arizona	58.45	1,466,000	85,688,000	568,000	349,320.000	263.632.000	429,000
(1)	Calif. & Ariz.	58.45	18,456,000	1,078,753,000	2,412,000	1,483,380,000	404,627,000	658,000
	Oregon	56.99	1,817,000	103,550,000	148,000	91,020,000	-12,530,000	-20,000
	Washington	56.99	2,944,000	167,778,000	258,000	158,670,000	-9,108,000	-15,000
	Idaho	56.99	695,000	39,608,000	221,000	135,915,000	96,307,000	156,000
(2)	Pacific Northwest	56.99	5,456,000	310,937,000	627,000	385,605,000	74,668,000	121,000
(3)	Montana & Wyoming	52.61	1,028,000	54,083,000	172,000	105,780,000	51,697,000	84,000
(4)	Colorado	52.61	1,883,000	99,064,000	815,000	501,225,000	402,161,000	654,000
(5)	Utah & Nevada	52.61	1,305,000	68,656,000	142,000	87,330,000	18,674,000	30,300
(6)	Northern Plains	53.09	5,053,000	268,263,000	2,986,000	1,836,390,000	1,550,127,000	2.520,000
(7)	Southern Plains	42.38	13,537,000	573,698,000	1,071,000	658,665,000	84,967,000	138,000
(8)	Corn Belt States	54.07	47,484,000	2,567,459,000	5,809,000	3,572,535,000	1,005,076,000	1,634,300
(9)	Eastern States	43.84	90,750,000	3,978,480,000	614,000	377,610,000	-3,640,870,000	-5,920,000
	NATIONAL	48.71	184,952	9,009,011,000	14,648,000	9,008,520,000	0	0

APPENDIX TABLE 10 Production - Consumption Balances for Fed Beef, 1963, by Region

	1	2	3	4	5	(Col. 5 - Col. 3)	
Region	Per Capita Consumption	Population	Total Consumption	Cattle Fed	Total Production Carcuss Weight	Balance Production - Consumption	
	Pounds	Number	Pounds	Head	Pounds	Pounds	Head
California	61.40	17,556,000	1,077,938,000	1,899,000	1,167,885,000	89,947,000	146,000
Arizona	61.40	1,517,000	93,144,000	608,000	373,920,000	280,776,000	456,600
(1) Calif. & Ariz.	61.40	19,073,000	1,177,082,000	2,507,000	1,541,805,000	370,723,000	602,800
Oregon	59.87	1,852,000	110,879,000	136,000	83,640,000	-27,239,000	-44,000
Washington	59.87	2,961,000	177,275,000	267,000	164,205,000	-13,070,000	-21,000
Idaho	59.87	689,000	41,250,000	233,000	143,295,000	102,045,000	165,000
(2) Pacific Northwest	59.87	5,502,000	329,404,000	636,000	391,140,000	61,736,000	100,000
(3) Montana & Wyoming	55.26	1,036,000	57,249,000	162,000	99,630,000	42,381,000	68,900
(4) Colorado	55.26	1,913,000	105,712,000	900,000	553,500,000	447,788,000	728,100
(5) Utah & Nevada	55.26	1,364,000	75,374,000	148,000	91,020,000	15,646,000	25,400
(6) Northern Plains	55.78	5,081,000	283,418,000	3,304,000	2,031,960,000	1,748,542,000	2,843,100
(7) Southern Plains	44.52	13,697,000	609,790,000	1,259,000	774,285,000	164,495,000	267,500
(8) Corn Belt States	56.80	47,941,000	2,723,048,000	6,121,000	3,764,415,000	1,041,367,000	1,693,300
(9) Eastern States	46.05	92,118,000	4,242,034,000	583,000	358,545,000	-3,883,489,000	-6,314,600
NATIONAL	51.17	187,725	9,597,111,000	15,620,000	9,534,300,000	0	0

APPENDIX TABLE 11 Production - Consumption Balances for Fed Beef, 1964, by Region

Region	1 Per Capita Consumption	2 Population	3 Total Consumption	4 Cattle Fed	5 Total Production Carcuss Weight	(Col. 5 - Col. 3) Balance Production - Consumption	
	Pounds	Number	Pounds	Head	Pounds	Pounds	Head
California	66.18	18,003,000	1,191,438,000	2,061,000	1,267,515,000	76,077,000	124,000
Arizona	66.18	1,549,000	102,513,000	600,000	369,000,000	266,487,000	433,000
(1) Calif., & Ariz.	66.18	19,552,000	1,293,951,000	2,661,000	1,636,515,000	342,564,000	557,000
Oregon	64.53	1,886,000	121,703,000	147,000	90,405,000	-31,298,000	-51,000
Washington	64.53	2,971,000	191,718,000	290,000	178,350,000	-13,368,000	-21,000
Idaho	64.53	687,000	44,332,000	251,000	154,365,000	110,033,000	178,000
(2) Pacific Northwest	64.53	5,544,000	357,754,000	688,000	423,120,000	65,366,000	106,000
(3) Montana & Wyoming	59.56	1,041,000	62,002,000	187,000	115,000,000	52,998,000	86,175
(4) Colorado	59.56	1,941,000	115,606,000	951,000	584,860,000	469,254,000	763,000
(5) Utah & Nevada	59.56	1,395,000	83,086,000	171,000	105,165,000	22,079,000	35,900
(6) Northern Plains	60.11	5,058,000	304,036,000	3,934,000	2,419,410,000	2,115,374,000	3,439,632
(7) Southern Plains	47.98	13,870,000	665,483,000	1,407,000	865,300,000	199,817,000	324,900
(8) Corn Belt States	61.22	48,518,000	2,970,272,000	6,450,000	3,966,750,000	996,478,000	1,620,000
(9) Eastern States	49.64	93,483	4,640,496,000	627,000	385,600,000	-4,254,896,000	6,918,530
NATIONAL	55.15	190,402,000	10,492,686,000	17,076,000	10,501,720,000	0	0

APPENDIX TABLE 12 Production - Consumption Balances for Fed Beef, 1965, by Region

		1	2	3	4	5	(Col. 5 - Col. 3)	
	Region	Per Capita Consumption	Population	Total Consumption	Cattle Fed	Total Production Carcuss Weight	Balance Production - Consumption	
		Pounds	Number	Pounds	Head	Pounds	Pounds	Head
	California	68.16	18,400,000	1,254,144,000	2,282,000	1,403,430,000	149,286,000	242.741
	Arizona	68.16	1,575,000	107,352,000	650,000	399,750,000	292,398,000	475,443
(1)	Calif. & Ariz.	68.16	19,975,000	1,361,496,000	2,932,000	1,803,180,000	441,684,000	718,185
	Oregon	66.46	1,937,000	128,733,000	168,000	103,320,000	-25,413,000	-41,321
	Washington	66.46	2,976,000	197,784,000	307,000	188,805,000	-8,979,000	-14,600
	Idaho	66.46	694,000	46,123,000	271,000	166,665,000	120,542,000	196,003
(2)	Pacific Northwest	66.46	5,607,000	372,641,000	746,000	458,790,000	86,149,000	140,080
(3)	Montana & Wyoming	61.34	1,033,000	63,364,000	204,000	125,460,000	62,096,000	100,969
(4)	Colorado	61.34	1,947,000	119,429,000	1,144,000	703,560,000	584,131,000	949,806
(5)	Utah & Nevada	61.34	1,423,000	87,286,000	175,000	107,625,000	20,339,000	33,071
(6)	Northern Plains	61.91	5,045,000	312,336,000	4,031,000	2,479,065	2,166,729,000	3,523,136
(7)	Southern Plains	49.42	14,016,000	692,670,000	1,567,000	963,705,000	271,035,000	440,707
(8)	Corn Belt States	63.05	49,066,000	3,093,611,000	7,244,000	4,455,060,000	1,361,449,000	2,213,738
(9)	Eastern States	51.12	94,723,000	4,842,240,000	675,000	415,125,000	-4,427,115,000	-7,198,560
	NATIONAL	56.80	192,835,000	10,953,765,000	17,811,000	10,953,765,000	0	0

APPENDIX TABLE 13 Production - Consumption Balances for Fed Beef, 1966, by Region

	Region	1 Per Capita Consumption	2 Population	3 Total Consumption	4 Cattle Fed	5 Total Production Carcuss Weight	(Col. 5 - Col. 3) Balance Production - Consumption	
		Pounds	Number	Pounds	Head	Pounds	Pounds	Head
	California	77.09	18,802,000	1,449,446,000	2,219,000	1,364,685,000	-84,761,000	-137,822
	Arizona	77.09	1,603,000	123,575,000	614,000	377,610,000	254,035,000	413,065
(1)	Calif. & Ariz.	77.09	20,405,000	1,573,021,000	2,833,000	1,742,295,000	169,274,000	275,242
	Oregon	75.16	1,973,000	148,290,000	189,000	116,235,000	-32,055,000	-52,121
	Washington	75.16	3,040,000	228,486,000	290,000	178,350,000	-50,136,000	-81,521
	Idaho	75.16	697,000	52,386,000	305,000	187,575,000	135,189,000	219,819
(2)	Pacific Northwest	75.16	5,710,000	429,163,000	784,000	482,160,000	52,997,000	86,173
(3)	Montana & Wyoming	69.38	1,021,000	70,836,000	233,000	143,295,000	72,459,000	117,819
(4)	Colorado	69.38	1,955,000	135,637,000	1,268,000	779,820,000	644,183,000	1,047,452
(5)	Utah & Nevada	69.38	1,438,000	101,156,000	191,000	117,465,000	16,309,000	26,518
(6)	Northern Plains	70.02	5,036,000	352,620,000	4,663,000	2,867,745,000	2,515,125,000	4,089,634
(7)	Southern Plains	55.89	14,226,000	795,091,000	1,985,000	1,220,775,000	425,684,000	692,169
(8)	Corn Belt States	71.13	49,632,000	3,539,258,000	7,697,000	4,733,655,000	1,194,397,000	1,942,108
(9)	Eastern States	57.81	95,522,000	5,522,127,000	698,000	429,270,000	-5,092,857,000	-8,281,068
	NATIONAL	64.24	194,945,000	12,522,630,000	20,362,000	12,522,630,000	0	0

APPENDIX TABLE 14 Production - Consumption Balances for Fed Beef, 1967, by Region

		1	2	3	4	5	(Col. 5 - Col. 3)	
	Region	Per Capita Consumption	Population	Total Consumption	Cattle Fed	Total Production Carcuss Weight	Balance Production - Consumption	
		Pounds	Number	Pounds	Head	Pounds	Pounds	Head
	California	81.35	18,899,000	1,537,433,000	2,049,000	1,260,135,000	-277,298,000	-450,891
	Arizona	81.35	1,644,000	133,739,000	658,000	404,670,000	270,931,000	440,538
(1)	Calif. & Ariz.	81.35	20,543,000	1,671,173,000	2,707,000	1,664,805,000	-6,368,000	-10,354
	Oregon	79.31	1,979,000	156,954,000	181,000	111,315,000	-45,639,000	-74,209
	Washington	79.31	3,215,000	254,981,000	315,000	193,725,000	-61,256,000	-99,603
	Idaho	79.31	703,000	55,754,000	365,000	224,475,000	168,721,000	274,343
(2)	Pacific Northwest	79.31	5,897,000	467,691,000	861,000	529,515,000	61,826,000	100,530
(3)	Montana & Wyoming	73.21	1,018,000	74,527,000	227,000	139,605,000	65,078,000	105,817
(4)	Colorado	73.21	2,018,000	147,737,000	1,330,000	817,950,000	670,213,000	1,089,777
(5)	Utah & Nevada	73.21	1,462,000	107,033,000	150,000	92,250,000	-14,783,000	-24,037
(6)	Northern Plains	73.89	5,022,000	371,075,000	5,135,000	3,158,025,000	2,786,950,000	4,531,626
(7)	Southern Plains	58.98	14,372,000	847,660,000	2,306,000	1,418,190,000	570,530,000	927,691
(8)	Corn Belt States	75.25	50,165,000	3,774,916,000	8,279,000	5,091,585,000	1,316,669,000	2,140,925
(9)	Eastern States	61.01	96,330,000	5,877,093,000	672,000	413,280,000	-5,463,813,000	-8,884,248
	NATIONAL	67.79	196,827,000	13,343,040,000	21,696,000	13,343,040,000	0	0

APPENDIX TABLE 15 Production - Consumption Balance for Fed Beef, 1968, by Region

		1	2	3	4	5	(Col. 5 - Col. 3)	
	Region	Per Capita Consumption	Population	Total Consumption	Cattle Fed	Total Production Carcuss Weight	Balance Production -	Consumption
		Pounds	Number	Pounds	Head	Pounds	Pounds	Head
	California	85.52	19,221,000	1,643,779,000	2,068,000	1,271,820,000	-371,959,000	-604,811
	Arizona	85.52	1,670,000	142,818,000	703,000	432,345,000	289,527,000	470,775
(1)	Calif. & Ariz.	85.52	20,891,000	1,786,598,000	2,771,000	1,704,165,000	-82,433,000	-134,037
	Oregon	83.39	2,008,000	167,447,000	181,000	111,315,000	-56,132,000	-91,271
	Washington	83.39	3,276,000	273,185,000	332,000	204,180,000	-69,005,000	-112,203
	Idaho	83.39	705,000	58,789,000	412,000	253,380,000	194,591,000	316,408
(2)	Pacific Northwest	83.39	5,989,000	499,422,000	925,000	568,875,000	69,453,000	112,931
(3)	Montana & Wyoming	76.97	1,008,000	77,585,000	226,000	138,990,000	61,405,000	99,845
(4)	Colorado	76.97	2,048,000	157,634,000	1,431,000	880,065,000	722,431,000	1,174,684
(5)	Utah & Nevada	76.97	1,487,000	114,454,000	160,000	98,400,000	-16,054,000	-26,104
(6)	Northern Plains	77.68	5,022,000	390,109,000	5,562,000	3,420,630,000	3,030,521,000	4,927,676
(7)	Southern Plains	62.00	14,505,000	899,310,000	2,705,000	1,663,575,000	764,265,000	1,242,707
(8)	Corn Belt States	79.11	50,606,000	4,003,441,000	8,628,000	5,306,220,000	1,302,779,000	2,118,339
(9)	Eastern States	64.14	97,248,000	6,237,487,000	631,000	388,065,000	-5,849,422,000	-9,511,255
	NATIONAL	71.27	198,804,000	14,168,985,000	23,039,000	14,168,985,000	0	0

APPENDIX II

Computer Program for Simulation of Cattle Feeding Industry

```
      PROGRAM FEEDLOT
      DIMENSION COWINV(9),FORCAT(9),PWSLBF(9),
     1   TSFDBF(9),PFDCAT(9),PFDRCT(9),PICTFED(9),
     2   CATFED(9),A1(9),B11(9),B21(9),B31(9),A2(9),
     3   B12(9),B22(9),A6(9),B16(9),B26(9),B36(9),
     4   A8(9),B18(9),A9(9),B19(9),B29(9),A13(9),
     5   B113(9),B213(9),A15(9),B115(9),B215(9),
     6   B315(9),PFDRCT1(9),RANGE(9),Y(9),BSPERCAP(9),
     7   FDCOST(9),CATFED1(9)
      REAL NFDCST(9),KFFDRCT,NPFDCAT
      DIMENSION TAB1(7,20),TAB2(9,20),TAB3(9,20),TAB4(9,20),
     1   TAB5(10,20),TAB6(20),TAB7(20),TAB8(20)
      INTEGER T
      DO 10 I=5,14
      CALL UNEQUIP(I)
      CALL EQUIP(I,5HLF    )
10    WRITE (1,101)
101   FORMAT (≠1SETTLES≠)
      WRITE(6,6000)
 6000 FORMAT(≠1≠,10X,≠BHAGIA   CATTLE FEEDLOT≠)
      WRITE(6,6001)
 6001 FORMAT(≠-CATFED(I,T+1)≠/≠0≠)
      WRITE(7,6000)
      WRITE(7,7001)
 7001 FORMAT(≠-FORCAT(I,T)≠/≠0≠)
      WRITE(8,6000)
      WRITE(8,8001)
 8001 FORMAT(≠-COWINV(1,T)≠/≠0≠)
      WRITE(9,6000)
      WRITE(9,9001)
 9001 FORMAT(≠-COWBEEF(U,T),PWSLBF(C,T),PFDRCT(K,T),PFDCAT(N,T)≠/≠0≠)
      WRITE(10,6000)
      WRITE(10,1010)
 1010 FORMAT(≠-PWSLBF(I,T)≠/≠0≠)
      WRITE(11,6000)
      WRITE(11,1011)
 1011 FORMAT(≠-TSFDBF(I,T)≠/≠0≠)
      WRITE(12,6000)
      WRITE(12,1012)
 1012 FORMAT(≠-PFDCAT(I,T)≠/≠0≠)
      WRITE(13,6000)
      WRITE(13,1013)
 1013 FORMAT(≠-PFDRCT(I,T)≠/≠0≠)
      WRITE(14,6000)
      WRITE(14,1014)
 1014 FORMAT(≠-PICTFED(I,T)≠/≠0≠)
      READ(2,1002) NT
      NT12=NT-2
 1002 FORMAT(I2)
      READ(1,1000) A1,B11,B21,B31,A2,B12,B22,A6,
     1   B16,B26,B36,A8,B18,A9,B19,B29,A13,B113,
     2   B213,A15,B115,B215,B315
 1000 FORMAT(23F10.0)
      READ(1,1001) A4,B14,B24,A5,B15,B25,B35,A10,
     1   B110,B210,A12,B112,B212,B312
 1001 FORMAT(3F10.0/4E10.0)
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      READ(2,2000) KPFDRCT,TCATFED1,TCATFED
 2000 FORMAT(F10.0)
      READ(2,1000) PFDRCT1,PFDRCT,CATFED1,CATFED
      READ(3,3000)((TAB1(I,J),I=1,7),J=1,NTM2)
 3000 FORMAT(7F10.0)
      READ(3,1000) ((TAB2(I,J),I=1,9),J=3,NT),
     1   ((TAB3(I,J),I=1,9),J=3,NT),((TAB4(I,J),
     2   I=1,9),J=3,NT)
      READ(3,3001)(TAB6(J),J=3,NT)
      READ(3,3001)(TAB7(J),J=3,NT)
      READ(3,3001)(TAB8(J),J=3,NT)
      READ(3,3001) ((TAB5(I,J),I=1,10),J=3,NT)
 3001 FORMAT(10F10.0)
      WRITE(5,5000) A1,B11,B21,B31
      WRITE(5,5000) A2,B12,B22
      WRITE(5,5000) A6,B16,B26,B36
      WRITE(5,5000) A8,B18
      WRITE(5,5000) A9,B19,B29
      WRITE(5,5000) A13,B113,B213
      WRITE(5,5000) A15,B115,B215,B315
 5000 FORMAT(≠0≠/(1X,9E13.5))
      WRITE(5,5000)A4,B14,B24
      WRITE(5,5000)A5,B15,B25,B35
      WRITE(5,5000)A10,B110,B210
      WRITE(5,5000)A12,B112,B212,B312
      WRITE(5,5004) KPFDRCT,TCATFED1,TCATFED
      WRITE(5,5000) PFDRCT1,PFDRCT,CATFED1,CATFED
      WRITE(5,5001)
 5001 FORMAT(≠1≠)
      WRITE(5,5002) ((TAB1(I,J),I=1,7),J=1,NTM2)
 5002 FORMAT(≠0≠/(1X,7E13.5))
      WRITE(5,5000)((TAB2(I,J),I=1,9),J=1,NT)
      WRITE(5,5000)((TAB3(I,J),I=1,9),J=1,NT)
      WRITE(5,5000)((TAB4(I,J),I=1,9),J=1,NT)
      WRITE(5,5004)(TAB6(J),J=1,NT)
      WRITE(5,5004)(TAB7(J),J=1,NT)
      WRITE(5,5004)(TAB8(J),J=1,NT)
      WRITE(5,5004)((TAB5(I,J),I=1,10),J=1,NT)
 5004 FORMAT(≠0≠/(1X,10E13.5))
      RANGE(8)=RANGE(9)=0.
      WRITE(5,6000)
      DO 500 T=3,NT
      DO 50 I=1,9
      Y(I)=TAB5(I,T)
      RSPERCAP(I)=TAB2(I,T)
      FDCOST(I)=TAB3(I,T)
      NFDCST(I)=TAB4(I,T)
      IF(I.GT.7) GO TO 50
      IT2=T-2
      RANGE(I)=TAB1(I,IT2)
   50 CONTINUE
      YN=TAB5(10,T)
      PKPRTC=TAB6(T)
      PRYPRCD=TAB7(T)
      CONSRF=TAB8(T)
      WRITE(5,5000) Y,RSPERCAP,FDCOST,NFDCST,RANGE,
```

```
     1      YN,PKPRIC,PBYPROD,CONSBF
        TCOWINV=TFDRCAT=0.
        DO 70 I=1,9
        COWINV(I)=A1(I)+B11(I)*RANGE(I)+B21(I)*T
     1     +B31(I)*PFDRCT1(I)
        TCOWINV=TCOWINV+COWINV(I)
        FDRCAT(I)=A2(I)+B12(I)*COWINV(I)+B22(I)*PFDRCT(I)
        TFDRCAT=TFDRCAT+FDRCAT(I)
 70     CONTINUE
        COWBEEF=A4+B14*TCOWINV+B24*KPFDRCT
        CPWSLBF=A5+B15*CONSBF+B25*YN+B35*PKPRIC
        DO 90 I=1,9
        PWSLBF(I)=A6(I)+B16(I)*CPWSLBF+B26(I)*Y(I)
     1     +B36(I)*BSPERCAP(I)
        TSFDBF(I)=A8(I)+B18(I)*CATFED(I)
        PFDCAT(I)=A9(I)+B19(I)*TSFDBF(I)+B29(I)*PWSLBF(I)
 90     CONTINUE
        NPFDCAT=A10+B110*CPWSLBF+B210*PBYPROD
        KPFDRCT=A12+B112*TFDRCAT+B212*NPFDCAT
     1     +B312*TCATFED1
        TCATFED1=TCATFED
        TCATFED=0.
        DO 110 I=1,9
        PFDRCT1(I)=PFDRCT(I)
        PFDRCT(I)=A13(I)+B113(I)*CATFED1(I)+B213(I)
     1     *KPFDRCT
        PICTFED(I)=PFDCAT(I)*10.25-PFDRCT(I)*6.00-FDCOST(I)-NFDCST(I)
        CATFED1(I)=CATFED(I)
        CATFED(I)=A15(I)+B115(I)*PICTFED(I)+B215(I)
     1     *FDRCAT(I)+B315(I)*CATFED(I)
        IF(T.NE.3)GO TO 95
        IF(I.EQ.2)CATFED(2)=1.10*CATFED(2)
        IF(I.EQ.6)CATFED(6)=.90*CATFED(6)
        IF(I.EQ.7)CATFED(7)=1.15*CATFED(7)
        GO TO 109
 95     IF(I.NE.8)GO TO 97
        IF(T.LT.4.OR.T.GT.8)GO TO 97
        IF(CATFED(8).LT.1.05*CATFED1(8))CATFED(8)=1.05*CATFED1(8)
 97     IF(CATFED(7).GT.1.15*CATFED1(7))CATFED(7)=1.15*CATFED1(7)
 109    CONTINUE
        TCATFED=TCATFED+CATFED(I)
 110    CONTINUE
        WRITE(6,6002) CATFED
 6002   FORMAT(1X,9E14.6)
        WRITE(7,6002) FDRCAT
        WRITE(8,6002) COWINV
        WRITE(9,6002) COWBEEF,CPWSLBF,KPFDRCT,NPFDCAT
        WRITE(10,6002) PWSLBF
        WRITE(11,6002) TSFDBF
        WRITE(12,6002) PFDCAT
        WRITE(13,6002) PFDRCT
        WRITE(14,6002) PICTFED
 500    CONTINUE
        CALL EXIT
        END
```

APPENDIX III

Computer Program for Interregional Shipments of Live and Carcass Beef

```
      PROGRAM BHAGIA2
      COMMON/DATA/A1,A2(9),A3(9),B11,B12,B13,B14,B21(9),B22(9),
     1  B23(9),B31(9),B32(9)
      COMMON/DATA/A(9),CONST1(9),CONST2(9)
      DATA (CONST1=3(10000000.),40000000.,10000000.,3(40000000.),
     1  10000000.),(CONST2=3(16700.),66800.,16700.,3(66800.),
     2  16700.)
      COMMON POPR(9),CATFED(9),TRCSTC(9,9),TRCSTL(9,9),SLCOST(9),
     1  SLCPY(9),FIXA(9,9),SUPCBR(9),PWHFBR(9),PFDCAT(9),FDNMFB(9,9),
     2  CANMFB(9,9),FNMFB(9),CNMFB(9),TL(9),SL(9),YTR(9),
     3  DIFWV(9,9),VFDCAT(9),VCAT(9),DIFLV(9,9),XILA(9,9),
     4  SUPCB(9),B(9)
      DATA (A1=75.752),(B11=.5546),(B12=.0761),(B13=.6925),
     1  (B14=0.),(A2=-6.2370,-8.3746,-6.0497,-9.3191,-5.7078,
     2  -12.1556,-6.7774,-17.0680,-4.9743),(B21=1.163484,1.076049,
     3  1.049963,1.102828,1.149151,1.133476,1.149403,1.178602,
     4  1.179943),(B22=.012816,-.12324,-.01846,.000831,-.007252,
     5  .001293,-.014073,-.141213,-.041251),(B23=.004679,-.00210,
     6  .002383,.002031,.000523,-.000500,-.006382,-.015413,.003863),
     7  (A3=3.42390,2.27921,.16966,.23515,-3.97397,-.50336,9.54019,
     8  -8.22576,14.86013),(B31=.78310,1.04339,1.04149,1.04586,
     9  1.10928,1.10088,.74782,1.25051,.60035),(B32=.000002207,
     X  -.000003238,.000003264,.000002307,.000018289,.000000241,
     1  -.000001217,.000000694,-.000000816)
      DIMENSION PCNM(9),PFNM(9)
      IYEAR=0
10    READ (1,1) NITER,NSKIP
1     FORMAT (2I4)
      IF (EOF(1)) CALL EXIT
      READ (1,102) POP,YT,PKPRIC
102   FORMAT (8F9.0)
      IF (EOF(1)) CALL EXIT
      READ (1,102) POPR
      IYEAR=IYEAR+1
      READ (1,101) YTR
101   FORMAT (9E8.0)
      READ (1,101) CATFED
      READ (1,101) ((TRCSTC(I,J),J=1,9),I=1,9)
      READ (1,101) ((TRCSTL(I,J),J=1,9),I=1,9)
      READ (1,101) SLCOST
      READ (1,101) SLCPY
      READ (1,101) A
      READ(1,101)(B(I),I=1,9)
      ITER=1
      TPROL=0.
      DO 20 I=1,9
      TPROL=TPROL+CATFED(I)
      FNMFB(I)=CNMFB(I)=0.
      PCNM(I)=PFNM(I)=0.
      DO 20 J=1,9
20    CANMFB(I,J)=FDNMFB(I,J)=0.
      TPRDC=615*TPROL
      CATFB=TPRDC/POP
      PWHFB=A1+B11*CATFB+B12*YT-B13*PKPRIC
      WRITE (2,302) TPROL,TPRDC,CATFB,PWHFB
302   FORMAT (≠ TPROL= ≠,E14.6,≠  TPRDC=≠,E14.6,≠  CATFB=≠,E14.6,
```

```
     1    ≠  PWHFB=≠,E14.6)
      WRITE(2,999)
999   FORMAT(1H0,≠I≠,10X,≠A(I)*POPR(I)≠,16X,≠CATFED(I)*615≠)
      DO 25 I=1,9
      TERM=A(I)*POPR(I)
      CTERM=CATFED(I)*615.
25    WRITE(2,1000)I,TERM,CTERM
1000  FORMAT(1H ,I1,8X,E14.6,15X,E14.6)
      DO 31 I=1,9
      SUPCB(I)=615.*CATFED(I)+615.*FNMFB(I)+CNMFB(I)
      SUPCBR(I)=SUPCB(I)/POPR(I)
      PWHFBR(I)=A2(I)+B21(I)*PWHFB+B22(I)*(CATFB-SUPCBR(I))+
     1  B23(I)*YTR(I)
31    CONTINUE
30    AMAXS=AMAXL=-1.E300
      M=N=MM=NN=0
      DO 35 I=1,9
      TL(I)=CATFED(I)+FNMFB(I)
      SL(I)=SLCPY(I)-TL(I)
      VFDCAT(I)=PWHFBR(I)-SLCOST(I)
      VCAT(I)=VFDCAT(I)/1.67
      PFDCAT(I)=A3(I)+B31(I)*VCAT(I)+B32(I)*SL(I)
35    CONTINUE
      DO 50 I=1,9
      DO 50 J=1,9
      IF (J.EQ.I) GO TO 50
      DIFWV(I,J)=PWHFBR(J)-PWHFBR(I)
      EIXA(I,J)=DIFWV(I,J)-TRCSTC(I,J)
      IF (EIXA(I,J).LE.AMAXS) GO TO 40
      AMAXS=EIXA(I,J)
      M=I
      N=J
40    DIFLV(I,J)=PFDCAT(J)-PFDCAT(I)
      XILA(I,J)=DIFLV(I,J)-TRCSTL(I,J)
      IF (XILA(I,J).LE.AMAXL) GO TO 50
      AMAXL=XILA(I,J)
      MM=I
      NN=J
50    CONTINUE
      AKON=5000000.
      IF(M.LT.4.OR.M.EQ.5.OR.M.GT.8)GO TO 150
      IF(N.EQ.4.OR.N.GE.6)AKON=10000000.
150   BMAXS=AKON*AMAXS
      AKON=8350.
      IF(MM.LT.4.OR.MM.EQ.5.OR.MM.GT.8)GO TO 160
      IF(NN.EQ.4.OR.NN.GE.6)AKON=16700.
160   BMAXL=AKON*AMAXL
      IF (BMAXS.LE.0..AND.BMAXL.LE.0.) GO TO 110
      IPRINT=10*(ITER/10)-ITER
      IF (ITER.LE.NSKIP) IPRINT=1
      IF (ITER.LE.4) IPRINT=0
      IF(ITER.LE.NSKIP)GO TO 54
      IF(ITER.GT.4.AND.IPRINT)GO TO 54
      WRITE (2,301) ITER
301   FORMAT (≠1≠,15X,≠ITERATION ≠,I4)
      IF (IPRINT) GO TO 51
```

```
      WRITE (2,2002)
      WRITE (2,2003) (I,SUPCBR(I),PWHFBR(I),PFDCAT(I),I=1,9)
51    WRITE (2,2004)
      WRITE (2,2005) (J,J=1,9)
      WRITE (2,2006) (I,(FDNMFB(I,J),J=1,9),I=1,9)
      WRITE (2,2007)
      WRITE (2,2005) (J,J=1,9)
      WRITE (2,2006) (I,(CANMFB(I,J),J=1,9),I=1,9)
      IF (ITER.GT.4) GO TO 54
      WRITE (2,306) M,N,BMAXS,MM,NN,BMAXL
306   FORMAT (≠  M=≠,I2,≠  N=≠,I2,≠  BMAXS=≠,E14.6/≠ MM=≠,I2,≠ NN=≠,
     1  I2,≠  BMAXL=≠,E14.6)
      WRITE (2,303) SUPCB
303   FORMAT (5X,≠SUPCB≠/1X,9E14.6)
      WRITE (2,304) ((DIFWV(I,J),J=1,9),I=1,9)
304   FORMAT (5X,≠DIFWV≠/(1X,9E14.6))
      WRITE (2,305) ((EIXA(I,J),J=1,9),I=1,9)
305   FORMAT (5X,≠EIXA≠/(1X,9E14.6))
      WRITE (2,307) TL,SL,VFDCAT,VCAT
307   FORMAT (5X,≠TL≠/1X,9E14.6//5X,≠SL≠/1X,9E14.6//5X,≠VFDCAT≠/
     1  1X,9E14.6//5X,≠VCAT≠/1X,9E14.6)
      WRITE (2,308) ((DIFLV(I,J),J=1,9),I=1,9)
308   FORMAT (/5X,≠DIFLV≠/(1X,9E14.6))
      WRITE (2,309) ((XILA(I,J),J=1,9),I=1,9)
309   FORMAT (/5X,≠XILA≠/(1X,9F14.6))
54    CONTINUE
55    IF (BMAXS.LE.0..AND.BMAXL.LE.0.) GO TO 110
      IF (AMAXS.GT.AMAXL) GO TO 75
      IF (MM.AND.NN) GO TO 60
      WRITE (61,103) ITER,MM,NN
103   FORMAT (≠ CAN NOT FIND MAX IN ITER ≠,I4,≠  MM= ≠,I2,≠ NN= ≠,I2)
      GO TO 200
60    FDNMFB(MM,NN)=BMAXL+FDNMFB(MM,NN)
      PFNMFBI=FNMFB(MM)
      FNMFB(MM)=-BMAXL+FNMFB(MM)
      PFNMFBJ=FNMFB(NN)
      FNMFB(NN)=BMAXL+FNMFB(NN)
      IF (ITER.LE.4) WRITE (2,401) FNMFB
401   FORMAT (1X,≠FNMFB≠,1X,9E14.6)
      CHECKM=SUPCBR(MM)+(615.*FNMFB(MM)-615.*PFNM(MM))/POPR(MM)
      CHECKN=SUPCBR(NN)+(615.*FNMFB(NN)-615.*PFNM(NN))/POPR(NN)
      GO TO (63,64,64,64,63,64,64,64,63) MM
63    IF (CHECKM.GT.A(MM)) 62,65
64    IF (CHECKM.LT.A(MM)) 62,65
65    GO TO (66,67,67,67,66,67,67,67,66) NN
66    IF (CHECKN.GT.A(NN)) 62,68
67    IF (CHECKN.LT.A(NN)) 62,68
68    TEST2=SLOPY(NN)-FNMFB(NN)-CATFED(NN)
      TEST3=CNMFB(MM)+FNMFB(MM)*615.+CATFED(MM)*615.-A(MM)*POPR(MM)
      IF (TEST2.LT.0..OR.TEST3.LT.0.) GO TO 62
      TERMNN=CATFED(NN)*615.+FNMFB(NN)*615.+CNMFB(NN)-
     1  A(NN)*POPR(NN)
      IF(TERMNN.GT.0.)GO TO 62
      IF (ITER.EQ.1) GO TO 70
      IF (ABS(PFNMFBI-FNMFB(MM)).LT..005.AND.ABS(PFNMFBJ-FNMFB(NN)).LT.
     1  .005) GO TO 200
```

```
70    ITER=ITER+1
      IF (ITER.GT.NITER) GO TO 110
      SUPCB(MM)=615.*FNMFB(MM)
      SUPCB(NN)=615.*FNMFB(NN)
      DSUPCBRM=(SUPCB(MM)-615.*PFNM(MM))/POPR(MM)
      DSUPCBRN=(SUPCB(NN)-615.*PFNM(NN))/POPR(NN)
      PFNM(MM)=FNMFB(MM)
      PFNM(NN)=FNMFB(NN)
      SUPCBR(MM)=SUPCBR(MM)+DSUPCBRM
      SUPCBR(NN)=SUPCBR(NN)+DSUPCBRN
      DPWHM=B(MM)*DSUPCBRM
      DPWHN=B(NN)*DSUPCBRN
      PWHFBR(MM)=PWHFBR(MM)+DPWHM
      PWHFBR(NN)=PWHFBR(NN)+DPWHN
      GO TO 30
62    XILA(MM,NN)=0.0
      FONMFB(MM,NN)=FONMFB(MM,NN)-BMAXL
      FNMFB(MM)=FNMFB(MM)+BMAXL
      FNMFB(NN)=FNMFB(NN)-BMAXL
      IF (ITER.LE.4) WRITE (2,401) FNMFB
      MM=NN=0
      AMAXL=-1.E300
      DO 74 I=1,9
      DO 74 J=1,9
      IF (J.EQ.I) GO TO 74
      IF (XILA(I,J).LE.AMAXL) GO TO 74
      AMAXL=XILA(I,J)
      MM=I
      NN=J
74    CONTINUE
      AKON=8350.
      IF(MM.LT.4.OR.MM.EQ.5.OR.MM.GT.8)GO TO 76
      IF(NN.EQ.4.OR.NN.GE.6)AKON=66800.
76    BMAXL=AKON*AMAXL
      GO TO 55
75    IF (M.AND.N) GO TO 80
      WRITE (61,104) M,N
104   FORMAT (* CAN NOT FIND MAX IN ITER *,I4,*  M= *,I2,*  N= *,I2)
      GO TO 200
80    CANMFB(M,N)=BMAXS+CANMFB(M,N)
      PCNMFBI=CNMFB(M)
      CNMFB(M)=-BMAXS+CNMFB(M)
      PCNMFBJ=CNMFB(N)
      CNMFB(N)=BMAXS+CNMFB(N)
      IF (ITER.LE.4) WRITE (2,402) CNMFB
      CHECKM=SUPCBR(M)+(CNMFB(M)-PCNM(M))/POPR(M)
      CHECKN=SUPCBR(N)+(CNMFB(N)-PCNM(N))/POPR(N)
      GO TO (81,82,82,82,81,82,82,82,81) M
81    IF (CHECKM.GT.A(M)) 92,83
82    IF (CHECKM.LT.A(M)) 92,83
83    GO TO (84,85,85,85,84,85,85,85,84) N
84    IF (CHECKN.GT.A(N)) 92,86
85    IF (CHECKN.LT.A(N)) 92,86
86    TEST1=CNMFB(M)+(FNMFB(M)+CATFED(M))*615.-A(M)*POPR(M)
      TEST2=CNMFB(M)+SLOPY(M)*615.-A(M)*POPR(M)
      IF (TEST1.LT.0.OR.TEST2.LT.0.) GO TO 92
```

```
      IF (CNMFB(M)+FNMFB(M)*615..LT.-.80*615.*CATFED(M)) GO TO 92
      TERMN=CATFED(N)*615.+FNMFB(N)*615.+CNMFB(N)-
     1   A(N)*POPR(N)
      IF(TERMN.GT.0.)GO TO 92
      IF (ITER.EQ.1) GO TO 90
      IF (ABS(PCNMFBI-CNMFB(M)).LT..005.AND.ABS(PCNMFBJ-CNMFB(N)).LT.
     1   .005) GO TO 200
90    ITER=ITER+1
      IF (ITER.GT.NITER) GO TO 110
      SUPCB(M)=CNMFB(M)
      SUPCB(N)=CNMFB(N)
      DSUPCBRM=(SUPCB(M)-PCNM(M))/POPR(M)
      DSUPCBRN=(SUPCB(N)-PCNM(N))/POPR(N)
      PCNM(M)=CNMFB(M)
      PCNM(N)=CNMFB(N)
      SUPCBR(M)=SUPCBR(M)+DSUPCBRM
      SUPCBR(N)=SUPCBR(N)+DSUPCBRN
      DPWHM=B(M)*DSUPCBRM
      DPWHN=B(N)*DSUPCBRN
      PWHFBR(N)=PWHFBR(N)+DPWHN
      PWHFBR(M)=PWHFBR(M)+DPWHM
      GO TO 33
92    EIXA(M,N)=0.0
      CANMFB(M,N)=CANMFB(M,N)-BMAXS
      CNMFB(M)=CNMFB(M)+BMAXS
      CNMFB(N)=CNMFB(N)-BMAXS
      IF (ITER.LE.4) WRITE (2,402) CNMFB
402   FORMAT (1X,≠CNMFB≠,1X,9E14.6)
      M=N=0
      AMAXS=-1.E300
      DO 94 I=1,9
      DO 94 J=1,9
      IF (J.EQ.I) GO TO 94
      IF (EIXA(I,J).LE.AMAXS) GO TO 94
      AMAXS=EIXA(I,J)
      M=I
      N=J
94    CONTINUE
      AKON=5000000.
      IF(M.LT.4.OR.M.EQ.5.OR.M.GT.8)GO TO 95
      IF(N.EQ.4.OR.N.GE.6)AKON=40000000.
95    BMAXS=AKON*AMAXS
      GO TO 55
110   WRITE (61,105) ITER,IYEAR
105   FORMAT (≠0 ITERATIONS EXCEED ≠,I4,≠ IN YEAR ≠,I4)
200   WRITE (2,2000)
2000  FORMAT (≠1≠,10X,≠REGIONAL SHIPMENTS CONVERGENCE PROGRAM≠)
      WRITE (2,2001) IYEAR
2001  FORMAT (≠-YEAR ≠,I2)
      WRITE (2,2002)
2002  FORMAT (≠-  I≠,7X,≠SUPCBR(I)≠,5X,≠PWHFBR(I)≠,5X,≠PFDCAT(I)≠/≠0≠)
      WRITE (2,2003) (I,SUPCBR(I),PWHFBR(I),PFDCAT(I),I=1,9)
2003  FORMAT (3X,I1,4X,3E14.6)
      WRITE (2,2004)
2004  FORMAT (≠-FONMFB(I,J)≠)
      WRITE (2,2005) (J,J=1,9)
2005  FORMAT (≠0≠,5X,≠J≠,I11,8I14/≠0≠)
      WRITE (2,2006) (I,(FONMFB(I,J),J=1,9),I=1,9)
2006  FORMAT (3X,I1,4X,9E14.6)
      WRITE (2,2007)
2007  FORMAT(≠-CANMFB(I,J)≠)
      WRITE (2,2005) (J,J=1,9)
      WRITE (2,2006) (I,(CANMFB(I,J),J=1,9),I=1,9)
      GO TO 10
      END
```