# OPTIMUM PATTERNS OF DISTRIBUTION
# FOR FEEDER CATTLE

By

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## PREFACE

The objective of this study was to determine optimum patterns of feeder cattle distribution in the United States. A comparison was made between rail and motor truck methods of transfer of feeder cattle from surplus production regions to alternative feeding regions. Analyses were made using the linear programming technique to solve the transportation problem.

The author wishes to express his appreciation to his major adviser, Dr. John W. Goodwin, for his guidance and assistance throughout this study. Special thanks are also given to Dr. Richard T. Crowder for his assistance with the Fortran IV routine. Recognition of helpful organization of the content of the final draft is given to the other members of the advisory committee, Dr. Vernon Eidman and Dr. Wayne Purcell.

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# CHAPTER I

# INTRODUCTION

Over the past twenty years, cattle feeding in the United States has expanded rapidly. The most rapid growth has been in areas outside the traditional North Central feeding states. Consequently, the market patterns for feeder cattle have changed substantially. As the number of alternative markets increases in the cattle feeding industry, producers of feeder cattle in states having a surplus of feeder animals must continuously assess the changing conditions in order to optimize their marketing patterns. Only through such assessments can they realize maximum profits. Normatively, the question is how much of the product should be shipped to each deficit area (or destination) from each surplus location (or origin) in order for the optimum pattern to be attained. The optimum pattern is that market pattern which minimizes the total cost of transportation for the feeder cattle industry when all demands of deficit regions have been fulfilled from alternative supply regions.

The transportation of stocker-feeder cattle from production areas to feeding areas presents the problem of how to minimize the total cost of transportation in the distribution of quantities shipped. The solution to this problem is especially important to the Western States where beef cattle form an important portion of the livestock sector of the agricultural economy within each state. In 1965 beef cattle and calves accounted for 22.7 percent of the agricultural cash income in the United States. Twenty-one states showed cash income from beef cattle and calves to be greater than one-fifth of their agricultural receipts. Eleven states depended upon beef cattle and calves sales for more than one-third of their agricultural income.[1] In Oklahoma, beef cattle is the number one agricultural commodity. Only Texas had more beef cows in the two-year-old and over category in 1965 than did Oklahoma. With the exception of the Northeastern states, substantial numbers of feeder cattle are produced in all sections of the country, and cattle feeding is commonplace in thirty-two states. Many states produce many more stocker-feeder cattle than they feed for slaughtered fed beef and therefore have a surplus of feeder cattle. Other states feed numbers of cattle in excess of that state's feeder calf production and must depend upon inshipments from other states to satisfy the local feeding demands.

This study is oriented toward the importance of the relative advantages or disadvantages of different feeder cattle producing regions as they market cattle in the various demand regions, with given transportation rates. Truck costs have been estimated for purposes of defining the minimum rates at which a trucker can haul feeder cattle.

## Existing Feeder Cattle Distribution in 1965

The expansion of livestock numbers from 1945-64 was made possible largely through the replacement of animal power on farms by tractor

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[1] U. S. Department of Agriculture, ERS, FIS, Farm Income - State Estimates 1949-1965 (Washington, 1966), pp. 86-127.

power. Beef cattle have been able to replace other forage consuming animals such as sheep, goats, and dairy stock in the relative share of livestock. Beef cattle now account for seventy-five percent of all roughage-consuming animal units in the Western States compared to fifty-five percent during World War II.

The existing patterns of feeder cattle distribution in the United States in 1965 as described by Abel and Capener[2] show the traditional patterns of movement and the recent changes observed. Traditionally, the Corn-Belt area of the North Central Region of the United States fed most of the fattened cattle for slaughter in the large terminal market areas of Sioux City, Iowa; Chicago, Illinois; Kansas City, Missouri; etc.

Feeder cattle were shipped from the large open range grazing areas of Montana, the Dakotas, Wyoming, Kansas, Oklahoma, Texas, and the Rocky Mountains States. With the advent of the local auction market and direct sales from ranch to feedlot, the importance of the large terminal market declined.

Within the last decade, the Western States have increased their feeding capacities tremendously. The large excess supply of feeder cattle which was once available for shipment from the Western States, has declined to the point where the North Central States must depend upon other regions for their supply of feeder cattle. The Southern and Southeastern regions of the United States have increased their supply rapidly over the last ten years and now supply a large portion of the

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[2] Harold Abel and William Capener, Shifts in the Production and Marketing of Western Stocker-Feeder Cattle (Pullman: Washington Agricultural Experiment Station Bulletin 667, 1965).

shipments of feeder cattle into the Northern and Western feeding regions.

Another trend in cattle feeding is the emphasis on larger-sized feedlots. Sixteen states report the number of feedlots by size and number of cattle on hand January 1 each year. There were 56,191 cattle feeders in those sixteen states on January 1, 1965. Two and one-half percent of the feeders in the sixteen states had feedlots with a capacity of more than 1,000 head, but that three percent of the feeders marketed sixty-five percent of the fed cattle in those states.

As the feeder cattle supply area expanded from the Great Plains and Rocky Mountain states to include the South and Southeastern states, the commercial feedlots, especially those in California, Arizona, Nebraska, and Colorado, began feeding many of the light weight mixed breeds or so-called "Okie" cattle from the South and Southeast. The pattern in 1965 was that the higher quality calves from the Great Plains and Mountain states still tended to be shipped into the Midwestern feedlots. But the lower quality feeders from the South and Southeast move West and North to California, Arizona, Colorado, and Nebraska. These feeding areas demand High Good to Choice finished beef, but results of experiments show that finished beef can be produced successfully from the so-called "lower grades" of feeder cattle.[3] It seems entirely possible that more profits can be made from feeding "lower grade" feeder cattle into High Good or Low Choice grade slaughter cattle than from Choice grade feeder cattle because of existing price differentials.

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[3]Ibid., p. 9.

## The Problem

Several studies using spatial equilibrium models have been conducted for the fed-cattle sector of the livestock economy. However, studies of this type emphasizing the stocker-feeder sector are rare. During the 1960's the numbers of slaughter cattle marketed from feedlots increased tremendously throughout the United States. Not all regions enjoyed the same rate of increase in fed-cattle production. The greatest relative increases have occurred in the Southern Plains and in the Western States. The North Central states, encompassing the traditional Corn-Belt production region, continue to produce a large share of the nation's fed beef, but their relative percentage of the total market has decreased within the past five years. The impact of this relative shift in production upon optimal patterns of feeder cattle distribution is of great interest to cattlemen and cattle haulers alike as they strive to minimize the cost of transferring their cattle from producing areas to the feedlots. Further, the development of the Interstate Highway System of roadways has made motor truck transportation of livestock the most frequently used mode of shipping cattle. Therefore, the problem is twofold. First, where should the excess producing areas ship their feeder cattle for purposes of minimizing shipping costs and maximizing profits? Second, what mode of transportation should be utilized?

## The Objectives

The overall objective is concerned with defining the optimal shipping patterns and the changes that occur in those patterns as truck rates change. A secondary objective is to compare the optimal shipping patterns to the patterns of feeder cattle distribution as now established within the cattle feeding industry. Included in the total objective are several intermediate objectives which are:

(1) to define a regional demarcation of the United States for feeder cattle,

(2) to ascertain which feeding regions are deficit with regard to feeder cattle production,

(3) to estimate the numbers of feeder cattle exported from or imported into each region,

(4) to show the differences between railroad rates and motor truck costs of transferring feeder cattle from production regions to alternative feeding regions,

(5) to find the volume and direction of trade between the surplus and deficit feeder cattle regions,

(6) to hypothesize what market patterns should become feasible as motor truck rates change,

(7) to project recent trends in the feeder cattle and cattle feeding industries to 1970 and predict the least-cost patterns of distribution under the conditions expected in 1970.

The discussion of the remainder of this study will be divided into five chapters. Chapter II will be utilized to explain briefly the application of location theory to the problem, the methodology of analyzing the problem, some previous related studies which have been made, the regional breakdown of the United States into eighteen demand and supply regions, and finally an explanation of the transfer cost models used in this study.

Chapter III will be the data chapter which will include a discussion of regional demarcation, motor carrier rates and backhauls, rail rates, cash cost of production and price of feeder cattle variables, production of feeder cattle, and the projection for 1970. The data in Chapters II and III will provide the framework for the analysis of the study.

Chapter IV discusses the results of the analysis of the transportation problem for 1965. Each of the four theoretical models as discussed in Chapter II are analyzed at two different truck rates as rail rates are held constant. The influence of backhauls on the optimum solutions is discussed. The patterns of distribution of feeder cattle in the United States is then analyzed on a regional basis. Finally a cost analysis is made of the optimum solutions of the models for 1965.

Chapter V analyzes the projections for 1970 as were made in Chapter III. The same theoretical models are used as for the 1965 analysis but with the 1970 projected demand and supply quantities of feeder cattle.

Chapter VI will summarize the study. The summary of the data and the results will be followed by the conclusions. Included in the conclusions will be the implications, limitations, and need for further study.

# CHAPTER II

# THEORETICAL CONSIDERATIONS

## Location Theory

There are two sets of economic factors which place society into a spatial framework for which an equilibrium is sought. The first is the deglomeration forces which are synonymous with decentralization as related to more economical production. The second is the inequality of resource endowments among different regions of the country. An implication of the deglomerating forces is the tendency for a production region to decline or increase in relative importance to other regions over a period of time long enough for resource adjustment. In other words, regions which can produce feeder cattle more economically in the long run will tend to cause shifts of production inputs from regions of less productive potential. No two regions are endowed with the same quality of resources for producing a unit of output. Some regions have resources which are better suited for production of feeder cattle while other regions have advantages in feeding cattle. Therefore, some regions will tend to produce a surplus of feeder cattle for the feeding regions which might often be deficit so far as feeder cattle production is concerned.

When differences between regions as caused by the above two economic factors exist, the spatial framework is outlined. There will be regions having a surplus to trade or sell, and other regions will have a deficit supply, because of excess local consumption (or feeding). These regions will need to import or buy the surplus of the other areas. In the dynamic sense, there is also the shift over time as resource owners attempt to maximize profits and as the feedlot firms minimize their costs of inputs per unit of output.

In this study the production and feeding of cattle throughout the United States can be considered in a manner similar to the above discussion. There are regions which can produce feeder cattle more efficiently than others. Some other regions feed cattle in numbers exceeding local supplies. The problem is to define the interregional patterns of trade which will maximize profits for the industry.

If all production and feeding regions were uniform and homogeneous in nature, we would see an approximation of a concentric zonal arrangement existing around the market center in each area.[1] Each region would be separated by some measurement of time and cost distances. Because all production areas differ from one another in their natural resource endowment, it is necessary to relax the assumption of uniformity in order to consider the realities of differentiation in soil, climate, and topography plus a finite number of irregularly placed transport routes.

The relaxation of this assumption causes the concentric market areas to become greatly distorted. Consideration must be given to the location of the production and feeding regions if the transportation problem in the feeder cattle industry is to be fully understood. Isard says that: "Location and trade are as the two sides of the same coin.

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[1]Walter Isard, Location and Space Economy (Boston: The Massachusetts Institute of Technology, 1956), p. 6.

The forces determining one simultaneously determine the other."[2] To properly assess changes which occur in the location of an industry, we must have knowledge of available resources, the position of the industry in the overall economy, topography, environmental characteristics, prices, production costs, and transport costs.

Isard discusses the impact of a shift of location upon the operation of an agricultural enterprise in terms of changes to the net farm prices.[3] Essentially, he states that as the distance between the location of supply and the market decreases, the higher is the net price to the supplier. In this study the location of supply is predetermined; therefore, the discussion will be oriented toward the impact on feeder cattle shipping patterns as new alternative feeding regions shift away from the traditional North Central region.

A brief mathematical formulation of location theory is condensed for the feeder cattle transportation problem below.

The function, V, is for a firm or the total industry to use as it tries to minimize costs or maximize profits.[4]

$$V = -p_1y_1 - p_2y_2 - \dots - p_ky_k - r_am_as_a - r_bm_bs_b$$
$$- \dots - r_\ell m_\ell s_\ell + p_{k+1}\,x_{k+1} + p_{k+2}\,x_{k+2} + \dots$$
$$+ p_n\,x_n,$$

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[2]Ibid.

[3]Ibid., p. 194.

[4]Ibid., pp. 223-224.

where:

| | |
|---|---|
| $p_1, p_2, \ldots p_n$ | are prices of feeder cattle, |
| $r_a, r_b, \ldots r_\ell$ | are transport rates, |
| $m_a, m_b, \ldots m_\ell$ | represent weights of products for shipments, |
| $s_a, s_b, \ldots s_\ell$ | represent distances that the output must move to market, |
| $y_1, y_2, \ldots y_k$ | are inputs other than transport inputs, and |
| $x_{k+1}, x_{k+2}, \ldots x_n$ | represent quantities of inputs. |

Because the location of the supply of feeder cattle and prices of inputs are predetermined, the problem of maximizing profits reduces to a problem of minimizing transport costs,

$$K = r_1m_1s_1 + r_2m_2s_2 + \ldots + r_nm_ns_n.$$

To minimize the transportation costs function, K, a necessary condition is that the first differential equal zero,

$$K = \delta(r_1m_1s_1) + \delta(r_2m_2s_2) + \delta(r_nm_ns_n) = 0$$

or in the case where n=3, then

$$\frac{r_1}{r_2} = - \frac{\delta(m_2s_2)}{\delta(m_1s_1)} ,$$

$$\frac{r_1}{r_3} = - \frac{\delta(m_3s_3)}{\delta(m_1s_1)} ,$$

and

$$\frac{r_2}{r_3} = - \frac{\delta(m_3s_3)}{\delta(m_2s_2)} .$$

In other words, the marginal rate of substitution between any two transport inputs for any two regions, the others held constant, must equal the inverse ratio of the transportation rates from those regions.

When the transportation rate per mile for all regions is fixed at a given level, all rates are equal and, therefore, the ratio of the marginal rates of substitution between all inputs is equal to one for the optimum allocation:

$$\frac{MRS_{m_2 s_2}}{MRS_{m_1 s_1}} = 1.$$

If the ratio of the marginal rates of substitution among regions is not equal to one, then a sub-optimal situation exists. In the case where the ratio of the marginal rate of substitution is greater than one, some region can ship additional quantities of cattle in order to increase profits. Where the ratio of the marginal rate of substitution is less than one, some region should reduce its shipments of cattle in order to minimize costs to the industry.

The transfer of feeder cattle from production to feeding regions involves the problems of how and where to ship feeder cattle from surplus production regions to alternative feeding regions. The next section discusses the theoretical aspects of the transportation model.

## Methodology

The linearly programmed transportation model was the main technique used to analyze the data collected. A short Fortran IV routine was utilized to compute and punch out the input data for the linear program. The use of the Fortran IV routine reduced the time and computation necessary for getting the linear programmed model ready for solution on the IBM 7040 computer.

There are five basic assumptions associated with the transportation model.[5]

1. The product or resources are homogeneous. This means that one unit of feeder cattle from one supply region will satisfy the demand in a deficit region just as well as will one unit of feeder cattle from an alternative source of supply. It is recognized that homogeneity of feeder cattle among all regions in the United States is the ideal rather than the actual situation of existing quality differences among regions. The cattle from the Southern and Southeastern states are reputed to have less feedlot potential than the range cattle from the Northern and Southern Plains' states. However, the several attempts that were made to adjust for regional quality differences for purposes of this study yielded estimates that were too inconsistent and too imprecise for universal acceptance. Since these suspected quality differences among regions cannot be accurately measured and quantified, the alternative assumption of homogeneity among regions was used. It is recognized that the quality differences among regions will cause the true pattern of distribution to differ slightly from the theoretical models.

2. The supplies of resources or products that are available at the various origins and the demands for the various destinations are known; total demand must equal total supply.

3. The cost (or profit) of (or from) converting resources to products or moving the commodity from origins to destinations is known and is independent of the number of units converted or moved.

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[5]Earl O. Heady and Wilfred Candler, Linear Programming Models, The Iowa State University Press (Ames, 1964), pp. 339-340.

4. There is an objective to be maximized or minimized. In this study the objective is to minimize transportation costs and to maximize profits for shipping feeder cattle to market.

5. Transportation from origins to alternative destinations can be carried on only at non-negative levels. This means that a region cannot ship more than it produces or that demand regions will not ship to other demand regions.

The above five assumptions can be also shown in equation form;

$$\sum_{j=1}^{n} \sum_{i=1}^{m} X_{ij} C_{ij} = \text{minimum}$$

Subject to:

$$\sum_{j=1}^{n} X_{ij} = s_i; \ i=1, \ldots, m$$

$$\sum_{i=1}^{m} X_{ij} = d_j; \ j=1, \ldots, n$$

$$\sum_{i=1}^{m} s_j = \sum_{j=1}^{n} d_j$$

and

$$X_{ij} \geq 0 \text{ for all } i, j.$$

Where:

$X_{ij}$ represents the number of feeder cattle shipped from the $i^{th}$ surplus region to the $j^{th}$ deficit region;

$s_i$ represents the number of feeder cattle available for export from the $i^{th}$ surplus region;

$d_j$ is the number of feeder cattle demanded in the $j^{th}$ deficit region; and

$C_{ij}$ is the cost of shipping from the $i^{th}$ surplus to the $j^{th}$ deficit region.

The transportation model has been used by other authors to solve spatial equilibrium problems of the beef sector of the economy. A brief reference is made to a few such studies in the following section.

## Previous Studies

A number of spatial equilibrium studies have been conducted on the livestock economy in the United States which were mainly concerned with the optimum solution for the fed beef sector. Many states have studied the transportation of cattle within their state boundaries or shipments to nearby points in adjacent states. King and Schrader[6] made a study of the regional location of cattle feeding which was published in 1963, but their results are concerned more with the feedlot-to-consumer than with the producer-to-feedlot transfer activities. Their method for estimation of state potential feeder cattle production is similar to the one used in this study. Dietrich[7] and Malone[8] both conducted analyses of the fed beef economy in the United States. Buchholz and Judge include some discussion of feeder cattle shipping patterns in the United States in their study: An Interregional Analysis of the Fed-Livestock

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[6] G. A. King and L. F. Schrader, "Regional Location of Cattle Feeding - A Spatial Equilibrium Analysis," Hilgardia, Vol. 34, Number 10 (Davis: California Agricultural Experiment Station, 1963).

[7] Raymond A. Dietrich, An Interregional Analysis of the Fed Beef Economy, Unpublished Ph.D. Thesis (Stillwater: Oklahoma State University, 1965).

[8] John W. Malone, A Spatial Equilibrium Analysis of the Fed Beef Economy, Unpublished Ph.D. Thesis (Stillwater: Oklahoma State University, 1963).

Economy published in 1965.[9] They criticize the method used by Trock[10] to estimate feeder cattle supply in his study on cattle feeding in the Northern Great Plains published in 1963. Trock computed his estimate of feeder cattle supply by starting with the number of calves born in each state, then deducted losses and calves used for purposes other than feeding. He deducted commercial calf slaughter which does not show the state of origin of the commercially slaughtered calves and therefore in many states causes a negative estimate of feeder cattle supply.

In this study, the entire United States is considered for potential feeder cattle production and feeding. The potential numbers of feeder cattle which are expected to contribute the greatest share to the beef transportation problem will be emphasized. Therefore, the discussion in the following section eliminates most of the cattle which are not considered to contribute materially to the feeder cattle distribution problem.

## Demand and Supply Areas

The terms "supply" and "demand" which will be used throughout the discussion of this study, should really be thought of as the "quantity supplied" and "quantity demanded" in the proper economic sense. But it is commonly accepted in practice to simply use "supply" and "demand" in the discussion of the transportation model. Therefore, wherever "supply" and "demand" are used, it shall be implied that the discussion

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[9] H. E. Buchholz and G. G. Judge, An Interregional Analysis of the Fed-Livestock Economy, Illinois Agricultural Experiment Station cerr 75 (Urbana, 1965), p. 14.

[10] Warren L. Trock, Cattle Feeding in the Northern Great Plains, Montana Agricultural Experiment Station Bulletin 576 (Bozeman, 1963), p. 9.

is of particular quantities rather than a complete schedule of prices and quantities supplied and demanded.

Demand Areas

Demand is represented by the total number of fed cattle marketed in the year "n+1". Feeder cattle were demanded in the year "n" to be placed on feed during that year, and then marketed as fat cattle the following year.

It is assumed that each region supplies its own demand before it will supply the demand in any other region. If a region cannot supply enough feeder cattle to satisfy its own demand, then the region shall be referred to as a deficit supply area or a demand region. A region which has a surplus of feeder cattle above local feeding requirements will ship that surplus to deficit supply areas for which it has the greatest advantage or least disadvantage in shipping cost, relative to other surplus regions.

Supply Areas

The supply in this problem is represented by an estimated figure of the potential number of feeder cattle which each region - under current feeding practices and technology - would have available for meeting the feeder cattle requirements in the demand regions. Although the quality of feeder cattle available in some areas of the country is alleged to be somewhat inferior to those available in other areas, it is assumed that the product is homogeneous.

The potential supply of feeder cattle was computed in the following manner. First, it was assumed that all "other" cows two years of age and over, as reported in the January 1 inventory report,[11] supplied the calves for beef feeding. It was further assumed that all commercial calf slaughter was of dairy cow origin because many of the dairy states exhibit high calf slaughter numbers. This assumption about calf slaughter alleviates the criticism made by Buchholz and Judge:

> Trock started from the number of calves born and deducted losses and calves needed for other purposes than feeding. This estimate suffers from use of calf slaughter data, which show regional slaughter of calves irrespective of origin. With this procedure, regions having heavy slaughter of calves that are not produced in the region turn out to have negative feeder cattle supplies.[12]

A state-by-state estimate was then made by multiplying the number of two-year-old-and-over other cows by the percent calving rate for all cows in each state in 1964. This produced a raw figure which had to be corrected to give a more realistic supply of feeder cattle in 1965. The death loss of calves as reported by the United States Department of Agriculture was deducted, an allowance for herd bull replacements, and then replacement heifers were considered at a rate of twenty percent of two-year-old-and-over other cows.

The second basic assumption of the general transportation model, which requires the total demand to equal the total supply, cannot always be found to exist for a given time period. An inequality of total demand and supply can easily be handled with a small modification to the transportation model. Through the use of a dummy variable for either demand or supply, the equality condition is restored to the

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[11] U. S. Department of Agriculture, AMS, Livestock and Poultry Inventory, January 1 - Number, Value, and Classes by States (Washington, various issues).

[12] Buchholz and Judge, p. 14.

problem. The dummy variable is a very useful device to handle imperfections of estimates or available market data. If the total demand exceeds the total supply, a dummy supply variable will ship to any deficit region when all other supply is used up but there remains some unfulfilled demand. A high cost is associated with the use of the dummy supply so that the least profitable demand areas will be forced to use the higher cost supply. In a similar manner, a dummy demand variable is used when the total supply exceeds the total demand. Unlike the dummy supply variable cost, the dummy demand has a zero cost associated with it. This simply means that once all real demand is satisfied, the excess supply is not shipped and thus adds no additional cost to the transportation solution. If the transportation problem is solved by linear programming techniques, then the slack or disposal variable replaces the dummy demand variable, but the dummy supply variable must be inserted in the linear programming problem if all demand is to be satisfied.

For this study, the continental United States is divided into eighteen regions. Each region represents a geographical area somewhat homogeneous in its production and feeding capabilities and practices. Additional criteria considered for the regional demarcation included: (1) the natural barriers to transportation such as the Rocky Mountains, (2) the availability of data - in this case by whole states, and (3) the shipping distances. The smallest region by political breakdown is a single state, but most of the regions encompass an aggregation of two or more contiguous states. Figure 1 depicts the regional breakdown which was used for this study.

Where all of the above criteria could not be met for every region,

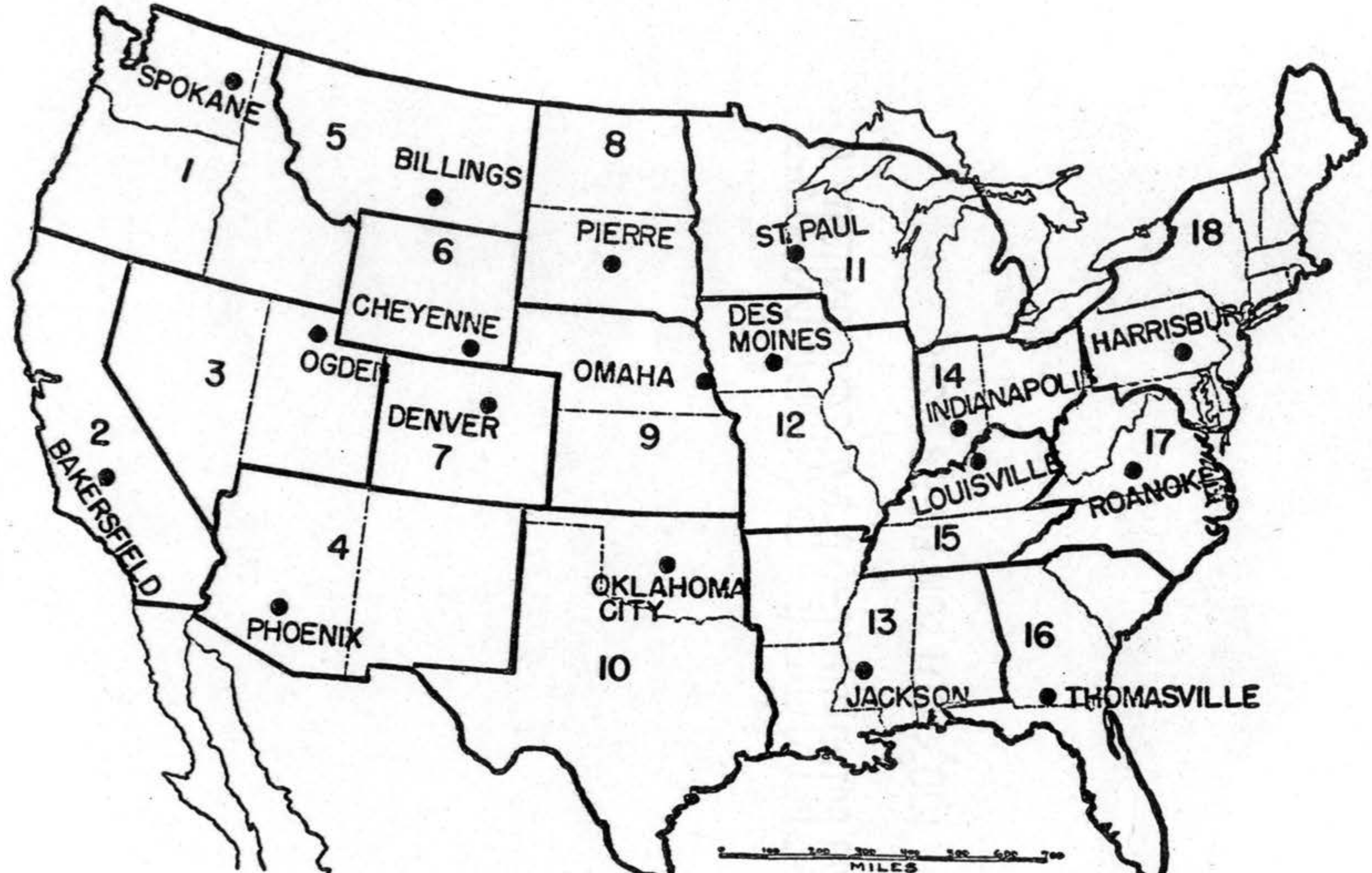


Figure 1. Regional Demarcation of the United States.

a compromise was made among the dominant criteria affecting the particular region. It was also necessary to select a set of shipping points for each region. Ideally, the point should be near the center of the region's production or feeding area. Here it is assumed that the production units or feedlots are uniformly distributed about the representative point of each region. Table I gives the detailed demarcation of states with the respective regional central shipping points.

Pure competition is assumed to dictate the requirements for regional patterns of prices and flows of feeder cattle. Profit maximization is assumed; therefore, each firm shall makes its decisions in such a manner as to get the greatest per unit net return. The differences between supply of feeder cattle and demand for feeder cattle within each region are computed in such a manner that each region is considered either as a surplus or deficit area for feeder cattle. It is assumed that there is no outside interference from governmental or other sources to hamper patterns of feeder cattle shipment. The product is considered to be homogeneous in nature such that the destinations or demand areas are indifferent to their source of supply. For the allocation of shipments in this problem, the impact of imports and exports of feeder cattle outside the continental United States is considered to be negligible.

With the method of determining demand and supply quantities of feeder cattle given, the next step is to show how the transportation costs between regions is computed. The transfer cost models in the next section show how this is done.

TABLE I

REGIONAL DEMARCATION AND CENTRAL SHIPPING POINTS

| Region | States | Shipping Center |
|---|---|---|
| 1 | Idaho, Oregon, Washington | Spokane, Washington |
| 2 | California | Bakersfield, California |
| 3 | Nevada, Utah | Ogden, Utah |
| 4 | Arizona, New Mexico | Phoenix, Arizona |
| 5 | Montana | Billings, Montana |
| 6 | Wyoming | Cheyenne, Wyoming |
| 7 | Colorado | Denver, Colorado |
| 8 | North Dakota, South Dakota | Pierre, South Dakota |
| 9 | Kansas, Nebraska | Omaha, Nebraska |
| 10 | Oklahoma, Texas | Oklahoma City, Oklahoma |
| 11 | Michigan, Minnesota, Wisconsin | St. Paul, Minnesota |
| 12 | Illinois, Iowa, Missouri | Des Moines, Iowa |
| 13 | Alabama, Arkansas, Louisiana, Mississippi | Jackson, Mississippi |
| 14 | Indiana, Ohio | Indianapolis, Indiana |
| 15 | Kentucky, Tennessee | Louisville, Kentucky |
| 16 | Florida, Georgia, South Carolina | Thomasville, Georgia |
| 17 | North Carolina, West Virginia, Virginia | Roanoke, Virginia |
| 18 | Conn., Maine, Maryland, Mass., New Hampshire, New YOrk, New Jersey, Pennsylvania, Rhode Island, Vermont, Delaware | Harrisburg, Pennsylvania |

Transfer Cost Models

If realistic predictions of shipment patterns which should exist in the competitive feeder cattle market are to be made, the total cost of transfer must be included in any analysis of transportation costs. It is necessary to consider the transportation charges for hauling feeder cattle from a surplus region to alternative deficit regions. However, there are other variables that might be expected to affect the deviations from the optimum pattern of feeder cattle distribution. These variables can be utilized in the computation of transfer costs. The price paid for feeder cattle at the point of origin is considered to be important because it represents the cost of an input for the demand region. If two supply points were equidistant from a demand point, but the price of feeder cattle was higher at one supply point than the other, then the lower-priced supply point would have an advantage in shipping feeder cattle to the demand point in question.

The cash cost of production is a second transfer cost variable used in this study. Some regions of the country have certain advantages in the ability or facilities for efficient feeder cattle production when compared with other regions. Economies of size and small winter hay requirements are two factors which cause differences in cash cost of production might be expected to have an advantage over another region which was relatively the same distance from a specified demand point but had a higher cash cost of production.

The third transfer cost variable, and probably the most important, is the enroute cost of shipping feeder cattle from the supply regions to demand regions. Where a supply region will ship its surplus feeder cattle depends to a large extent upon the distance to the demand region.

Small differences in the price or cash cost of production cannot offset the shipping cost when differences in distances from supply to demand regions amount to several hundred miles. Not only is the hauling cost substantially different, but the added time required for longer distances means additional expense for shrinkage losses, and in many cases, longer return trips without a payload.

The three transportation cost (or transfer comparability) variables can easily be incorporated into the transportation model. One can analyze the transportation cost by using one, two or all three of the variables. To use the price and cash cost of production, simply choose one shipping center as a base and set it's price and/or cash costs equal to zero. Then compute the price and cash cost for every other region as the deviation from the price and cash cost in the base region. The total transfer cost for each alternative shipping route for each supply region would be the summation of the variable costs considered in each region.

Therefore, this study incorporates four transfer cost models to depict the impact of each cost variable separately and then together to predict the different patterns of distribution under the different transfer cost assumptions.

Model I. Model I simultaneously considered all three variables which would be expected to affect the profitability of transferring feeder cattle from surplus to deficit regions. In this model, the analysis of optimum distribution patterns included the price, the cash cost of production, and the rate for hauling the cattle between alternative supply and demand regions.

Model II. Model II considered only the price for feeder cattle plus the transportation charges between supply and demand regions.

Model III. Model III considered the cash cost of production for feeder cattle plus the transportation charges between supply and demand regions.

Model IV. Model IV analyzed the optimum pattern for distribution when just the transportation charges between surplus and deficit regions were considered.

Each of the four models has been used to analyze optimum patterns of shipment given the 1965 distributions of feeder cattle production and cattle feeding. In addition, these models have been used to estimate optimal patterns for the expected 1970 distributions of feeder production and cattle feeding. The differences in these two sets of optima should give some indication of the areas which might be expected to have competitive strength or weakness for future marketing of feeder cattle.

This chapter has defined the framework for the study. Chapter III contains the data which are needed to fulfill objectives (2), (3), and (4) as stated in Chapter I.

# CHAPTER III

## THE DATA

The numerical data were programmed for computer analysis by using a cost-minimization technique for linear programming to solve the transportation problem. Because railroads represent feasible competition with the motor truck cattle haulers, the simultaneous solutions for truck and railroad movements were considered very realistic situations for the livestock industry. The discussion begins with an analysis of the data used.

The reported number of cattle on feed marketed in 1965, which represented the demand for feeder cattle during 1965, was 17,593,000 head. Fed cattle marketings during 1965 represented an increase of thirty-six percent over the number marketed in 1960 (see Table II). The estimated number of feeder cattle potentially available for feeding in 1965 was 17,978,543 head - an increase of 24.9 percent over the numbers of feeder cattle potentially available in 1960 (see Table III). The relatively larger increase in the numbers of cattle demanded for feeding, compared with the percentage increase in the supply of feeders over the same period, is easily explained. Consumers have required progressively higher average grades of beef at the retail level. Fed beef tends to be much more uniform in quality than does non-fed beef. Cattle feeding has also helped to stabilize the supply and the sources

TABLE II

ESTIMATED DEMAND FOR FEEDER CATTLE BY REGIONS, 1960-65

| Region | 1960 (1,000 head) | 1961 (1,000 head) | 1962 (1,000 head) | 1963 (1,000 head) | 1964 (1,000 head) | 1965 (1,000 head) |
|---|---|---|---|---|---|---|
| 1. Spokane | 568 | 612 | 627 | 636 | 688 | 745 |
| 2. Bakersfield | 1595 | 1699 | 1844 | 1899 | 2061 | 2282 |
| 3. Ogden | 162 | 146 | 142 | 148 | 171 | 175 |
| 4. Phoenix | 581 | 613 | 697 | 753 | 766 | 823 |
| 5. Billings | 115 | 113 | 100 | 98 | 128 | 141 |
| 6. Cheyenne | 82 | 74 | 72 | 64 | 59 | 62 |
| 7. Denver | 747 | 790 | 815 | 900 | 951 | 1144 |
| 8. Pierre | 540 | 705 | 621 | 639 | 812 | 752 |
| 9. Omaha | 1950 | 2284 | 2365 | 2640 | 3122 | 3073 |
| 10. Oklahoma-Texas | 620 | 711 | 942 | 1114 | 1241 | 1394 |
| 11. St. Paul | 952 | 977 | 962 | 987 | 1076 | 1045 |
| 12. Des Moines | 4250 | 4291 | 4267 | 4522 | 4717 | 4649 |
| 13. Jackson | -- | 10 | 64 | 58 | 101 | 135 |
| 14. Indianapolis | 580 | 587 | 580 | 612 | 657 | 631 |
| 15. Louisville | -- | -- | -- | -- | 155 | 141 |
| 16. Thomasville | -- | 20 | 121 | 95 | 246 | 285 |
| 17. Roanoke | -- | -- | -- | -- | -- | -- |
| 18. Harrisburg | 146 | 141 | 142 | 124 | 123 | 116 |
| Total | 12888 | 13773 | 14361 | 15289 | 17074 | 17593 |

TABLE III

POTENTIAL FEEDER CATTLE SUPPLY BY REGIONS, 1960-65

| Region | 1960 (1,000 head) | 1961 (1,000 head) | 1962 (1,000 head) | 1963 (1,000 head) | 1964 (1,000 head) | 1965 (1,000 head) |
|---|---|---|---|---|---|---|
| 1. Spokane | 701 | 732 | 772 | 815 | 852 | 864 |
| 2. Bakersfield | 524 | 527 | 516 | 536 | 534 | 559 |
| 3. Ogden | 335 | 297 | 292 | 306 | 311 | 295 |
| 4. Phoenix | 588 | 520 | 542 | 576 | 589 | 576 |
| 5. Billings | 718 | 713 | 740 | 741 | 804 | 800 |
| 6. Cheyenne | 319 | 338 | 341 | 347 | 374 | 351 |
| 7. Denver | 459 | 481 | 492 | 522 | 549 | 536 |
| 8. Pierre | 1230 | 1246 | 1314 | 1347 | 1442 | 1500 |
| 9. Omaha | 1631 | 1701 | 1801 | 1917 | 2045 | 2081 |
| 10. Oklahoma-Texas | 2742 | 3289 | 3392 | 3638 | 3825 | 3741 |
| 11. St. Paul | 243 | 351 | 367 | 383 | 417 | 435 |
| 12. Des Moines | 1540 | 1749 | 1813 | 1863 | 1975 | 2013 |
| 13. Jackson | 1627 | 1505 | 1528 | 1572 | 1642 | 1639 |
| 14. Indianapolis | 304 | 356 | 366 | 372 | 382 | 378 |
| 15. Louisville | 187 | 606 | 673 | 744 | 819 | 847 |
| 16. Thomasville | 801 | 652 | 678 | 749 | 800 | 798 |
| 17. Roanoke | 326 | 402 | 417 | 447 | 465 | 445 |
| 18. Harrisburg | 120 | 120 | 114 | 128 | 125 | 120 |
| Total | 14275 | 15585 | 16158 | 17003 | 17950 | 17978 |

of beef for meat packers and chain food stores. More than half of all slaughtered beef in 1965 was fed beef. The remaining portion of slaughtered beef (or non-fed beef) was comprised of cull cows, cull bulls, and dairy cows. Grass-fat or range beef is a very small and declining portion of the beef industry.

## Demarcation of Regions

As was indicated in the previous chapter, the United States was divided into eighteen regions for this study. Each of the eighteen regions had regional supply and demand for feeder cattle (with the exception of Region 17 for which there was no available information concerning demand). The differences between the supply and demand were computed within each region, showing that seven of the regions had a local supply of feeder cattle insufficient for their feeding needs. That is, these regions were feeding more cattle than were produced within their individual regions. These regions are said to have a "deficit" supply of feeder cattle and thus are referred to as "destination" or "demand" regions. The remaining eleven regions - while they did not report feeding activity within their regions (except Region 17) - produced a potential supply of feeder cattle in excess of what was being fed within their regions in 1965. These latter regions are said to have a surplus of feeder cattle over local feeding requirements and often are referred to as "supply" or "origin" regions. The objective of the transportation model is to fulfill all demand from the surplus production areas in such a manner as to minimize the cost of distribution of the feeder cattle among alternative regions. Table IV gives the estimated potential regional supply and demand and the net differences

TABLE IV

ESTIMATED REGIONAL POTENTIAL SUPPLY AND DEMAND
FOR FEEDER CATTLE, 1965

| Region | Estimated Potential Supply (1,000 head) | Estimated Demand (1,000 head) | Net Supply (+) or Demand (-) (1,000 head) |
|---|---|---|---|
| 1. Spokane | 864 | 745 | 119 |
| 2. Bakersfield | 559 | 2282 | -1723 |
| 3. Ogden | 295 | 175 | 120 |
| 4. Phoenix | 576 | 823 | -247 |
| 5. Billings | 800 | 141 | 659 |
| 6. Cheyenne | 351 | 62 | 289 |
| 7. Denver | 536 | 1144 | -608 |
| 8. Pierre | 1500 | 752 | 748 |
| 9. Omaha | 2081 | 3073 | -992 |
| 10. Oklahoma City | 3741 | 1394 | 2347 |
| 11. St. Paul | 435 | 1045 | -610 |
| 12. Des Moines | 2013 | 4649 | -2636 |
| 13. Jackson | 1643 | 135 | 1508 |
| 14. Indianapolis | 378 | 631 | -253 |
| 15. Louisville | 847 | 141 | 706 |
| 16. Thomasville | 798 | 285 | 513 |
| 17. Roanoke | 445 | 0 | 445 |
| 18. Harrisburg | 120 | 116 | 4 |

within each region for feeder cattle in 1965. Figure 2 shows the geographical distribution of supply and demand regions in 1965 after aggregating the total supply and demand for feeder cattle within each region.

## Motor Carrier Rates and Backhauls

A limited number of cattle haulers were interviewed in several locations across Oklahoma to gather data on current costs of operation and rates charged for cattle transportation in intrastate and interstate shipment of feeder cattle.

The most common type of long haul rig used by cattle haulers in Oklahoma is the drop-center (or "possum-belly") semi-trailer with diesel tractor power. On short hauls, both the open-top semi-trailer and the "bob-tail" truck types are utilized. But by far the bulk of long-haul motor carrier transportation of Oklahoma cattle is done by tractor possum-belly semi-trailer combination.

Most of the cattle haulers interviewed in Oklahoma indicated that they were averaging in excess of 100,000 miles per truck annually. This large annual mileage greatly reduces the per mile cost for depreciation, federal use tax, licenses, insurance, adminstrative help, and capital investment.

The majority of the truckers have some type of garage facilities to take care of minor maintenance work on their trucks. None had facilities to conduct major overhauls and a few had all maintenance work done by someone else. The general case would be some type of facility in which to perform services such as tire changing, grease and oil change, and cleaning.

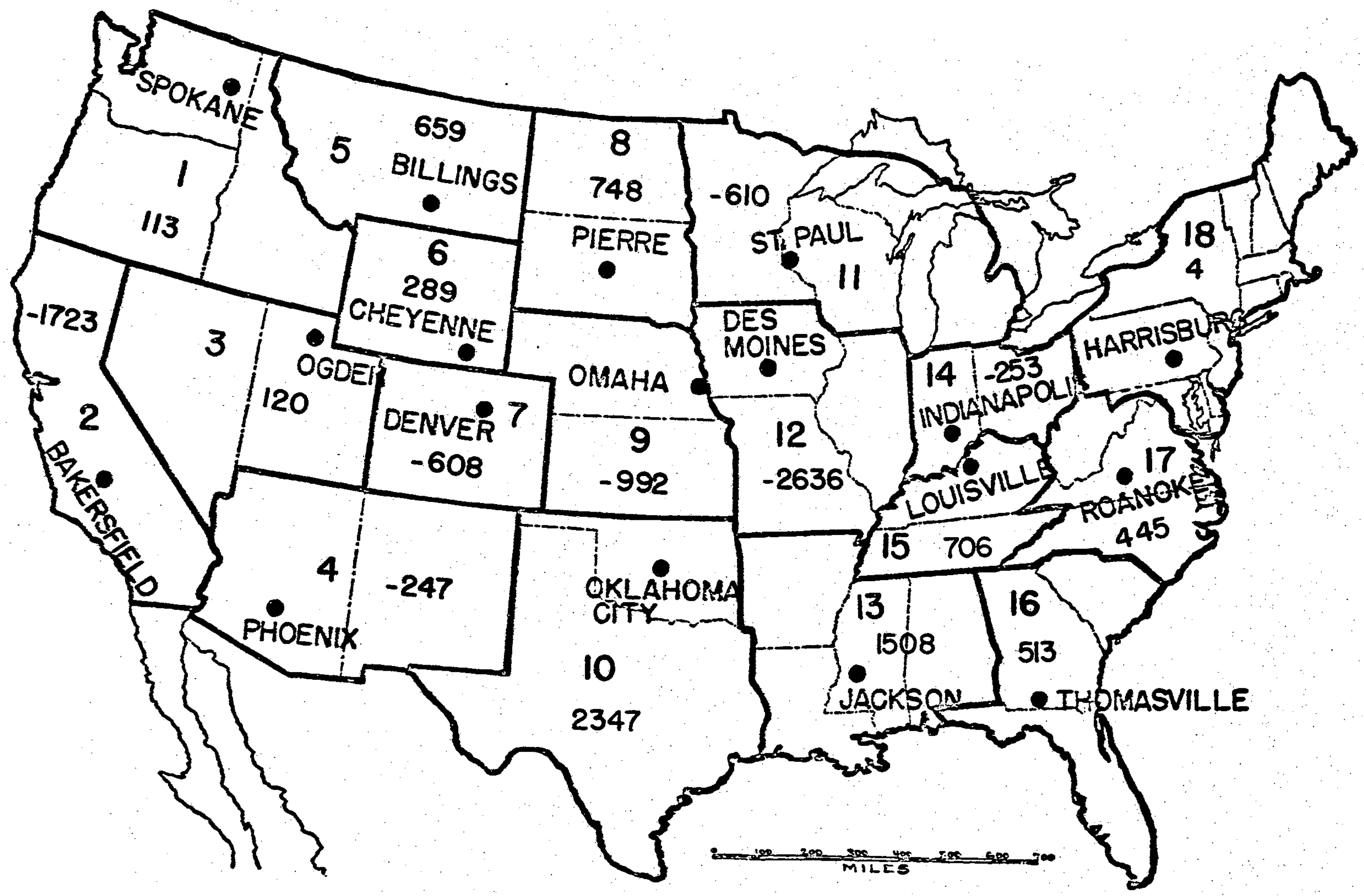


Figure 2. Regional Net Inmovement and Net Outmovement of Feeder Cattle, 1965 (1000 head).

The variable which most influences the market distribution of product shipments is the cost of transportation. Although the rate per mile may decrease as mileage increases, the total cost of transfer continues to increase as distances between the markets increase. In this study, only the interstate and/or interregional movements of feeder cattle are considered. Intrastate transportation rates for motor trucks are set up by each state, but these rates vary from state to state. Further, not all carriers within a state are bound to these rates. The problem examined in this study is not one of optimizing shipping patterns within individual states. It would be impossible to assemble the rates each state has for intrastate hauls and try to compute the transportation costs from all the different mileages and rates. The end result would be applicable to only a very specified route of travel. For these reasons, an average rate which is currently received by the truckers was used as a basis for computation of transfer costs. Most cattle haulers are private carriers[1] rather than common or contract carriers. These private truckers are hauling the class "B" commodities and are largely exempt from most Interstate Commerce Commission regulations.[2] Therefore, they are not strictly held to a fixed set of rates for services rendered. The fixed rates are used merely as a guide for these cattle haulers, and for the most part are not strictly observed. The overwhelming majority of long distance cattle haulers surveyed

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[1]T. Q. Hutchinson, Private Motor Carriers of Exempt Agricultural Commodities, (Washington: MED, ERS, USDA, Marketing Research Report No. 696, 1965), p. 25.

[2]Mildred R. DeWolfe, For-Hired Motor Carriers Hauling Exempt Agricultural Commodities...Nature and Extent of Commodities, (Washington MED, ERS, USDA, Marketing Research Report No. 585, 1963), p. 17.

specified a per mile rate of sixty cents one-way for distances in excess of three hundred miles in length. Therefore, sixty cents per mile, one-way, has been used as the beginning point for this analysis.

There is considerable capital invested in a complete tractor-semi-trailer unit; therefore, the more time the unit is loaded with cattle the less is the fixed cost per mile of travel. Many times the truck is loaded one way with an empty truck returning to the original starting point. Backhauls are desirable, but unfortunately are irregular, inconvenient, or seasonal in nature for many of the truckers. A small operator usually does not have the necessary contacts at most points of destination to insure regular backhauls. The cattle semi-trailer cannot be converted for effective use in any activity other than hauling livestock. Therefore, the trucker is very limited in the ways in which he can supplement his revenue in terms of backhauls. Baled hay or straw could be hauled with a minimum of cleaning effort but the returns are below that for hauling livestock. Therefore, the trucker will generally backhaul livestock if at all possible.

Because backhauls have a definite effect on the competitive position of motor truck versus railroad, and because the carriers interviewed indicated that backhauls were available on about one-third of the cases, a backhaul frequency of one-third was assumed. Without any backhauls the trucker would get sixty cents for each mile, one-way. If he were able to get backhauls one-third of the time, he could charge a one-way rate of forty-six cents per mile, and still earn the same per mile income as with the sixty cent rate without backhauls. Thus, the forty-six cents rate per mile was an alternative motor truck rate for which optimum solutions were computed.

A field survey was conducted for purposes of estimating the per mile cost of operating a possum belly-trailer combination headquartered in the Oklahoma area. The results of interviews with cattle haulers across Oklahoma, with two major manufacturers of tractors, and with three trailer manufacturers are shown in Table V. These cost estimates were for diesel trucks running an average of 100,000 miles per year. Information on operating costs of smaller trucks and for trucks traveling less annual mileage may be found in the appropriate references in the bibliography. Since this study is concerned with interstate and interregional movements, the cost estimates for trucks operating under conditions similar to the data in Table V are considered to be the most relevant.

It is apparent that a per-mile operating cost of $.291 for operating the truck and semi-trailer does not leave much room for profits to be earned from a $.60 per mile one-way rate if the trucker does not have access to backhauls. The availability of backhauls is an important consideration in establishing truck rates. From all indications of available data, transportation of livestock by motor truck is the most commonly used method of transport.[3] Therefore, shippers must have an increasing dependence upon truckers and the truck operators must feel that it is profitable to haul cattle or they would not continue to do so over a long period of time. Some of the cattle haulers who were interviewed in Oklahoma indicated very little backhaul traffic existed for their operation. Other truckers said they had backhauls part of the time, a few said backhauls were available only in

[3]See Table VI.

TABLE V

OPERATING COST PER MILE FOR MOTOR TRUCKS

| | Cost/Mile (cents) |
|---|---|
| **Tractor:** | |
| Maintenance and Repairs | .030 |
| Fuel (plus fuel use tax - $.055/gal.) | .051 |
| Depreciation | .022 |
| Tires | .010 |
| Wash and Lube | .003 |
| Interest | .004 |
| Substitute tractor ("down time") | .004 |
| | .124 |
| **Trailer:** | |
| Maintenance and Repairs | .005 |
| Depreciation | .015 |
| Tires | .008 |
| Wash and Lube | .003 |
| Interest | .002 |
| | .033 |
| **Fixed Unit Costs:** | |
| Driver | .080 |
| License | .007 |
| Federal Use Tax | .002 |
| Insurance | |
| Public Liability and Property Damage | .010 |
| Collision and Comprehensive | .008 |
| Cargo (2 1/2% of load value) | .002 |
| Workman's compensation (6.5% of income) | .005 |
| Other overhead - office, etc. | .020 |
| | .134 |
| Total Cost Per Mile | .291 |

TABLE VI

METHOD OF TRANSPORTING WESTERN BEEF CATTLE
TWELVE WESTERN STATES, 1962[a]

| State | Truck (Percent) | Rail (Percent) |
|---|---|---|
| Arizona | 91.0 | 9.0 |
| California | 73.0[a] | 27.0[a] |
| Colorado | NA | NA |
| Idaho | NA | NA |
| Montana | 65.0 | 35.0 |
| Nevada | 88.0 | 12.0 |
| New Mexico | 61.0 | 39.0 |
| Oregon | NA | NA |
| Utah | 72.0 | 28.0 |
| Washington | 95.0[b] | 5.0[b] |
| Wyoming | 93.0 | 7.0 |
| Texas | 72.0 | 28.0 |
| Total 12 Western States | 74.3[c] | 25.7[c] |

[a]Inshipments only.

[b]Estimate

[c]Weighted by state marketings of cattle and calves, 1961

Source: Records of State Brand Inspectors, State Statisticians (SRS) and Special surveys by state experiment station workers.

certain seasons. One interstate operator who had eight units in operation reported that he had backhauls two-thirds of the time. This operator hauled about the same number of miles as the other seven surveyed. Thus, approximately one-sixth of the total miles driven were backhaul mileage (i. e., one-third of the backhaul mileage represented "load" mileage).

For the purpose of realistically describing the shift from railroad to truck transportation of feeder cattle for all hauls except the really long hauls, and to estimate the impact of backhauls one-third of the time, the rate charged by truckers was decreased from $.60 per loaded mile to $.46 per loaded mile. This reduction in rate recognizes that independent truckers will - when the possibility of backhauls exist - cut rates substantially in order to compete with other carriers for the available freight.

It also is appropriate to consider trucks to be fully loaded for long distance hauls. The forty-foot possum belly semi-trailer has the equivalent of a sixty-foot single deck trailer. An average weight of five hundred pounds per animal is assumed for all feeder cattle. Thus, sixty-five head will constitute a full load.

## Rail Rates

Although motor truck transportation accounts for most of the intrastate movement of cattle in most states today, railroads still compete for the longer haul destinations. Actual point-to-point rates were obtained for shipments of cattle by rail.[4] The standard for comparing

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[4]Railroad charges were furnished by Lowell Waitman, General Livestock Agent, the Atchison, Topeka and Santa Fe Railway Company, Wichita, Kansas.

railway charges with motor truck rates was a forty-foot by eight foot boxcar with a capacity for fifty head of five-hundred-pound feeder cattle. The rail rates which were used for this study are given in Appendix A.

### Cash Cost of Production and Price of Feeder Cattle Variables

A second variable considered to affect the pattern of regional shipments was the price of the feeder animal. The prices for Good 500-800 pound feeder steers were determined from price data available for markets in each region. The Good grade price was used because price data for Choice grade feeder steers were not available for all regions. Good and Choice prices were not averaged since the averaged price would necessarily be weighted according to the number of Good and Choice cattle in any particular region. In order for valid interregional comparisons to be made, it would be necessary to weight data for each region according to the predominance of Choice or Good feeder cattle. The price used for each region was a nine-year average for 1956-64, which is approximately from trough to trough on the cycle of cattle prices. The price at Oklahoma City was defined as the base price. The prices for other regions were computed in terms of the differential from the price of feeder cattle in Oklahoma City (Table VII). Theoretically, the difference in the price differential between market points should approximate the transportation cost. This means that the further an area is from the terminal market, the lower the price must be in the shipping region to allow for the increased transportation cost. If this condition does not exist for two sales points, then either these

TABLE VII

REGIONAL PRICE AND CASH COST OF PRODUCTION ESTIMATES, 1965

| Region | Price/cwt. (Ave. 1956-64) | Price Dif. | Cash Cost/cwt. | Cash Cost Dif. |
|---|---|---|---|---|
| 1 | $21.80 | $-.60 | $23.70 | $11.66 |
| 2 | 22.37 | -.03 | 24.31 | 12.27 |
| 3 | 21.68 | -.72 | 14.95 | 2.91 |
| 4 | 21.95 | -.45 | 9.32 | -2.72 |
| 5 | 22.65 | .25 | 9.39 | -2.65 |
| 6 | 21.76 | -.64 | 13.62 | 1.58 |
| 7 | 22.37 | -.03 | 13.62 | 1.58 |
| 8 | 22.80 | .40 | 12.10 | .06 |
| 9 | 23.06 | .66 | 16.95 | 4.91 |
| 10 | 22.40 | 0 | 12.04 | 0 |
| 11 | 22.75 | .35 | 16.95 | 4.91 |
| 12 | 23.32 | .92 | 16.95 | 4.91 |
| 13 | 21.50 | -.90 | 17.09 | 5.05 |
| 14 | 21.67 | -.73 | 21.13 | 9.09 |
| 15 | 21.58 | -.82 | 21.13 | 9.09 |
| 16 | 21.13 | -1.27 | 17.09 | 5.05 |
| 17 | 23.43[a] | 1.03 | 19.10 | 7.06 |
| 18 | 23.43[a] | 1.03 | 21.13 | 9.09 |

[a]Estimated

sales points are not in the same market area or there are other factors compensating for the transportation cost that are not included in the price differential.

A third variable potentially affecting the competitive position of each region was the cash cost per hundred pounds of feeder animal produced. Most states or regions have published bulletins and fact sheets estimating production costs for producing feeder cattle in areas of each state or region.[5] The cash cost is the most relevant comparative index of interregional production efficiency and comparative advantage for feeder cattle production. To compute the cash cost of production, the following procedure was used. First, all annual inputs of expenditures were determined for a hundred-cow production unit. These annual inputs included: native range, improved pasture, hay, feed supplement, minerals, veterinarian and medicine, bull depreciation, hauling and marketing cost, miscellaneous costs, interest, repairs and depreciation, taxes, and insurance. Second, the value of the sale of cull cows was subtracted from the annual input expense. Third, the number of pounds of feeder cattle produced for sale was determined. Fourth, the annual input cost minus the value of cull cows was divided by the total pounds of feeder cattle to get the cash cost per pound of feeder animal. The cost of land was not considered because that cost often includes other factors such as mineral rights which have little to do with the agricultural productivity of that land. Where hay must be fed part of the year to the cattle, the cash cost usually will be above that of regions which require little or no hay or feed supplement. Again

[5]A detailed list of the references used is given in the bibliography.

Oklahoma City was defined as the base point and the cash costs of production in other regions were computed as differentials from the cash cost in the region represented by Oklahoma City. Table VII gives the cash cost of production for each region. Figure 3 shows the specific areas of each region for which the cash cost of production was computed. The cost of the specific areas within each region are used to represent the cash cost of the entire region.

## Production of Feeder Cattle

Feeder cattle are produced throughout the United States but the contribution made by the Northeastern and Lake States is small compared to the remaining regions (Figure 4). The Southern Plains produce the largest share of feeder cattle, followed by the Central Plains and Western Corn Belt Regions. The South Central States and Northern Plains complete the main five areas for the production of feeder cattle. By state breakdown, the top ten potential feeder cattle producing states in 1965 were: Texas, Nebraska, Oklahoma, South Dakota, Kansas, Missouri, Montana, Iowa, California, and Colorado. However, the picture changes drastically when the individual state demands are considered so that the heavy-feeding states such as California, Colorado, Iowa, and Nebraska are actually deficit supply regions. This problem is concerned only with the surplus supply of feeder cattle which may potentially be shipped via interstate or interregional channels.

## Projection for 1970

A five-year projection of demand and supply is analyzed to hypothesize the expected relative shifts of regional production of feeder

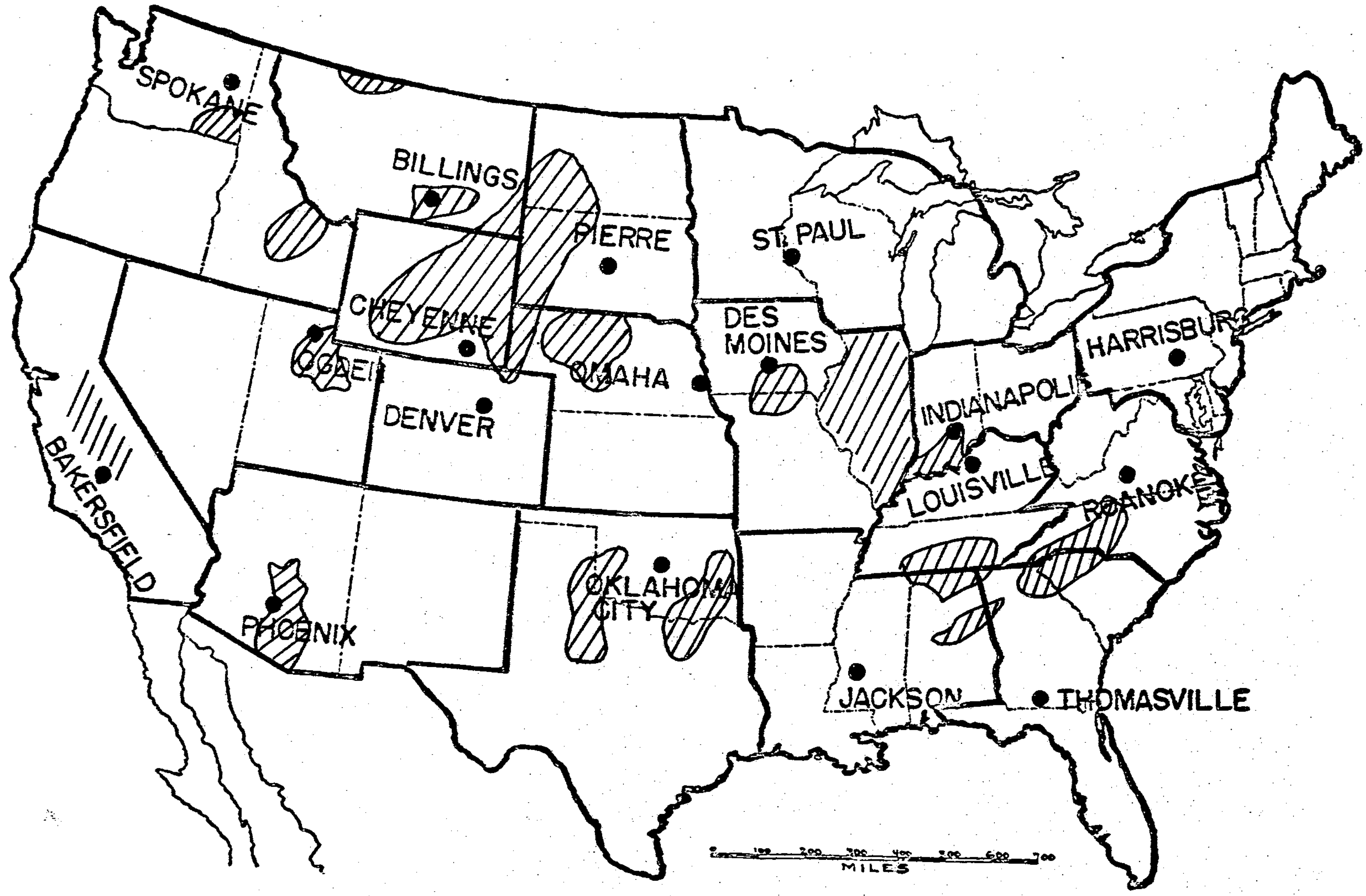


Figure 3. Areas within Regions Which Were Used to Calculate Cash Cost of Production For Entire Region.

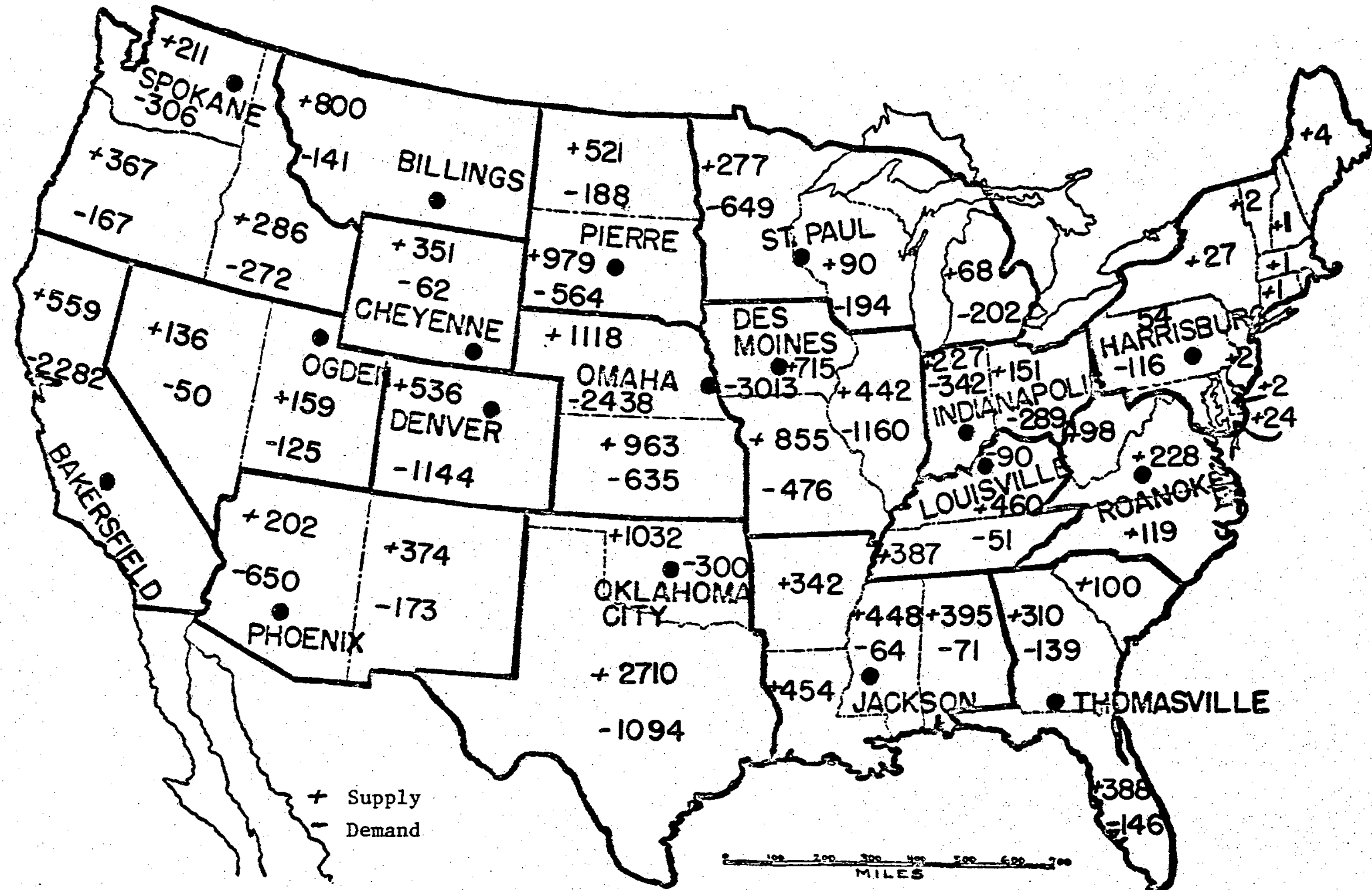


Figure 4. Estimated Potential Supply and Demand for Feeder Cattle, 1965 (1,000 Head).

TABLE VIII

ESTIMATED PROJECTED REGIONAL POTENTIAL SUPPLY AND DEMAND FOR FEEDER CATTLE, 1970

| Region | Estimated Potential Supply (1,000 head) | Estimated Demand (1,000 head) | Net Supply (+) or Demand (-) (1,000 head) |
|---|---|---|---|
| 1. Spokane | 1005 | 892 | 113 |
| 2. Bakersfield | 635 | 2895 | -2260 |
| 3. Ogden | 351 | 190 | 161 |
| 4. Phoenix | 545 | 1082 | -537 |
| 5. Billings | 945 | 154 | 791 |
| 6. Cheyenne | 399 | 36 | 363 |
| 7. Denver | 586 | 1447 | -861 |
| 8. Pierre | 1747 | 984 | 763 |
| 9. Omaha | 2288 | 4401 | -2113 |
| 10. Oklahoma City | 4104 | 2225 | 1879 |
| 11. St. Paul | 492 | 1176 | -684 |
| 12. Des Moines | 2331 | 5238 | -2907 |
| 13. Jackson | 2065 | 305 | 1760 |
| 14. Indianapolis | 477 | 719 | -242 |
| 15. Louisville | 941 | 15 | 926 |
| 16. Thomasville | 992 | 681 | 311 |
| 17. Roanoke | 559 | 0 | 559 |
| 18. Harrisburg | 159 | 85 | 74 |

cattle. The projection of the demand for 1970 was derived by first considering the demand for feeder cattle within the eighteen regions and for the United States for the years 1960 through 1965. A least squares regression function was then fitted to the demand data. Useful demand data for all regions were not available for years earlier than 1960.

More data were available for analyzing the trend in supply. Potential supply data were used for the years 1945 through 1964. Again a least squares regression function trend line was fitted to the data by regions and for the United States as a whole.

Supply and demand projections were computed for 1970 for each region and for the United States. Since the sum of the parts must equal the whole, the regional trend estimates were adjusted on a percentage basis such that the sum of the individual regional predictions would equal the expected total United States trend in the cases of both demand and supply (Table VIII and Figure 5). The demand and supply regression equations are shown in Appendix H.

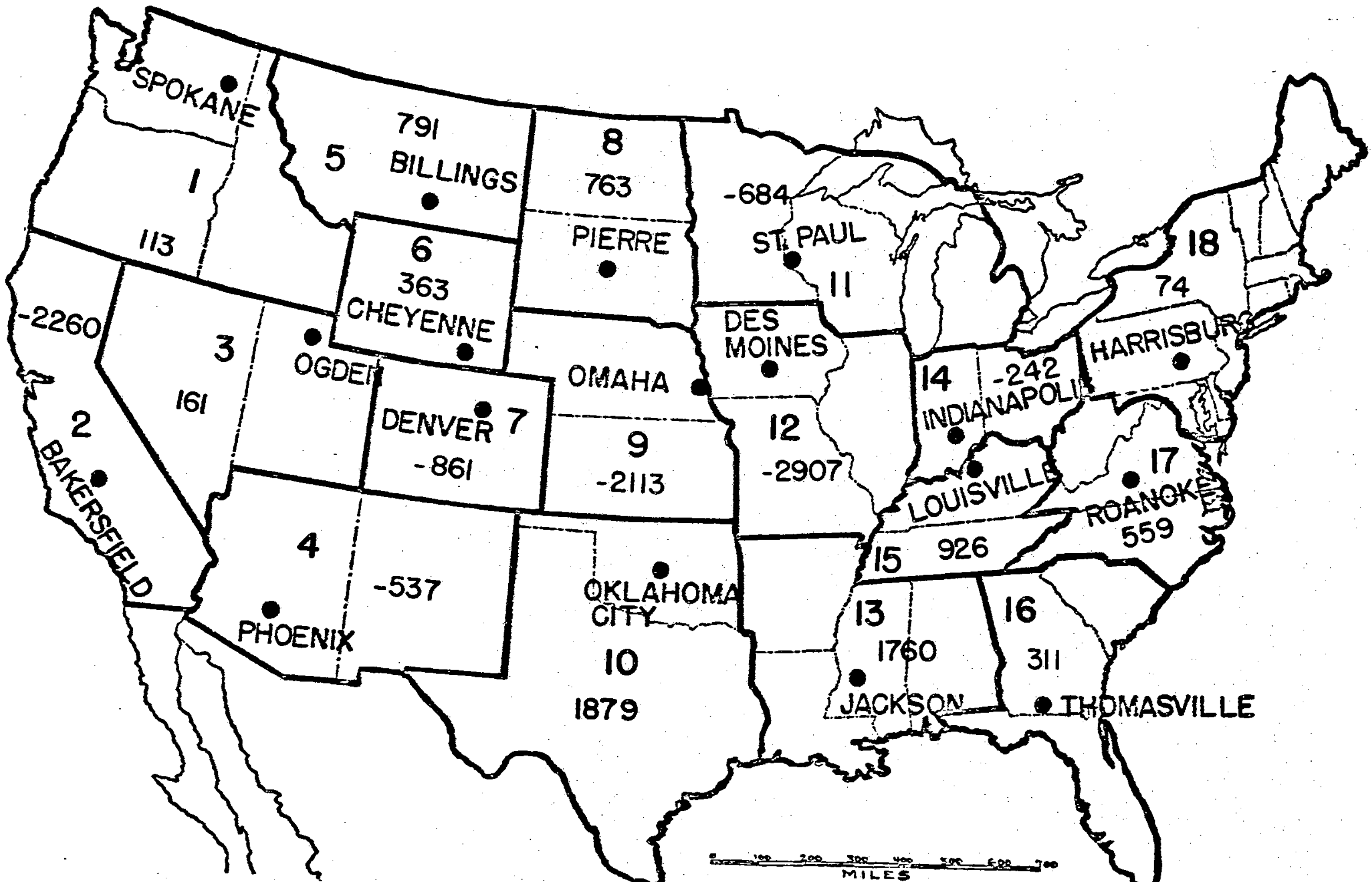


Figure 5. Estimated Regional Net Inmovement and Net Outmovement of Feeder Cattle, 1970, (1000 Head).

# CHAPTER IV

## ANALYSIS OF RESULTS FOR 1965

### Results of Model I for 1965

Model I analyzed the impact on the feeder cattle market pattern distribution from the eleven supply regions to the seven demand regions using simultaneous consideration of all three of the transport-comparative supply cost variables: mileage cost, local market price differential, and cash cost differential.

The rate for trucks was set at sixty cents per load mile, assuming no backhauls, and the problem of whether to ship by motor truck or by railroad and in what quantities in each case was analyzed. The results show that the railroads have a definite advantage in the cost of transportation in the absence of motor truck backhauls and should be utilized for all interstate movements except the relatively short ones. Table IX gives the results of the above analysis and Figure 6 shows the geographic directions and the magnitudes of movements.

The Far West (Bakersfield) receives about forty-five percent of its feeder cattle from the Billings and Ogden supply regions and the remaining fifty-five percent from the Oklahoma-Texas supply region. Phoenix receives all of its supply of feeders from the Oklahoma-Texas area. Oklahoma and Texas also account for more than half of Denver's inshipments while Cheyenne ships all of its available supply to Denver

TABLE IX

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL I ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 659* | 38.2 | 9.3 | 100.0 |
| Oklahoma City | Bakersfield | 944* | 54.8 | 13.4 | 40.2 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Oklahoma City | Denver | 319* | 52.5 | 4.5 | 13.6 |
| Pierre | Omaha | 138* | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 837 | 84.4 | 12.1 | 35.7 |
| Jackson | Omaha | 17* | 1.7 | .2 | 1.1 |
| Pierre | St. Paul | 610* | 100.0 | 8.6 | 81.6 |
| Louisville | Des Moines | 632 | 24.0 | 8.9 | 89.5 |
| Jackson | Des Moines | 1,491* | 56.6 | 21.1 | 98.9 |
| Thomasville | Des Moines | 513* | 19.4 | 7.3 | 100.0 |
| Louisville | Indianapolis | 74 | 29.2 | 1.0 | 10.5 |
| Roanoke | Indianapolis | 179 | 70.8 | 2.5 | 40.2 |

*Railroad shipments.

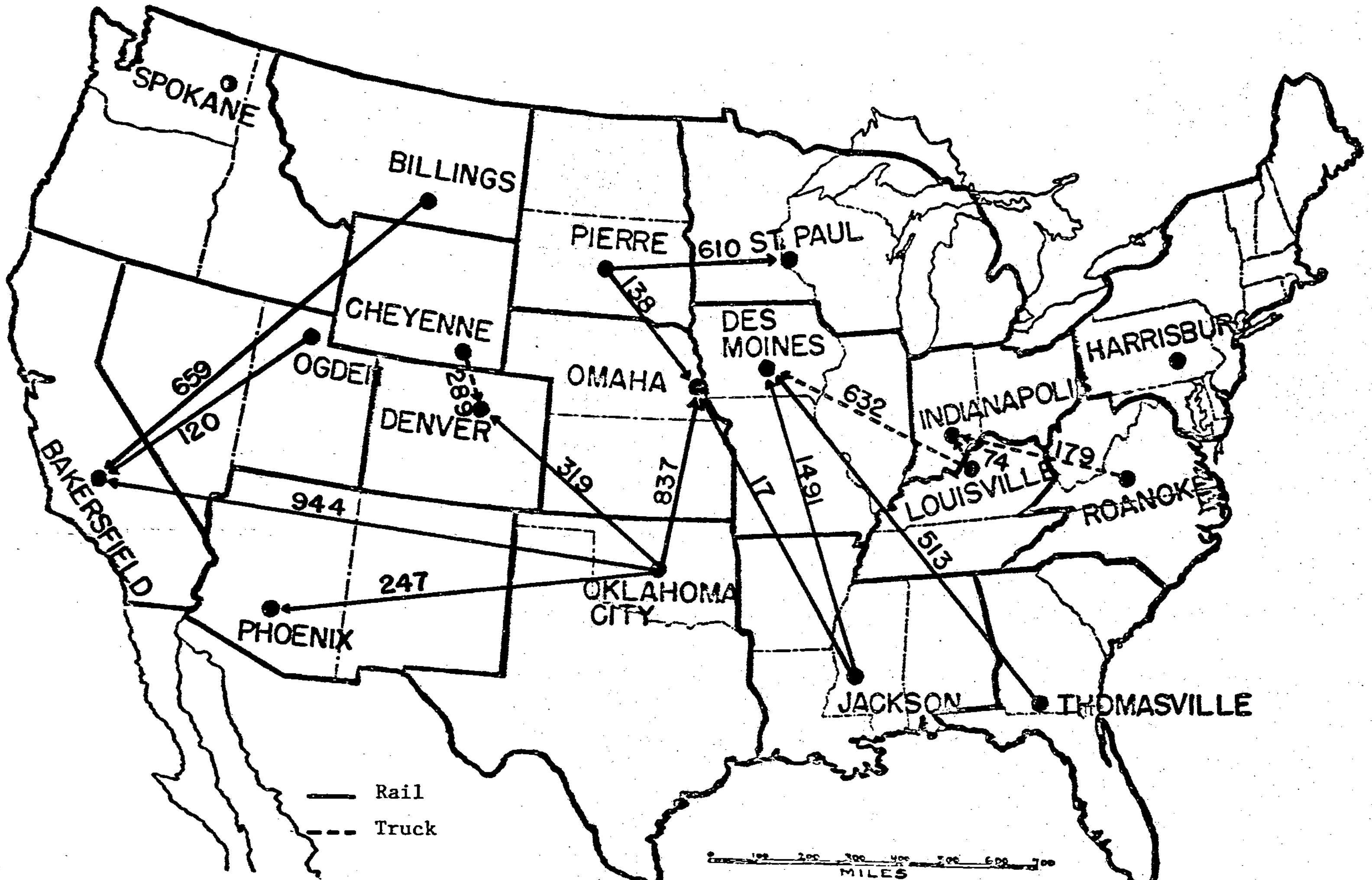


Figure 6. Interregional Flows of Feeder Cattle According to Model I with Truck Rate of $.60 Per Mile, 1965.

to complete Denver's demand. In the Midwestern demand region of Omaha, the Oklahoma-Texas supply region accounts for eighty-four percent of the inshipments while Pierre ships in from the North and Jackson ships in from the South. St. Paul is supplied solely by the Pierre supply region. In the heart of the Corn-Belt states, Des Moines draws heavily from the Southeastern quarter of the United States represented by the Louisville, Jackson and Thomasville supply regions. The Eastern Corn-Belt region of Indianapolis is supplied by Louisville and Roanoke.

Because the total supply exceeded the total demand, two supply regions did not have a feasible market for their small supplies. Spokane in the Northwest and Harrisburg in the Northeast did not ship feeder cattle in Model I.

## Results of Model II for 1965

Model II considered the impact of the optimum distribution pattern of feeder cattle when only the price differentials and transportation charges were used as determinants, assuming no motor truck backhauls and a truck rate of $.60 per load mile. The computer analysis of Model II indicated that without consideration for the cash cost of production, optimum shipping patterns are altered slightly. Railroads continued to have a substantial advantage in transportation cost over motor trucks except for the very short hauls. Table X gives the results of a Model II analysis and Figure 7 shows the geographic directions of the distribution.

Bakersfield was supplied by the Spokane, Ogden, Billings, and Oklahoma-Texas regions with eighty-six percent of the inshipments coming from the Billings and Oklahoma-Texas regions. Again, the

TABLE X

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL II ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Spokane | Bakersfield | 119* | 6.9 | 1.7 | 100.0 |
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 659* | 38.2 | 9.3 | 100.0 |
| Oklahoma City | Bakersfield | 825* | 47.9 | 11.7 | 35.2 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Oklahoma City | Denver | 319* | 52.5 | 4.5 | 13.6 |
| Pierre | Omaha | 138* | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 854* | 86.1 | 12.1 | 36.4 |
| Pierre | St. Paul | 610* | 100.0 | 8.6 | 81.6 |
| Louisville | Des Moines | 513 | 19.5 | 7.3 | 72.7 |
| Oklahoma City | Des Moines | 102* | 3.9 | 1.4 | 4.3 |
| Jackson | Des Moines | 1,508* | 57.2 | 21.3 | 100.0 |
| Thomasville | Des Moines | 513* | 19.5 | 7.3 | 100.0 |
| Louisville | Indianapolis | 193 | 76.3 | 2.7 | 27.3 |
| Roanoke | Indianapolis | 60 | 23.7 | .8 | 13.5 |

*Railroad shipments.

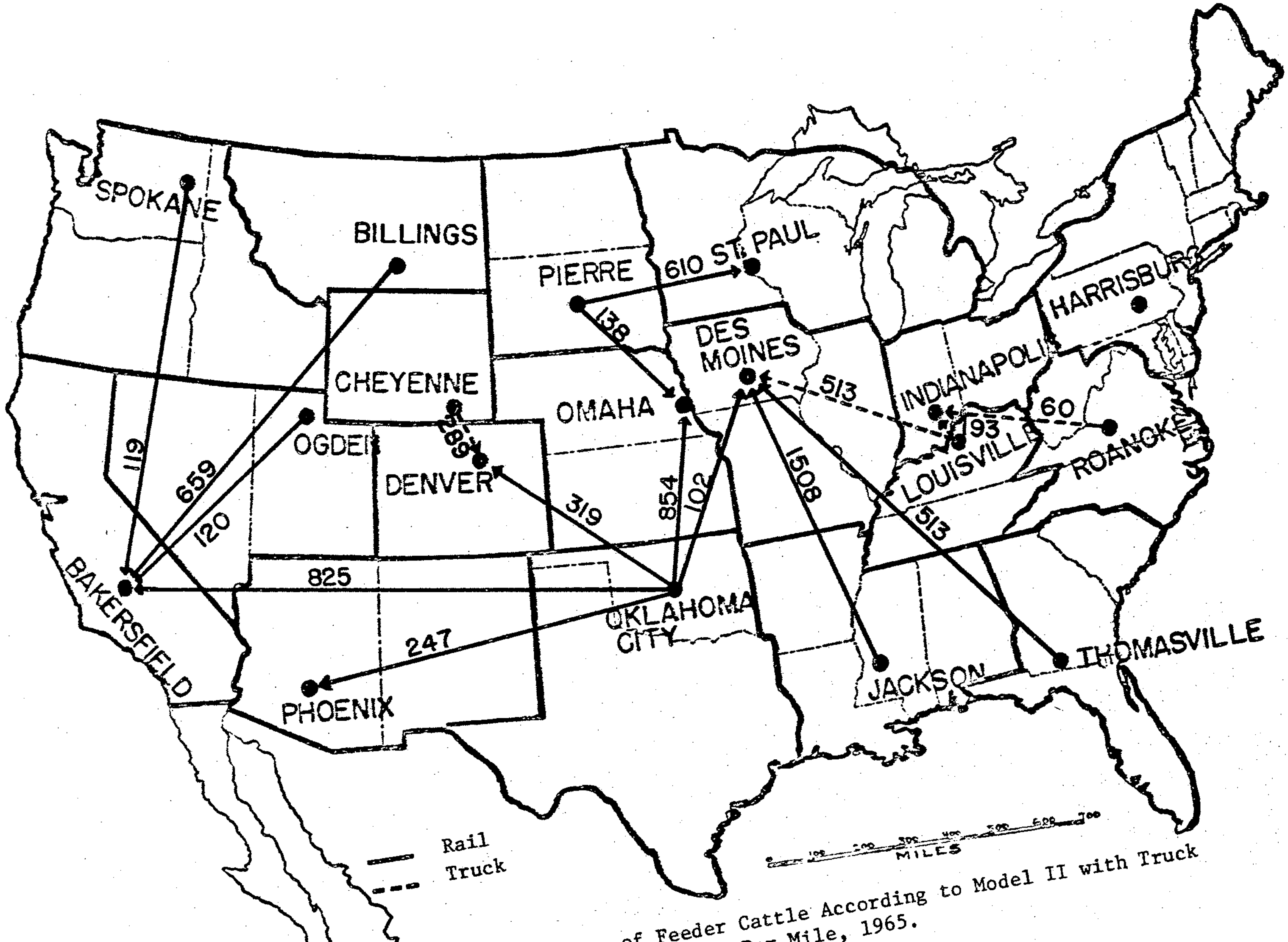


Figure 7. Interregional Flows of Feeder Cattle According to Model II with Truck Rate of $.60 Per Mile, 1965.

Oklahoma-Texas region accounted for all needs in the Phoenix area. Denver was supplied by the Oklahoma-Texas and Cheyenne supply regions as in Model I. In the Midwest, Omaha continued to depend upon the Oklahoma-Texas supply region for most of its inshipments of feeder cattle while Pierre supplied about fourteen percent of the feeder cattle for Omaha. Pierre was the only supply region shipping to the St. Paul demand area. In Model II, the Des Moines demand region again received most of its supply from the South and Southeastern regions of Louisville, Jackson, and Thomasville, but the Oklahoma-Texas region also supplied more than 100,000 head of feeder cattle to this region. The Eastern Corn-Belt region of Indianapolis again received inshipments of feeder cattle from the Louisville and Roanoke supply regions.

Without the cash cost of production differentials considered in the model, the transportation cost overshadows the relatively small price differentials among regions. Therefore, Spokane is close enough to Bakersfield to competitively supply Bakersfield. The Oklahoma-Texas region ships fewer feeder cattle to Bakersfield in Model II than Model I because of the entrance of the Spokane supply shipments to Bakersfield in Model II. Thus, the Oklahoma-Texas region has more feeder cattle available to ship to the Omaha and Des Moines regions in Model II. Another difference in the results from Model II as compared with the results from Model I is that Louisville ships more feeder cattle to Indianapolis under Model II conditions. Jackson ships its entire supply to the Des Moines region in Model II while discontinuing its shipments to Omaha. The Oklahoma-Texas region in Model II replaces the quantity supplied to Omaha by Jackson in Model I and in addition, Oklahoma-Texas exhausts its remaining supply to the Des Moines region.

Because Oklahoma-Texas has taken part of the Des Moines market in Model II - a part which Louisville had in Model I - Louisville increases its shipments to Indianapolis, thereby decreasing the share of the Indianapolis market available for Roanoke.

The Northeastern supply region of Harrisburg did not ship its small supply of feeder cattle in Model II.

## Results of Model III for 1965

Model III analyzes the impact of the differentials in cash costs of production and the transportation rate on the optimum pattern of distribution of feeder cattle marketings. Ignoring the possibility of truck backhauls, the results of the optimum problem solution for Model III show essentially the same distribution of feeder cattle as Model I except that Roanoke ships to Des Moines as well as Indianapolis in Model III. The only other change is that Louisville ships only to Des Moines in Model III rather than to both Des Moines and Indianapolis.

As in Model I, neither Spokane in the Northwest nor Harrisburg in the Northeast made any shipments in Model III.

Table XI gives the results of the above analysis and Figure 8 shows the geographical directions of the distribution.

## Results of Model IV for 1965

In Model IV the optimum feeder cattle market distribution was estimated using only the enroute cost of transportation. This model defines the least-cost array of shipments, with a truck rate of $.60 per load mile. The optimum solution for Model IV was identical with the distribution defined by Model II. This indicates either that the existing

TABLE XI

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL III ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 659* | 38.2 | 9.3 | 100.0 |
| Oklahoma City | Bakersfield | 944* | 54.8 | 13.4 | 40.2 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Oklahoma City | Denver | 319* | 52.5 | 4.5 | 13.6 |
| Pierre | Omaha | 138* | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 837* | 84.4 | 12.1 | 35.7 |
| Jackson | Omaha | 17* | 1.7 | .2 | 1.1 |
| Pierre | St. Paul | 610* | 100.0 | 8.6 | 81.6 |
| Louisville | Des Moines | 440 | 16.7 | 6.2 | 62.3 |
| Roanoke | Des Moines | 192 | 7.3 | 2.7 | 43.1 |
| Jackson | Des Moines | 1,491* | 56.6 | 21.1 | 98.9 |
| Thomasville | Des Moines | 513* | 19.5 | 7.3 | 100.0 |
| Roanoke | Indianapolis | 253 | 100.0 | 3.5 | 56.9 |

*Railroad shipments.

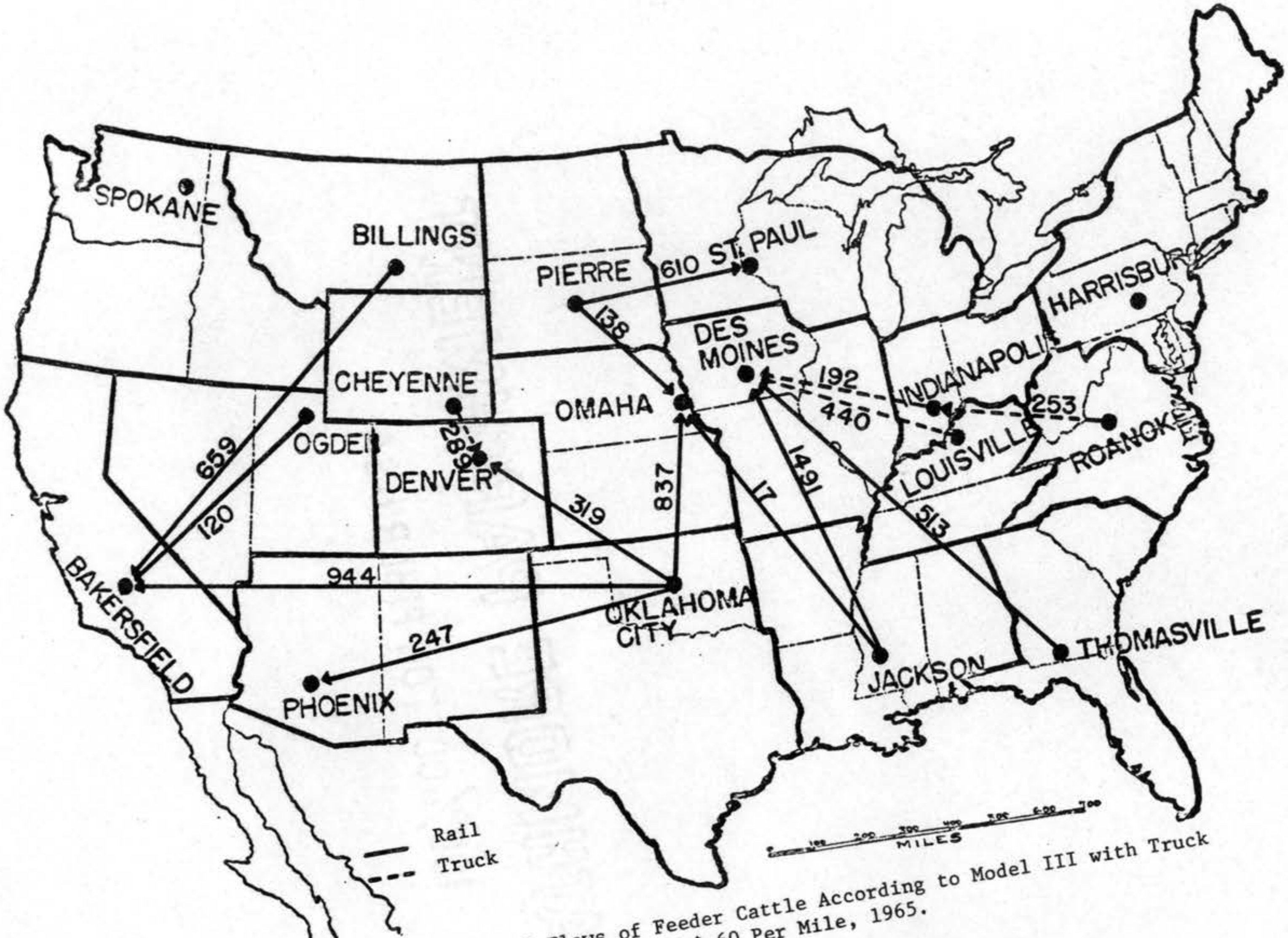


Figure 8. Interregional Flows of Feeder Cattle According to Model III with Truck Rate of $.60 Per Mile, 1965.

price differentials are in fact compatible with the optimum pattern that should theoretically prevail (i.e., that the price differentials do reflect transportation costs) according to the transportation cost, or that the influence of the transportation cost is such a dominant determinant of market patterns of feeder cattle shipments that the price differentials are inconsequential.

Table XII gives the results of the above analysis and Figure 9 shows the geographical directions of the distribution.

## Influence of Backhauls on the Optimum Solution

Up to this point, the optimum solution has been considered under the condition that no backhuals were available to alter the revenue picture for the truck cattle haulers. Without backhauls, the trucker must charge enough on the half of the trip when his truck is loaded to pay for the return trip without any load.

The results of the $.46 per load mile charge for motor trucks, accounting for the presence of backhauls for truckers in about one-third of the cases while keeping the railroads rate constant, suggest that current shipping practices of hauling most of the feeder cattle by truck are generally consistent with the expected economic optimum. Generally, the shipping direction and patterns remain about the same as the $.60 per load mile charge for motor trucks but with motor trucks replacing railroads in the majority of interregional shipments. Tables XIII through XVI and Figures 10 through 13 give the results of the optimum model solutions with a truck rate of $.46 per load mile.

When the truck rate was decreased from $.60 to $.46 per load mile, some significant changes are worth noting in addition to the fact that

TABLE XII

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL IV ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Spokane | Bakersfield | 119* | 6.9 | 1.7 | 100.0 |
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 659* | 38.2 | 9.3 | 100.0 |
| Oklahoma City | Bakersfield | 825* | 47.9 | 11.7 | 35.2 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Oklahoma City | Denver | 319* | 52.5 | 4.5 | 13.6 |
| Pierre | Omaha | 138* | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 854* | 86.1 | 12.1 | 36.4 |
| Pierre | St. Paul | 610* | 100.0 | 8.6 | 81.6 |
| Louisville | Des Moines | 513 | 19.5 | 7.3 | 72.7 |
| Oklahoma City | Des Moines | 102* | 3.9 | 1.4 | 4.3 |
| Jackson | Des Moines | 1,508* | 57.2 | 21.3 | 100.0 |
| Thomasville | Des Moines | 513* | 19.5 | 7.3 | 100.0 |
| Louisville | Indianapolis | 193 | 76.3 | 2.7 | 27.3 |
| Roanoke | Indianapolis | 60 | 23.7 | .8 | 13.5 |

*Railroad shipments.

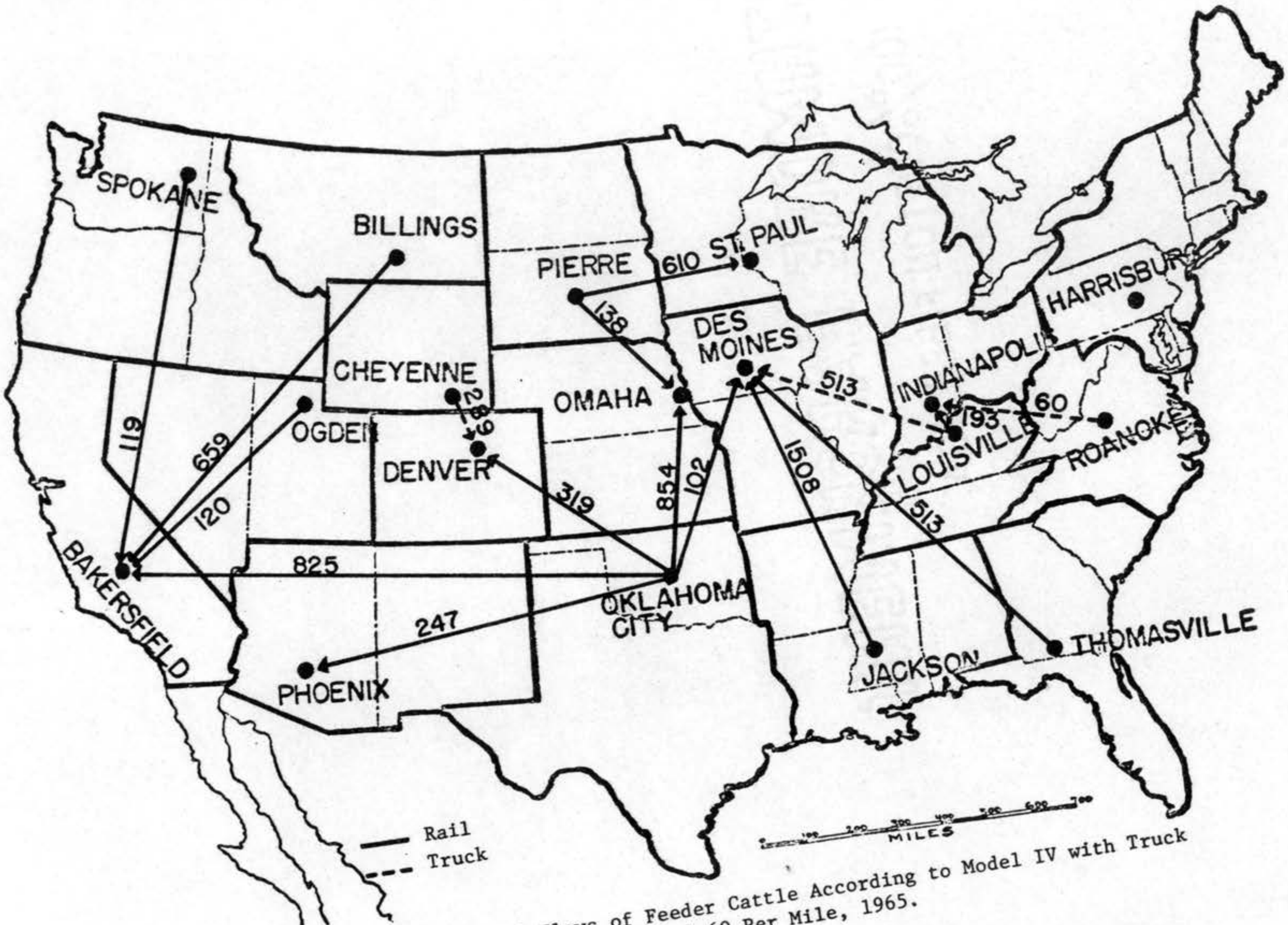


Figure 9. Interregional Flows of Feeder Cattle According to Model IV with Truck Rate of $.60 Per Mile, 1965.

TABLE XIII

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL I ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 340* | 19.7 | 4.8 | 51.6 |
| Oklahoma City | Bakersfield | 1,263* | 73.3 | 17.9 | 53.8 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Billings | Denver | 319 | 52.5 | 4.5 | 48.4 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Pierre | Omaha | 138 | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 837 | 84.4 | 11.8 | 35.7 |
| Jackson | Omaha | 17* | 1.7 | .2 | 1.1 |
| Pierre | St. Paul | 610 | 100.0 | 8.6 | 81.6 |
| Jackson | Des Moines | 1,491 | 56.6 | 21.1 | 98.9 |
| Louisville | Des Moines | 632 | 24.0 | 8.9 | 89.5 |
| Thomasville | Des Moines | 513 | 19.4 | 7.3 | 100.0 |
| Louisville | Indianapolis | 74 | 29.2 | 1.0 | 10.5 |
| Roanoke | Indianapolis | 179 | 70.8 | 2.5 | 40.2 |

*Railroad shipments.

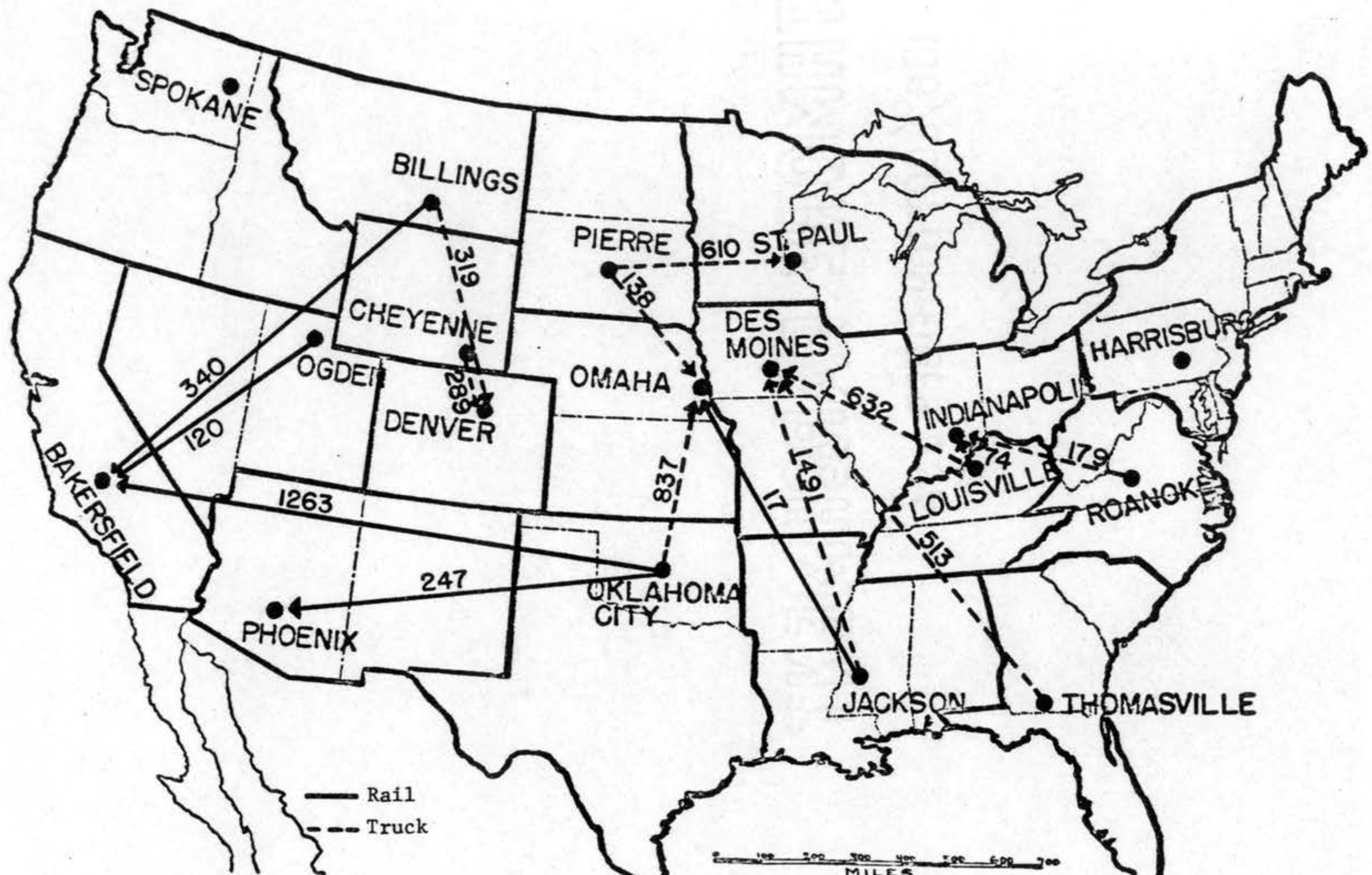


Figure 10. Interregional Flows of Feeder Cattle According to Model I with Truck Rate of $.46 Per Mile, 1965.

TABLE XIV

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL II ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Spokane | Bakersfield | 119* | 6.9 | 1.7 | 100.0 |
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 340* | 19.7 | 4.8 | 51.6 |
| Oklahoma City | Bakersfield | 1,144* | 66.4 | 16.2 | 48.7 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Billings | Denver | 319 | 52.5 | 4.5 | 48.4 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Pierre | Omaha | 138 | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 854 | 86.1 | 12.1 | 36.4 |
| Pierre | St. Paul | 610 | 100.0 | 8.6 | 81.6 |
| Jackson | Des Moines | 1,508 | 57.2 | 21.3 | 100.0 |
| Louisville | Des Moines | 513 | 19.5 | 7.3 | 72.7 |
| Thomasville | Des Moines | 513 | 19.5 | 7.3 | 100.0 |
| Oklahoma City | Des Moines | 102* | 3.9 | 1.4 | 4.3 |
| Louisville | Indianapolis | 193 | 76.3 | 2.7 | 27.3 |
| Roanoke | Indianapolis | 60 | 23.7 | .8 | 13.5 |

*Railroad shipments.

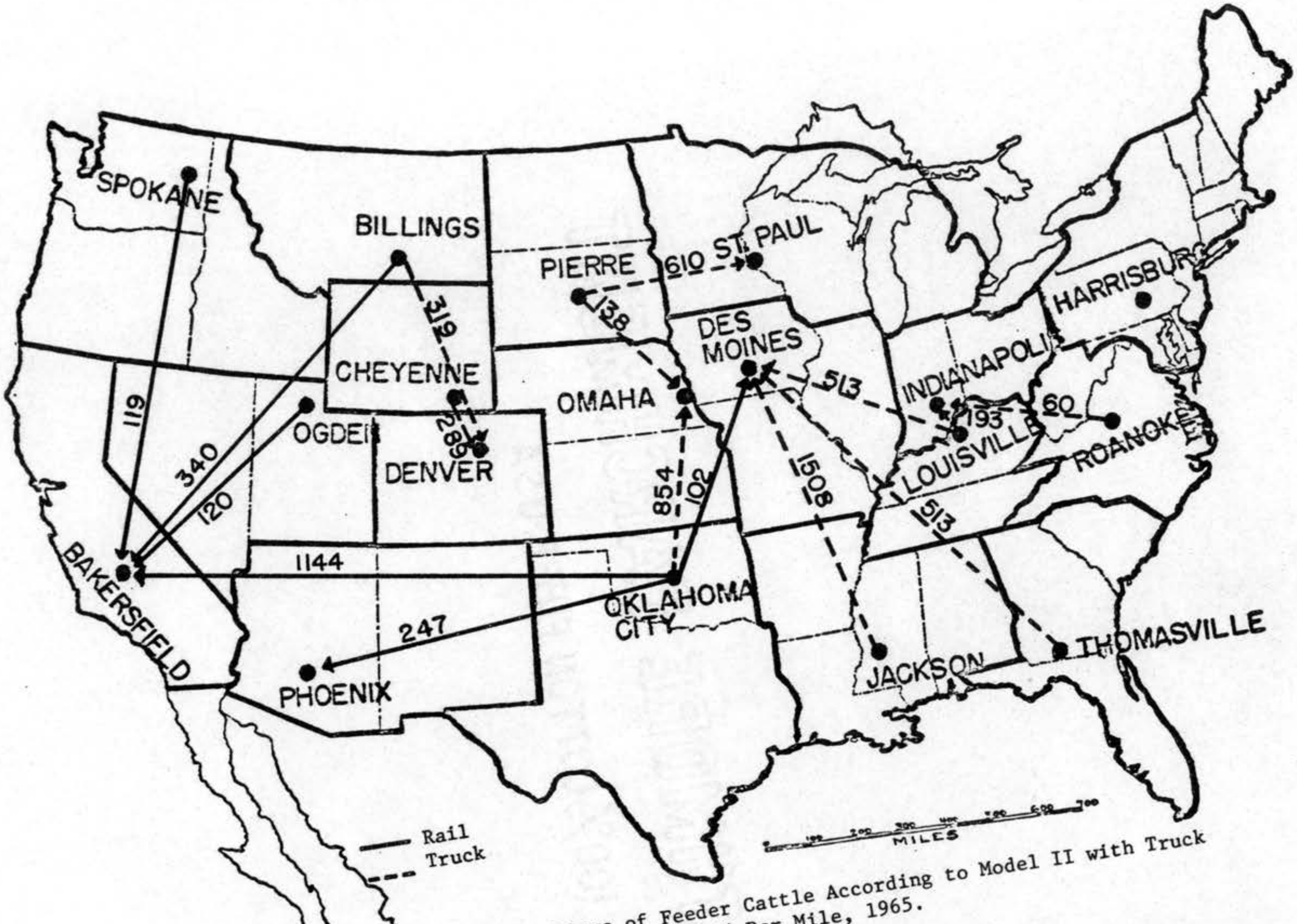


Figure 11. Interregional Flows of Feeder Cattle According to Model II with Truck Rate of $.46 Per Mile, 1965.

TABLE XV

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL III ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 340* | 19.7 | 4.8 | 51.6 |
| Oklahoma City | Bakersfield | 1,263* | 73.3 | 17.9 | 53.8 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Billings | Denver | 319 | 52.5 | 4.5 | 48.4 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Pierre | Omaha | 138 | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 837 | 84.4 | 11.8 | 35.7 |
| Jackson | Omaha | 17* | 1.7 | .2 | 1.1 |
| Pierre | St. Paul | 610 | 100.0 | 8.6 | 81.6 |
| Jackson | Des Moines | 1,491 | 56.6 | 21.1 | 98.9 |
| Louisville | Des Moines | 440 | 16.7 | 6.2 | 62.3 |
| Thomasville | Des Moines | 513 | 19.4 | 7.3 | 100.0 |
| Roanoke | Des Moines | 192 | 7.3 | 2.7 | 43.1 |
| Roanoke | Indianapolis | 253 | 100.0 | 3.5 | 56.9 |

*Railroad shipments.

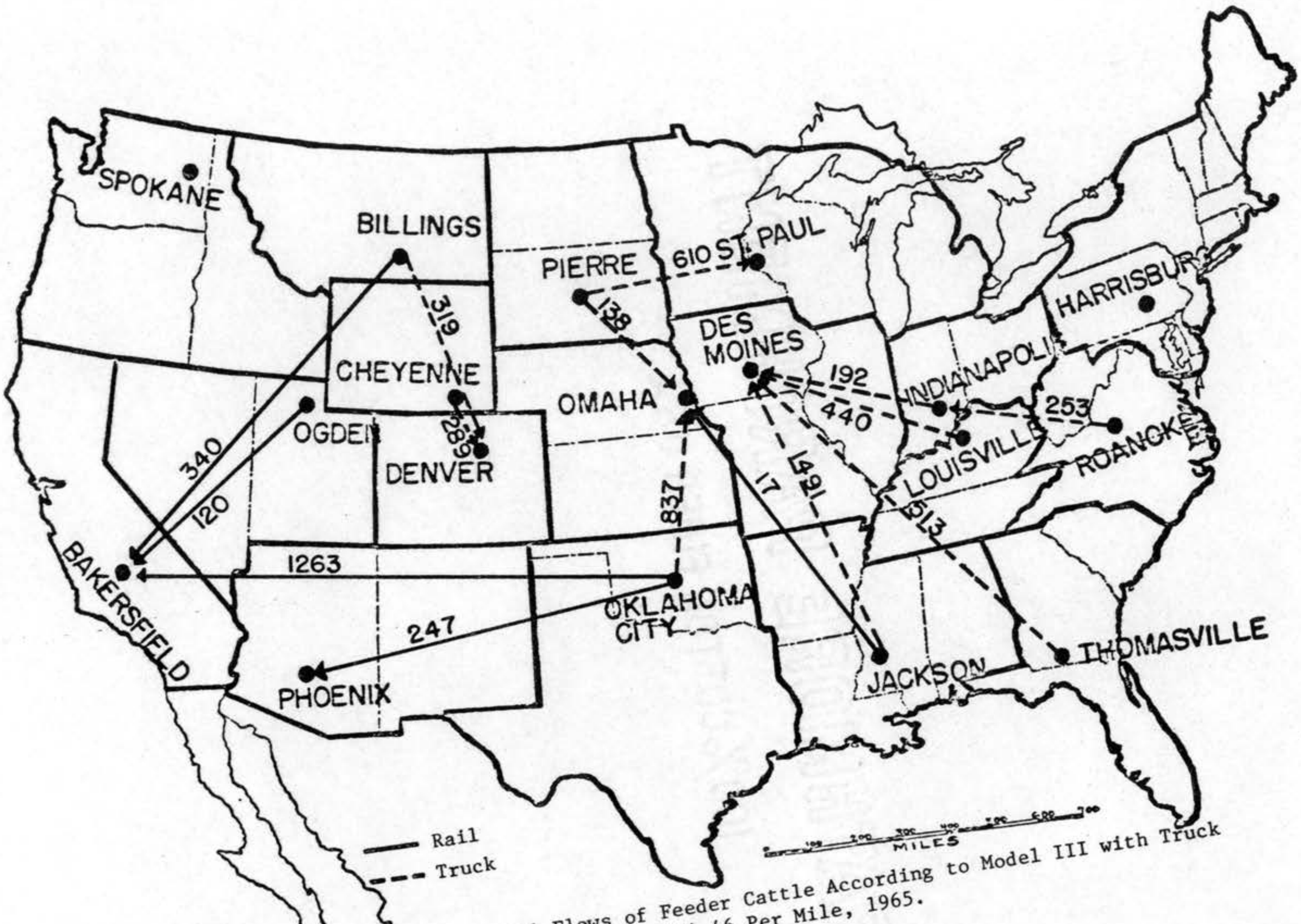


Figure 12. Interregional Flows of Feeder Cattle According to Model III with Truck Rate of $.46 Per Mile, 1965.

TABLE XVI

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL IV ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| From Region | To Region | Quantity Shipped (1,000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Spokane | Bakersfield | 119* | 6.9 | 1.7 | 100.0 |
| Ogden | Bakersfield | 120* | 7.0 | 1.7 | 100.0 |
| Billings | Bakersfield | 340* | 19.7 | 4.8 | 51.6 |
| Oklahoma City | Bakersfield | 1,144* | 66.4 | 16.2 | 48.7 |
| Oklahoma City | Phoenix | 247* | 100.0 | 3.5 | 10.5 |
| Billings | Denver | 319 | 52.5 | 4.5 | 48.4 |
| Cheyenne | Denver | 289 | 47.5 | 4.1 | 100.0 |
| Pierre | Omaha | 138 | 13.9 | 2.0 | 18.4 |
| Oklahoma City | Omaha | 854 | 86.1 | 12.1 | 36.4 |
| Pierre | St. Paul | 610 | 100.0 | 8.6 | 81.6 |
| Jackson | Des Moines | 1,508 | 57.2 | 21.3 | 100.0 |
| Louisville | Des Moines | 706 | 26.8 | 10.0 | 100.0 |
| Thomasville | Des Moines | 128 | 4.9 | 1.8 | 25.0 |
| Roanoke | Des Moines | 192 | 7.3 | 2.7 | 43.1 |
| Oklahoma City | Des Moines | 102* | 3.9 | 1.4 | 4.3 |
| Roanoke | Indianapolis | 253 | 100.0 | 3.6 | 56.9 |

*Railroad shipments.

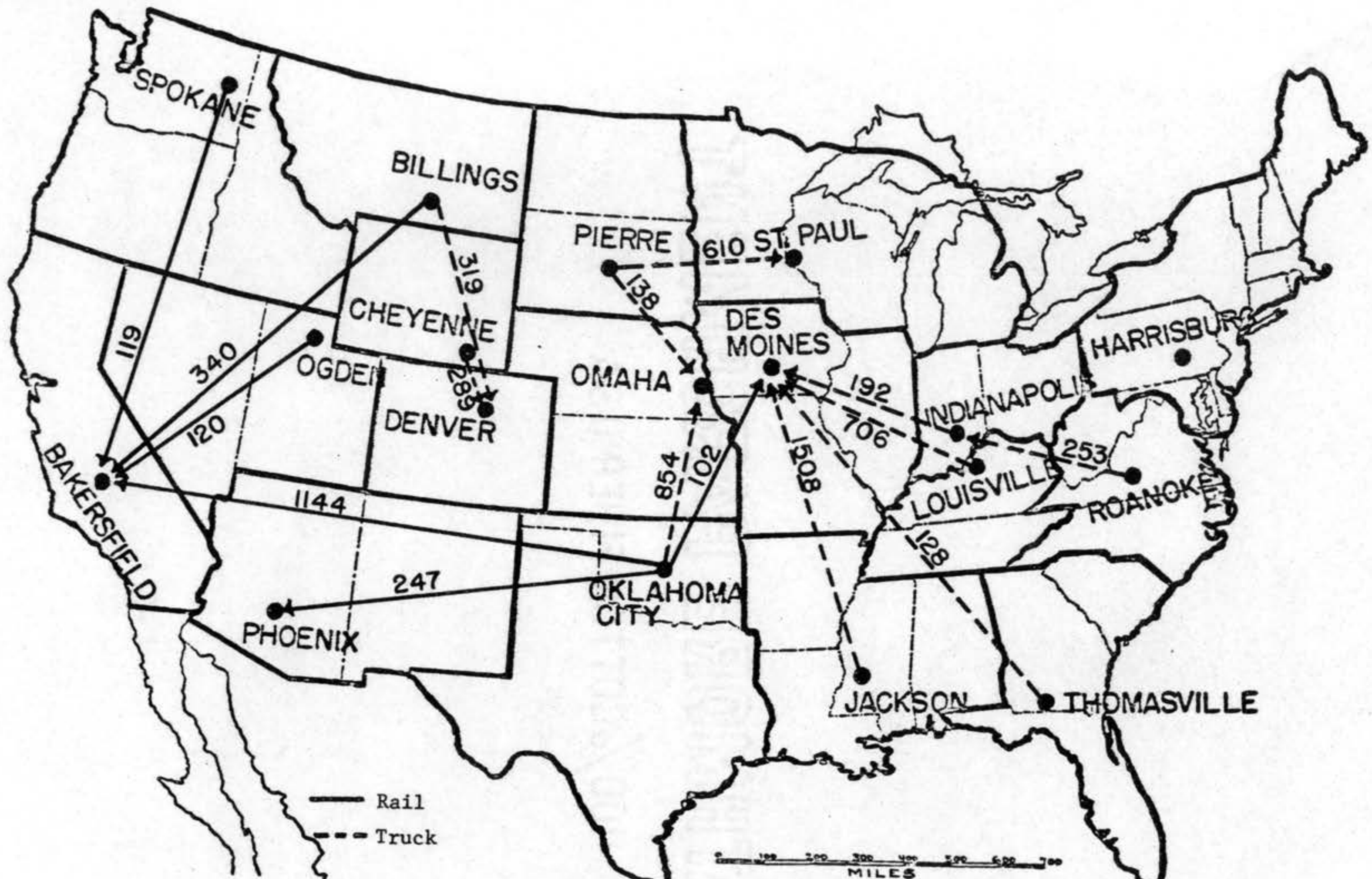


Figure 13. Interregional Flows of Feeder Cattle According to Model IV with Truck Rate of $.46 Per Mile, 1965.

most of the hauls shift to motor truck transportation at the $.46 per load mile rate. In the West, Bakersfield receives only forty percent of Billings' supply of feeder cattle under the $.46 rate whereas it received all of Billings' supply at the $.60 truck rate. The Oklahoma-Texas region substantially increases its supply shipments to Bakersfield to replace the reduced supply from Billings. Billings replaces the Oklahoma-Texas region as a source of supply for part of Denver's demand. The Bakersfield and Phoenix demand regions continue to be supplied entirely via railroad while the remainder of the United States is served by motor trucks except for a small shipment to Omaha from Jackson in Models I and III and a small shipment to Des Moines from Oklahoma-Texas in Models II and IV. Except for the specific cases just pointed out, the optimum solutions at the $.46 truck rate are identical with the quantities and patterns of shipments as the $.60 rate optimum solutions.

## Regional Patterns of Distribution Observed in 1965

California, represented by Bakersfield in the model, shipped very few nonfed or feeder cattle out of state. It had many more inshipments than outshipments and, therefore, was a deficit supply area. It received forty percent of its feeder cattle from Texas, sixteen percent from Arizona, ten percent from Oregon, eight percent from Nevada, four percent from New Mexico, three percent from Idaho, Oklahoma, and Utah, a few from Colorado and Kansas, and about ten percent from miscellaneous sources which were mainly the Southern states.

Arizona and New Mexico (Phoenix in the model) received the majority of their inshipments of feeder cattle from the Southern Plains and the Southeast. Arizona actually shipped over eighty percent of its 331,000 head of exported stocker-feeders into California and most of its inshipments moved into the two principal feeding areas around Phoenix and Yuma. New Mexico presently is exporting more feeder cattle than it imports. Texas supplies fifty-five percent of Arizona's inshipments. The remainder of Arizona's inshipments comes mostly from four other sources: about seven percent each from New Mexico and Oklahoma, fifteen percent from Old Mexico, and fourteen percent from the Gulf States. Texas supplies most of the inshipments to New Mexico while New Mexico exports the majority of its stocker-feeders into Colorado, Kansas, Oklahoma, and Texas feedlots.

Region 7, represented by Denver, encompassing Colorado, exported feeder cattle into every state bordering it but the main pattern of shipments moved east into Nebraska, Kansas and the Western Corn-Belt region. Colorado imports more stocker-feeder cattle than it exports which makes it a demand region as shown in the model. Colorado receives thirty-nine percent of its inshipments from Texas, fourteen percent from Kansas, thirteen percent from New Mexico, nine percent from Nebraska, eight percent from Wyoming, seven percent from Oklahoma, small inshipments from Idaho and Montana, and seven percent from other sources.

The Nebraska-Kansas feeding region (Omaha) shipped very few feeder cattle to points outside its area but received large numbers of feeder cattle from Colorado, Texas-Oklahoma, Wyoming, and Montana.

The Corn-Belt states which comprise Region 12 (Des Moines) and Region 14 (Indianapolis) received inshipments of feeder cattle from Montana, Wyoming, the Dakotas, Colorado, Oklahoma, Texas, New Mexico, Alabama, Mississippi, and Tennessee. Table XVII is useful to depict the trend of feeder cattle shipments into the North Central states by state or origin during recent years.

TABLE XVII

DIRECT SHIPMENTS OF STOCKER-FEEDER CATTLE AND CALVES INTO SELECTED NORTH CENTRAL STATES BY STATE OF ORIGIN

| | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | 27,923 | 27,852 | 30,374 | 29,539 |
| Arizona | 2,784 | 661 | 3,413 | 2,561 | 3,327 | 6,683 | 2,830 |
| California | 4,971 | 1,902 | 3,003 | 8,730 | 21,504 | 5,115 | 4,196 |
| Colorado | 132,819 | 154,712 | 137,350 | 181,139 | 163,613 | 209,590 | 117,870 |
| Idaho | 30,241 | 20,784 | 26,333 | 38,334 | 25,761 | 48,450 | 50,264 |
| Illinois | 15,874 | 16,064 | 16,409 | 14,025 | 32,557 | 37,552 | 25,207 |
| Iowa | 44,356 | 44,857 | 40,695 | 61,845 | 63,598 | 68,410 | 66,046 |
| Kansas | 448,984 | 351,528 | 355,187 | 473,952 | 545,421 | 554,708 | 431,243 |
| Kentucky | -- | -- | -- | 59,602 | 92,511 | 105,745 | 121,149 |
| Minnesota | -- | -- | -- | 44,092 | 41,334 | 44,944 | 77,397 |
| Mississippi | -- | -- | -- | 54,012 | 69,775 | 75,435 | 61,584 |
| Missouri | 218,715 | 190,560 | 216,219 | 285,591 | 303,300 | 290,281 | 353,391 |
| Montana | 458,903 | 543,217 | 516,475 | 499,490 | 412,942 | 507,541 | 541,395 |
| Nebraska | 360,401 | 372,861 | 348,722 | 394,436 | 377,966 | 426,276 | 349,173 |
| Nevada | 7,006 | 3,048 | 4,578 | 7,410 | 3,024 | 5,391 | 4,534 |
| New Mexico | 58,276 | 71,296 | 48,150 | 143,766 | 104,446 | 96,895 | 65,315 |
| North Dakota | -- | -- | -- | 213,458 | 165,832 | 196,815 | 242,041 |
| Ohio | -- | -- | -- | 4,713 | 5,514 | 6,708 | 8,776 |
| Oklahoma | 148,139 | 113,112 | 156,801 | 209,425 | 199,281 | 209,339 | 207,685 |
| Oregon | 18,520 | 11,630 | 16,480 | 39,220 | 13,193 | 36,490 | 40,494 |
| South Dakota | 577,317 | 497,140 | 508,543 | 476,592 | 464,759 | 510,916 | 544,899 |
| Tennessee | -- | -- | -- | 34,650 | 32,271 | 34,440 | 35,814 |
| Texas | 354,022 | 391,302 | 416,599 | 562,573 | 526,765 | 448,943 | 386,173 |
| Utah | 6,589 | 4,417 | 4,199 | 6,228 | 6,119 | 6,245 | 6,587 |

TABLE XVII (CONTINUED)

| | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|
| Washington | 4,593 | 1,443 | 3,420 | 8,023 | 2,810 | 8,005 | 10,739 |
| Wisconsin | -- | -- | -- | 50,958 | 66,365 | 55,537 | 39,474 |
| Wyoming | 183,986 | 195,340 | 198,772 | 206,298 | 203,234 | 214,139 | 222,361 |
| Other States | 752,712 | 761,406 | 968,699 | 272,285 | 260,262 | 215,969 | 185,835 |
| Canada | -- | -- | -- | 222,380 | 124,875 | 81,165 | 329,261 |
| Total | 3,829,208 | 3,747,280 | 3,990,047 | 4,603,711 | 4,360,211 | 4,538,101 | 4,561,272 |

Source: U. S. Department of Agriculture, Livestock and Meat Statistics, Selected Issues, AMS, SRS, ERS, Statistical Bulletins 230 and 333. (Selected States: Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, South Dakota, and Nebraska).

The results from the computer analysis of the transportation problem in 1965, with two exceptions, follow rather accurately the overall shift in the market pattern for shipping feeder cattle in the United States. The model indicates that Montana should ship much of its supply into California. The actual data shows that Montana ships most of its cattle into the Midwest or North Central states and very small amounts into California. The model also shows that Wyoming (Region 6) should ship mostly into Colorado but the actual data indicate that Wyoming has its largest market in Nebraska and the Western Corn-Belt region. These differences of the actual shipping patterns from the theoretical model are most likely explained through the recognition of the weakness of the assumption of homogeneity of feeder cattle among regions. As was indicated in Chapter II, the homogeneity assumption is the ideal rather than what actually exists. The feeder cattle from the Northern Plains region are a high quality source of supply which the Corn-Belt region traditionally places on feed. The trend of higher quality feeder demand in the Corn-Belt region is partially illustrated by the fact that Corn-Belt terminal markets exhibit the highest average prices of any region in the United States (see Figure 14). California's average price for feeder cattle is lower than the average price in the Corn-Belt region; therefore, Montana tends to ship to the higher priced area. For the same reason, Wyoming ships into the Corn-Belt region rather than into Colorado. California and Colorado both have adequate sources of feeder cattle inshipments at lower prices than Montana and Wyoming, thus, the Southern Plains are in a very favorable position to supply California and Colorado. The model considers only the net movement of feeder cattle between regions, and, therefore, the solution

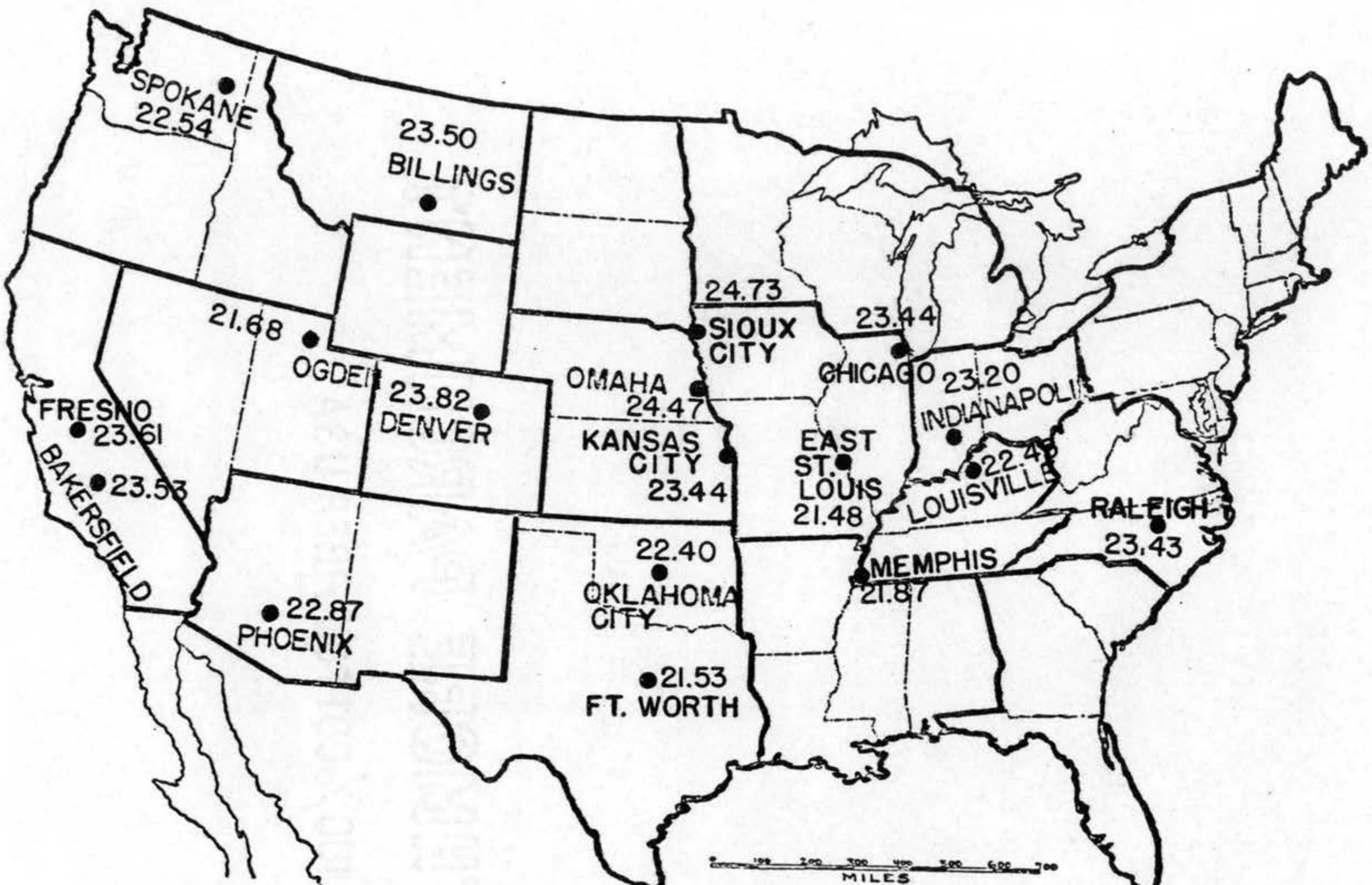


Figure 14. Average Prices for Good 500-800 Pound Feeder Cattle From 1956-64 for Various Markets in the United States.

Source: U. S. Department of Agriculture, AMS, Livestock Division Market News Service.

will only show the particular region either as a deficit or surplus region. This assumes that local demand will be supplied by local supply, if it exists, before requiring inshipments. There is no accurate way of estimating the degree to which different regions exchange supplies.

## Cost Analysis of Models for 1965

The preceding discussion outlined the general optimum shipment patterns for the different models in terms of quantities shipped and the geographical distribution. Each of the optimum solutions also specified the transfer cost per hundredweight and the cost ranges over which the optimum solution remains unchanged.

A detailed explanation of two model solutions will illustrate the usefulness of the cost ranging information contained in the linear program solution. The illustration will begin with a truck rate of \$.60 per mile for 1965 quantities and then compare the changes which occur as the truck rate decreases to \$.46 per mile for 1965 quantities. To complete the cost analysis, the same two models will be examined in the following chapter for the predicted 1970 supply and demand quantities. The remaining model solutions are included in Appendix F.

The first model solution considered is Model IV with a truck rate of \$.60 per mile. Table XVIII is the table of reference at this point. Starting from the left side, the first three columns of Origin, Destination, and Quantity Shipped are self-explanatory. The column headed "Transfer Cost/Cwt." gives the present transfer cost to ship one hundred pounds of feeder cattle from the corresponding origin to the designated demand point. The next four columns come under the general heading "Cost Range over which Optimum Solution Remains Unchanged." In other

TABLE XVIII

COST ANALYSIS OF MODEL IV OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1965

| Origin | Destination | Quantity Shipped (1,000 Head) | Transfer Cost/ cwt. ($) | Cost Range over which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Spokane | Bakersfield | 119* | 1.38 | INFINITE | UNBOUNDED | 2.11 | Spokane-Bakersfield |
| Ogden | Bakersfield | 120* | .97 | INFINITE | UNBOUNDED | 1.42 | Ogden-Bakersfield |
| Billings | Bakersfield | 659* | 1.59 | INFINITE | UNBOUNDED | 1.74 | Billings-Denver* |
| Oklahoma City | Bakersfield | 825* | 1.59 | 1.44 | Billings-Denver* | 1.78 | Jackson-Bakersfield* |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.41 | Jackson-Phoenix* |
| Cheyenne | Denver | 289 | .19 | INFINITE | UNBOUNDED | .38 | Cheyenne UNUSE |
| Oklahoma City | Denver | 319* | .82 | .46 | Cheyenne-Bakersfield* | .84 | Pierre-Denver* |
| Pierre | Omaha | 138* | .67 | .52 | Jackson-St. Paul* | .70 | Pierre-Denver* |
| Oklahoma City | Omaha | 854* | .68 | .66 | Pierre-Denver* | .75 | Jackson-Omaha* |
| Pierre | St. Paul | 610* | .68 | INFINITE | UNBOUNDED | .73 | Pierre-St. Paul |
| Louisville | Des Moines | 513 | 1.06 | .94 | Thomasville UNUSE | 1.17 | Roanoke-Des Moines |
| Oklahoma City | Des Moines | 102* | .74 | .67 | Jackson-Omaha* | .78 | Pierre-Des Moines* |
| Jackson | Des Moines | 1508* | 1.16 | INFINITE | UNBOUNDED | 1.23 | Jackson-Omaha* |
| Thomasville | Des Moines | 513* | 1.56 | INFINITE | UNBOUNDED | 1.65 | Thomasville-Omaha |
| Louisville | Indianapolis | 193 | .21 | .09 | Roanoke-Des Moines | .32 | Thomasville UNUSE |
| Roanoke | Indianapolis | 60 | .83 | .71 | Thomasville UNUSE | .95 | Roanoke-Des Moines |

*Railroad shipments.

words, the last four columns give the interval over which the present transfer cost may vary without generating a change in the optimum solution. Should the cost of transfer fall outside the specified interval, the sixth and eighth columns define the first change that would be made in reaching a new optimum. If, for example, the cost of shipping from Oklahoma City to Bakersfield should decrease by $.15 per hundredweight. Billings will begin shipping to Denver by rail. At the other end of the interval, if the rate from Oklahoma City to Bakersfield should increase to $1.78 per hundredweight (an increase of $.19), Jackson will begin to ship to Bakersfield by rail, thus partially replacing Oklahoma City in the Bakersfield market. When an incoming vector gives the name of the shipping point followed by the word "UNUSE", this indicates that that particular shipping point is forced out of competition and has no feasible market to which to ship its feeder cattle. Any shipment route which has an "INFINITE" lower limit will continue to ship to the same point as in the current optimum solution regardless of any decrease in the shipping cost.

Two generalizations may be drawn concerning the cost range from the West Coast to the Eastern Corn-Belt. For all model solutions, the cost ranges over which the optimum solution remained unchanged were very wide on the West and East coasts but very narrow or sensitive to change through the mid-section of the country. If the rates were to increase or decrease by $.05 per hundredweight or less for five different shipments into the Great Plains or the Corn Belt, the optimum solution would change. The second generalization is that the optimum solution is more sensitive to change from rate increases than rate decreases.

The optimum solution for Model IV with a truck rate of $.46 per mile for 1965 quantities in general gives the same geographic distribution of shipping as with the $.60 per mile rate for trucks (Table XIX). The primary difference with the lower truck rate is that most of the shipping is done by trucks whereas the $.60 truck rate caused most shipments to be sent by railroad. Another difference (besides a decrease in the "transfer cost per cwt." column) is that as the truck rate is decreased, the interval for cost changes is reduced also.

The second model which is considered in detail is Model III. It will be observed that the overall geographic distribution for Model III as shown in Table XX is much the same as for Model IV. However, the cost figures per hundredweight transferred include an additional cost variable - cash cost of production. In general, the costs for Model III are greater than Model IV costs because of the inclusion of this variable. However, the same pattern as for Model IV with wide transfer cost intervals on the West and East coasts but very narrow intervals in the middle of the country was also exhibited by Model III. Model III also exhibits a greater sensitivity to truck rate increases than to rate decreases.

Much the same conclusions can be drawn from the Model III solution as the truck rate is decreased to $.46 per mile as for the Model IV solution at the $.46 per mile truck rate. The Model III solution cost analysis for 1965 with a truck rate of $.46 per mile is given in Table XXI.

The transition from the linear programming results of the optimum shipment pattern to the transportation problem type of tableau can be made easily. Table XXII illustrates the optimum shipments of Model IV, with the $.46 truck rate, for 1965 quantities in the general

TABLE XIX

COST ANALYSIS OF MODEL IV OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1965

| Origin | Destination | Quantity Shipped (1,000 head) | Transfer Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Spokane | Bakersfield | 119* | 1.38 | INFINITE | UNBOUNDED | 1.62 | Spokane-Bakersfield |
| Ogden | Bakersfield | 120* | .97 | INFINITE | UNBOUNDED | 1.09 | Ogden-Bakersfield |
| Billings | Bakersfield | 340* | 1.59 | 1.58 | Oklahoma-Denver* | 1.94 | Billings-Bakersfield |
| Oklahoma City | Bakersfield | 1144* | 1.59 | 1.24 | Ogden-Phoenix | 1.60 | Oklahoma-Denver* |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.40 | Oklahoma-Phoenix |
| Billings | Denver | 319 | .81 | .46 | Cheyenne-Bakersfield | .82 | Oklahoma-Denver* |
| Cheyenne | Denver | 289 | .14 | INFINITE | UNBOUNDED | .38 | Cheyenne UNUSE |
| Pierre | Omaha | 138 | .55 | .55 | Pierre-SD. Paul* | .59 | Pierre-Denver |
| Oklahoma City | Omaha | 854 | .67 | .65 | Pierre-Denver* | .68 | Oklahoma-Omaha* |
| Pierre | St. Paul | 610 | .56 | INFINITE | UNBOUNDED | .56 | Pierre-St. Paul* |
| Jackson | Des Moines | 1508 | 1.16 | INFINITE | UNBOUNDED | 1.16 | Jackson UNUSE |
| Louisville | Des Moines | 706 | .81 | INFINITE | UNBOUNDED | .90 | Louisville-Indianapolis |
| Thomasville | Des Moines | 128 | 1.50 | 1.45 | Louisville UNUSE | 1.52 | Harrisburg-Indianapolis |
| Roanoke | Des Moines | 192 | 1.37 | 1.35 | Harrisburg-Indianapolis | 1.50 | Roanoke UNUSE |
| Oklahoma City | Des Moines | 102* | .74 | .67 | Harrisburg-St. Paul | .76 | Pierre-Des Moines* |
| Roanoke | Indianapolis | 253 | .64 | INFINITE | UNBOUNDED | .66 | Harrisburg-Indianapolis |

*Railroad shipments.

TABLE XX

COST ANALYSIS OF MODEL III OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1965

| | | | | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| Origin | Destination | Quantity Shipped (1,000 head) | Trans-fer Cost/ cwt. ($) | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Ogden | Bakersfield | 120* | 3.88 | INFINITE | UNBOUNDED | 4.33 | Ogden-Bakersfield |
| Billings | Bakersfield | 659* | -1.06 | INFINITE | UNBOUNDED | -.91 | Billings-Denver* |
| Oklahoma City | Bakersfield | 944* | 1.59 | 1.44 | Billings-Denver* | 1.62 | Roanoke-Bakersfield* |
| Oklahoma City | Phoenix | 247* | 1.28 | 1.26 | Roanoke-Bakersfield | 1.34 | Jackson-Phoenix* |
| Cheyenne | Denver | 289 | 1.77 | INFINITE | UNBOUNDED | 1.96 | Cheyenne UNUSE |
| Oklahoma City | Denver | 318* | .82 | .46 | Cheyenne-Bakersfield* | .84 | Pierre-Denver* |
| Pierre | Omaha | 138* | .73 | .65 | Jackson-St. Paul* | .76 | Pierre-Denver* |
| Oklahoma City | Omaha | 837* | .68 | .66 | Pierre-Denver* | .71 | Roanoke-Omaha* |
| Jackson | Omaha | 17* | 6.22 | 6.15 | Oklahoma-Des Moines* | 6.24 | Thomasville-Omaha* |
| Pierre | St. Paul | 610* | .74 | INFINITE | UNBOUNDED | .79 | Pierre-St. Paul |
| Louisville | Des Moines | 440 | 10.15 | 8.98 | Roanoke UNUSE | 10.26 | Louisville-Indianapolis |
| Roanoke | Des Moines | 192 | 8.85 | 8.73 | Louisville-Indianapolis | 8.95 | Roanoke-St. Paul |
| Jackson | Des Moines | 1491* | 6.21 | 6.19 | Thomasville-Omaha | 6.28 | Oklahoma-Des Moines* |
| Thomasville | Des Moines | 513* | 6.61 | INFINITE | UNBOUNDED | 6.63 | Thomasville-Omaha* |
| Roanoke | Indianapolis | 253 | 7.89 | INFINITE | UNBOUNDED | 8.01 | Louisville-Indianapolis |

*Railroad shipments.

TABLE XXI

COST ANALYSIS OF MODEL III OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1965

| Origin | Destination | Quantity Shipped (1,000 head) | Transfer Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Ogden | Bakersfield | 120* | 3.88 | INFINITE | UNBOUNDED | 4.00 | Ogden-Bakersfield |
| Billings | Bakersfield | 340* | -1.06 | -1.07 | Oklahoma-Denver | -.71 | Billings-Bakersfield |
| Oklahoma City | Bakersfield | 1263* | 1.59 | 1.24 | Ogden-Phoenix | 1.60 | Oklahoma-Denver* |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.33 | Jackson-Phoenix* |
| Billings | Denver | 319 | -1.84 | -2.18 | Cheyenne-Bakersfield* | -1.83 | Oklahoma-Denver* |
| Cheyenne | Denver | 289 | 1.72 | INFINITE | UNBOUNDED | 1.96 | Cheyenne UNUSE |
| Pierre | Omaha | 138 | .61 | .61 | Pierre-St. Paul* | .65 | Pierre-Denver |
| Oklahoma City | Omaha | 837 | .67 | .75 | Pierre-Denver* | .68 | Oklahoma-Omaha* |
| Jackson | Omaha | 17* | 6.22 | 6.13 | Oklahoma-Des Moines* | 6.24 | Thomasville-Omaha* |
| Pierre | St. Paul | 610 | .62 | INFINITE | UNBOUNDED | .62 | Pierre-St. Paul* |
| Jackson | Des Moines | 1491 | 6.21 | 6.19 | Thomasville-Omaha* | 6.21 | Jackson-Des Moines* |
| Louisville | Des Moines | 440 | 9.90 | 8.92 | Roanoke UNUSE | 9.99 | Louisville-Indianapolis |
| Thomasville | Des Moines | 513 | 6.55 | INFINITE | UNBOUNDED | 6.61 | Thomasville UNUSE |
| Roanoke | Des Moines | 192 | 8.43 | 8.34 | Louisville-Indianapolis | 8.48 | Roanoke-Phoenix* |
| Roanoke | Indianapolis | 253 | 7.70 | 7.65 | Roanoke-Phoenix* | 7.78 | Louisville-Indianapolis |

*Railroad shipments.

TABLE XXII

TRANSPORTATION TABLEAU FOR OPTIMUM SOLUTION
FOR ESTIMATED 1965 QUANTITIES

| Origins (Surplus Regions) | Destinations (Deficit Regions) 2 | 4 | 7 | 9 | 11 | 12 | 14 | Dummy Demand | Feeder Cattle (1,000 Head) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 119 | ... | ... | ... | ... | ... | ... | ... | 119 |
| 3 | 120 | ... | ... | ... | ... | ... | ... | ... | 120 |
| 5 | 340 | ... | 319 | ... | ... | ... | ... | ... | 659 |
| 6 | ... | ... | 289 | ... | ... | ... | ... | ... | 289 |
| 8 | ... | ... | ... | 138 | 610 | ... | ... | ... | 748 |
| 10 | 1144 | 247 | ... | 854 | ... | 102 | ... | ... | 2,347 |
| 13 | ... | ... | ... | ... | ... | 1508 | ... | ... | 1,508 |
| 15 | ... | ... | ... | ... | ... | 706 | ... | ... | 706 |
| 16 | ... | ... | ... | ... | ... | 128 | ... | 385 | 513 |
| 17 | ... | ... | ... | ... | ... | 192 | 253 | ... | 445 |
| 18 | ... | ... | ... | ... | ... | ... | ... | 4 | 4 |
| Dummy Supply Feeder Cattle (1,000 Head) | 1723 | 247 | 608 | 992 | 610 | 2636 | 253 | 389 | 7,458 |

transportation type tableau. To determine the supply of each origin, merely sum across the columns for a particular row. The total supply from each origin is given in the right-hand column of the table. The demand for each destination is found by summing down the rows for a particular column. The total demand of the deficit feeder cattle regions is given in the bottom row of the table. If the bottom row and the right-hand column are each summed, the totals should be equal. Therefore, the condition exists that total demand equals total supply.

The shadow prices which are associated with the optimum solutions are useful for defining which supply regions are very close to entering the least cost solutions. The cost analyses indicated the cost ranges over which the activities in the optimum solution could vary, but do not tell how competitive alternative shipping routes are with respect to the ones appearing in the optimum solution. Therefore, the shadow prices are included in Appendix G for the reader's appraisal.

This chapter has analyzed the feeder cattle situation for 1965. In Chapter III, a projection was made for 1970 demand and supply quantities. In Chapter V the analysis of the results for 1970 will be discussed.

# CHAPTER V

## ANALYSIS OF RESULTS FOR 1970

Because the rate of increase in the demand for feeder cattle has been greater than the rate at which supply has increased, demand projected for 1970 exceeds the projected supply. Demand and supply could be forced into equality either by adjusting demand downward or by adjusting supply upward. The reasoning underlying such an assumption would be that no more cattle could be fed than were supplied. However, equating demand and supply by this means to a degree predetermines the results and does not adequately show which regions have the greatest competitive strength for purchasing or supplying feeder cattle.

An alternative manner of handling the problem of demand exceeding supply and the one selected for use in this study is to assume that each region will continue its present trend in demand until 1970, with no adjustment forcing total demand to equal total supply. This assumption allows the most profitable demand or feeding areas to use all available supplies of feeder cattle first. A dummy supply activity is placed in the model in order to equate total demand with total supply. Since the model requires that all demand must be satisfied, the dummy supply is needed to satisfy the demand in th less competitve regions. A high cost is associated with the use of the dummy supply in order to show that the region which uses it must endure abnormal costs to maintain their projected feeding rate. The high-cost demand areas will be forced either to scale down their feeding activity or increase local production in order to meet their needs.

### The Model Solutions

Models I, II, III, and IV all gave identical geographical optimum patterns of distribution of feeder cattle without regard to truck rates, except the shift from predominantly rail-to-truck transportation when the truck rate decreased from \$.60 to \$.46 per load mile, as was observed with the 1965 quantities. This indicates a stable pattern of distribution over a substantial change in truck rates (see Tables XXIII and XXIV and Figures 15 and 16).

The results of the optimum solution for the 1970 projection are given in Table XXIII and the geographical directional distribution is shown in Figure 15. Bakersfield (California) and Phoenix (Arizona and New Mexico) are found to be the least profitable to supply with feeder cattle by 1970. In fact, Bakersfield shows that it must get three-fourths of its inshipments from the high-cost dummy variable and Phoenix receives forty percent of its supply from the dummy activity. Oklahoma-Texas no longer finds it profitable to ship feeder cattle to California. However, California, Arizona and New Mexico do have access to a feeder cattle supply not considered in the model - from Mexico.

The Northwest and Ogden will ship all available surplus supply into California while Billings ships to California what is left over after Colorado requirements are satisfied. Oklahoma City supplies Phoenix with limited quantities of feeder cattle, but only after exhausting its market opportunities in the Omaha region. Denver receives all of its

TABLE XXIII

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING ESTIMATED COSTS OF MODEL I, II, III, AND IV WITH TRUCK RATE OF $.60 PER MILE, 1970

| From Demand | To Region | Quantity Shipped (1000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 74.9 | 17.6 | NA |
| Spokane | Bakersfield | 113* | 5.0 | 1.2 | 100.0 |
| Ogden | Bakersfield | 161* | 7.1 | 1.7 | 100.0 |
| Billings | Bakersfield | 293* | 13.0 | 3.0 | 37.0 |
| Dummy Supply | Phoenix | 211 | 39.3 | 2.2 | NA |
| Oklahoma City | Phoenix | 326* | 60.7 | 3.4 | 17.3 |
| Billings | Denver | 498* | 57.8 | 5.2 | 63.0 |
| Cheyenne | Denver | 363 | 42.2 | 3.8 | 100.0 |
| Pierre | Omaha | 153* | 7.2 | 1.6 | 20.1 |
| Oklahoma City | Omaha | 1553* | 73.5 | 16.2 | 82.7 |
| Jackson | Omaha | 407* | 19.3 | 4.2 | 23.1 |
| Pierre | St. Paul | 610* | 89.2 | 6.3 | 79.9 |
| Harrisburg | St. Paul | 74* | 10.8 | .8 | 100.0 |
| Jackson | Des Moines | 1353* | 46.5 | 14.1 | 76.9 |
| Louisville | Des Moines | 926 | 31.9 | 9.7 | 100.0 |
| Thomasville | Des Moines | 311* | 10.7 | 3.2 | 100.0 |
| Roanoke | Des Moines | 317 | 10.9 | 3.3 | 56.7 |
| Roanoke | Indianapolis | 242 | 100.0 | 2.5 | 43.3 |

*Railroad shipments.

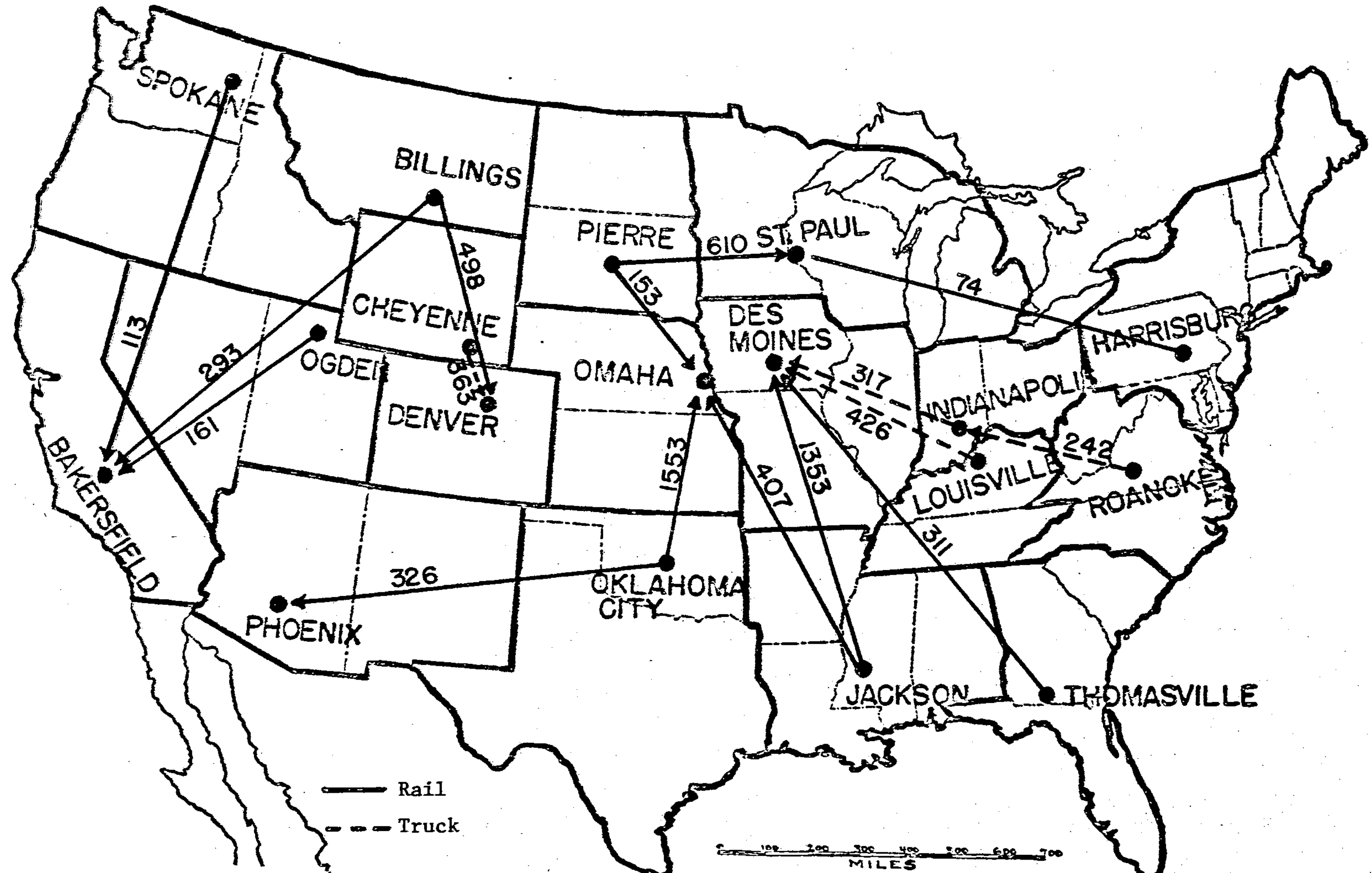


Figure 15. Interregional Flows of Feeder Cattle According to Models I, II, III, And IV with Truck Rate of $.60 Per Mile, 1970.

TABLE XXIV

OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING ESTIMATED COSTS OF MODEL I, II, III, AND IV WITH TRUCK RATE OF $.46 PER MILE, 1970

| From Demand | To Region | Quantity Shipped (1000 Head) | Percent of Regional Demand | Percent of Total Demand | Percent of Supplying Region's Supply |
|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 74.9 | 17.6 | NA |
| Spokane | Bakersfield | 113* | 5.0 | 1.2 | 100.0 |
| Ogden | Bakersfield | 161* | 7.1 | 1.7 | 100.0 |
| Billings | Bakersfield | 293* | 13.0 | 3.0 | 37.0 |
| Dummy Supply | Phoenix | 211 | 39.3 | 2.2 | NA |
| Oklahoma City | Phoenix | 326* | 60.7 | 3.4 | 17.3 |
| Billings | Denver | 498 | 57.8 | 5.2 | 63.0 |
| Cheyenne | Denver | 363 | 42.2 | 3.8 | 100.0 |
| Pierre | Omaha | 153 | 7.2 | 1.6 | 20.1 |
| Oklahoma City | Omaha | 1553 | 73.5 | 16.2 | 82.7 |
| Jackson | Omaha | 407* | 19.3 | 4.2 | 23.1 |
| Pierre | St. Paul | 610 | 89.2 | 6.3 | 79.9 |
| Harrisburg | St. Paul | 74 | 10.8 | .8 | 100.0 |
| Jackson | Des Moines | 1353 | 46.5 | 14.1 | 76.9 |
| Louisville | Des Moines | 926 | 31.9 | 9.7 | 100.0 |
| Thomasville | Des Moines | 311 | 10.7 | 3.2 | 100.0 |
| Roanoke | Des Moines | 317 | 10.9 | 3.3 | 56.7 |
| Roanoke | Indianapolis | 242 | 100.0 | 2.5 | 43.3 |

*Railroad shipments

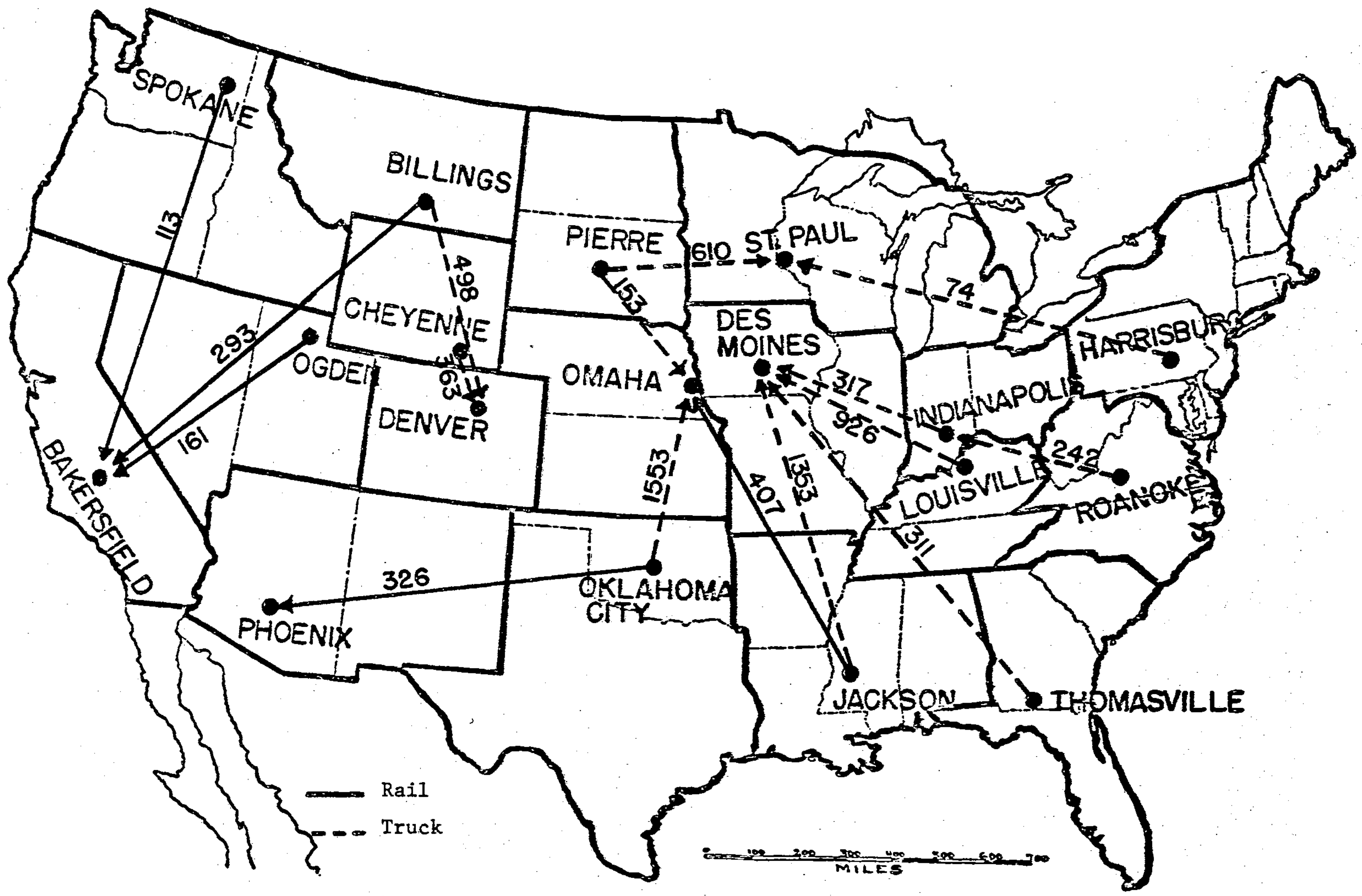


Figure 16. Interregional Flows of Feeder Cattle According to Models I, II, III, And IV with Truck Cost of $.46 Per Mile, 1970.

supply from Wyoming and Montana. Oklahoma City supplies about three-fourths of Omaha's demand for more than two million feeder cattle. Omaha receives its remaining inshipments from Pierre and Jackson. St. Paul still receives the majority of its supply from Pierre but Harrisburg ships all of its available supply to St. Paul. The Corn-Belt regions of Des Moines and Indianapolis receive their entire supply of inshipments of feeder cattle from Jackson, Louisville, Thomasville, and Roanoke.

The potential total supply for 1970 is expected to increase about fifteen percent over that of 1965. However, the total demand is expected to increase by about twenty-eight percent over the same five-year period. Not all regions are expected to show parallel demand and supply shifts with the totals. Some regions will continue to increase but decrease in relative standings with the other regions. Other regions will actually decrease in their demand or supply potential. The expected relative shifts in regional supply and demand are shown in Table XXV.

## Cost Analysis of Models for 1970

When the Model III and Model IV optimum solutions for the projected 1970 quantities are examined in a similar manner as discussed for 1965 in Chapter IV, an interpretation of the cost ranges show that when demand exceeds supply, the intervals over which the optimum solution remains unchanged tend to be somewhat smaller than when supply exceeds the demand. The 1970 Model III and IV optimum solution analyses are given in Tables XXVI, XXVII, XXVIII, and XXIX.

TABLE XXV

REGIONAL PERCENT OF TOTAL DEMAND AND SUPPLY, 1965 - 1970

| Region | 1965 Percent | 1970 Percent | Net Percent Change |
|---|---|---|---|
| | | Demand | |
| Bakersfield | 24.4 | 23.5 | -.9 |
| Phoenix | 3.5 | 5.6 | 2.1 |
| Denver | 8.6 | 9.0 | .4 |
| Omaha | 14.0 | 22.0 | 8.0 |
| St. Paul | 8.6 | 7.1 | -1.5 |
| Des Moines | 37.3 | 30.3 | -7.0 |
| Indianapolis | 3.6 | 2.5 | -1.1 |
| | | Supply | |
| Spokane | 1.6 | 1.5 | -.1 |
| Ogden | 1.6 | 2.1 | .5 |
| Billings | 8.8 | 10.3 | 1.5 |
| Cheyenne | 3.9 | 4.7 | .8 |
| Pierre | 10.0 | 9.9 | -.1 |
| Oklahoma City | 31.5 | 24.4 | -7.1 |
| Jackson | 20.2 | 22.8 | 2.6 |
| Louisville | 9.4 | 12.0 | 2.6 |
| Thomasville | 6.9 | 4.0 | -2.9 |
| Roanoke | 6.0 | 7.3 | 1.3 |
| Harrisburg | .1 | 1.0 | .9 |

TABLE XXVI

COST ANALYSIS OF MODEL III OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1,000 head) | Transfer Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Billings-Omaha* | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | 13.04 | INFINITE | UNBOUNDED | 13.52 | Spokane-Phoenix* |
| Ogden | Bakersfield | 161* | 3.89 | INFINITE | UNBOUNDED | 4.24 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | -1.06 | -1.22 | Oklahoma-Denver* | -1.02 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.84 | Oklahoma-Denver* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.24 | Billings-Omaha* | 1.34 | Jackson-Phoenix* |
| Billings | Denver | 498* | -1.68 | -2.00 | Cheyenne-Phoenix* | -1.59 | Billings-Denver |
| Cheyenne | Denver | 363 | 1.77 | INFINITE | UNBOUNDED | 1.96 | Cheyenne UNUSE |
| Pierre | Omaha | 153* | .73 | .68 | Billings-St. Paul* | .73 | Pierre-Omaha |
| Oklahoma City | Omaha | 1553* | .68 | .62 | Jackson-Phoenix* | .72 | Billings-Omaha* |
| Jackson | Omaha | 407* | 6.22 | 6.17 | Harrisburg-Des Moines* | 6.24 | Thomasville-Omaha* |
| Pierre | St. Paul | 610* | .74 | .74 | Pierre-Omaha | .79 | Pierre UNUSE |
| Harrisburg | St. Paul | 74* | 10.90 | INFINITE | UNBOUNDED | 10.94 | Harrisburg-Des Moines* |
| Jackson | Des Moines | 1353* | 6.21 | 6.19 | Thomasville-Omaha* | 6.26 | Harrisburg-Des Moines* |
| Louisville | Des Moines | 926 | 10.15 | INFINITE | UNBOUNDED | 10.26 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311* | 6.61 | INFINITE | UNBOUNDED | 6.63 | Thomasville-Omaha* |
| Roanoke | Des Moines | 317 | 8.85 | 8.80 | Harrisburg-Indianapolis | 8.95 | Roanoke-St. Paul |
| Roanoke | Indianapolis | 242 | 7.89 | INFINITE | UNBOUNDED | 7.94 | Harrisburg-Indianapolis |

*Railroad shipments

TABLE XXVII

COST ANALYSIS OF MODEL III OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1970

| | | | | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| Origin | Destination | Quantity Shipped (1,000 head) | Transfer Cost/ cwt. ($) | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Ogden-Phoenix | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | 13.04 | INFINITE | UNBOUNDED | 13.28 | Spokane-Bakersfield |
| Ogden | Bakersfield | 161* | 3.88 | INFINITE | UNBOUNDED | 3.93 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | -1.06 | -1.37 | Oklahoma-Denver* | -1.00 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.69 | Oklahoma-Bakersfield* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.23 | Billings-Omaha* | 1.33 | Jackson-Phoenix |
| Billings | Denver | 498 | -1.84 | -2.00 | Cheyenne-Phoenix* | -1.68 | Billings-Denver* |
| Cheyenne | Denver | 363 | 1.72 | INFINITE | UNBOUNDED | 1.96 | Cheyenne-UNUSE |
| Pierre | Omaha | 153 | .61 | .61 | Pierre-St. Paul* | .65 | Harrisburg-Indianapolis |
| Oklahoma City | Omaha | 1553 | .67 | .62 | Jackson-Phoenix* | .68 | Oklahoma-Omaha* |
| Jackson | Omaha | 407* | 6.22 | 6.18 | Harrisburg-Indianapolis | 6.24 | Thomasville-Omaha* |
| Pierre | St. Paul | 610 | .62 | .58 | Harrisburg-Indianapolis | .62 | Pierre-St. Paul* |
| Harrisburg | St. Paul | 74 | 10.59 | INFINITE | UNBOUNDED | 10.63 | Harrisburg-Indianapolis |
| Jackson | Des Moines | 1353 | 6.21 | 6.19 | Thomasville-Omaha* | 6.21 | Jackson-Des Moines* |
| Louisville | Des Moines | 926 | 9.90 | INFINITE | UNBOUNDED | 9.99 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311 | 6.55 | INFINITE | UNBOUNDED | 6.61 | Thomasville-UNUSE |
| Roanoke | Des Moines | 317 | 8.43 | 8.39 | Harrisburg-Indianapolis | 8.48 | Roanoke-Phoenix* |
| Roanoke | Indianapolis | 242 | 7.70 | 7.65 | Roanoke-Phoenix* | 7.74 | Harrisburg-Indianapolis |

*Railroad shipments

TABLE XXVIII

COST ANALYSIS OF MODEL IV OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| | | | | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Billings-Omaha* | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | 1.38 | INFINITE | UNBOUNDED | 1.86 | Spokane-Phoenix* |
| Ogden | Bakersfield | 161* | .97 | INFINITE | UNBOUNDED | 1.33 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | 1.59 | 1.44 | Oklahoma-Denver* | 1.64 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.84 | Oklahoma-Denver* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.26 | Roanoke-Omaha* | 1.34 | Jackson-Phoenix* |
| Billings | Denver | 498* | .97 | .65 | Cheyenne-Phoenix* | 1.06 | Billings-Denver |
| Cheyennne | Denver | 363 | .19 | INFINITE | UNBOUNDED | .38 | Cheyenne-UNUSE |
| Pierre | Omaha | 153* | .67 | .62 | Billings-St. Paul* | .72 | Pierre-Omaha |
| Oklahoma City | Omaha | 1553* | .68 | .62 | Jackson-Phoenix* | .71 | Roanoke-Omaha* |
| Jackson | Omaha | 407* | 1.17 | 1.12 | Harrisburg-Des Moines* | 1.19 | Thomasville-Omaha* |
| Pierre | St. Paul | 610* | .68 | .63 | Harrisburg-Des Moines* | .73 | Pierre-St. Paul |
| Harrisburg | St. Paul | 74* | 1.80 | INFINITE | UNBOUNDED | 1.86 | Harrisburg-Des Moines* |
| Jackson | Des Moines | 1353* | 1.16 | 1.14 | Thomasville-Omaha* | 1.21 | Harrisburg-Des Moines |
| Lousiville | Des Moines | 926 | 1.06 | INFINITE | UNBOUNDED | 1.17 | Lousiville-Indianapolis |
| Thomasville | Des Moines | 311* | 1.56 | INFINITE | UNBOUNDED | 1.58 | Thomasville-Omaha* |
| Roanoke | Des Moines | 317 | 1.79 | 1.74 | Harrisburg-Indianapolis | 1.89 | Roanoke-St. Paul |
| Roanoke | Indianapolis | 242 | .83 | INFINITE | UNBOUNDED | .88 | Harrisburg-Indianapolis |

*Railroad shipments

TABLE XXIX

COST ANALYSIS OF MODEL IV OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/ cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Ogden-Phoenix | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | 1.38 | INFINITE | UNBOUNDED | 1.62 | Spokane-Bakersfield |
| Ogden | Bakersfield | 161* | .97 | INFINITE | UNBOUNDED | 1.02 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | 1.59 | 1.28 | Oklahoma-Denver* | 1.65 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.69 | Oklahoma-Bakersfield* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.23 | Billings-Omaha* | 1.33 | Jackson-Phoenix* |
| Billings | Denver | 498 | .81 | .65 | Cheyenne-Phoenix* | .97 | Billings-Denver* |
| Cheyenne | Denver | 363 | .14 | INFINITE | UNBOUNDED | .38 | Cheyenne UNUSE |
| Pierre | Omaha | 153 | .55 | .55 | Pierre-St. Paul* | .59 | Harrisburg-Indianapolis |
| Oklahoma City | Omaha | 1553 | .67 | .62 | Jackson-Phoenix* | .68 | Oklahoma-Omaha* |
| Jackson | Omaha | 407* | 1.17 | 1.13 | Harrisburg-Indianapolis | 1.19 | Thomasville-Omaha* |
| Pierre | St. Paul | 610 | .56 | .52 | Harrisburg-Indianapolis | .56 | Pierre-St. Paul* |
| Harrisburg | St. Paul | 74 | 1.50 | INFINITE | UNBOUNDED | 1.54 | Harrisburg-Indianapolis |
| Jackson | Des Moines | 1353 | 1.16 | 1.14 | Thomasville-Omaha | 1.16 | Jackson-Des Moines* |
| Louisville | Des Moines | 926 | .81 | INFINITE | UNBOUNDED | .90 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311 | 1.50 | INFINITE | UNBOUNDED | 1.56 | Thomasvillle UNUSE |
| Roanoke | Des Moines | 317 | 1.37 | 1.33 | Harrisburg-Indianapolis | 1.42 | Roanoke-Phoenix* |
| Roanoke | Indianapolis | 242 | .64 | .59 | Roanoke-Phoenix* | .68 | Harrisburg-Indianapolis |

*Railroad shipments

Table XXX illustrates the optimum shipments of Model III and IV for 1970 quantities in the general transportation type tableau which was previously explained for the 1965 results in Chapter IV.

TABLE XXX

TRANSPORTATION TABLEAU FOR OPTIMUM SOLUTION
FOR ESTIMATED 1970 QUANTITIES

| Origins (Surplus Regions) | Destinations (Deficit Regions) | | | | | | | | Feeder Cattle (1000 head) |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 7 | 9 | 11 | 12 | 14 | Dummy Demand | |
| 1 | 113 | | | | | | | | 113 |
| 3 | 161 | | | | | | | | 161 |
| 5 | 293 | | 498 | | | | | | 791 |
| 6 | | | 363 | | | | | | 363 |
| 8 | | | | 153 | 610 | | | | 763 |
| 10 | | 326 | | 1553 | | | | | 1879 |
| 13 | | | | 407 | | 1353 | | | 1760 |
| 15 | | | | | | 926 | | | 926 |
| 16 | | | | | | 311 | | | 311 |
| 17 | | | | | | 317 | 242 | | 559 |
| 18 | | | | | 74 | | | | 74 |
| Dummy Supply | 1693 | 211 | | | | | | | 1904 |
| Feeder Cattle (1000 head) | 2260 | 537 | 861 | 2113 | 684 | 2907 | 242 | 0 | 9604 |

# CHAPTER VI

# SUMMARY AND CONCLUSIONS

## Summary of Data

This study has analyzed the feeder cattle industry in the United States for purposes of estimating the optimum patterns of feeder cattle distribution. The locations of basic breeding herds were taken as predetermined but consideration was given to changes in the relative importance of regional contributions to total feeder cattle supplies over time. Available data showed that when the United States was divided into eighteen regions, aggregation of available supply and demand in each region resulted in eleven surplus regions (supply areas) and seven deficit regions (demand areas).

The primary motor truck unit used for this study was the tractor semi-trailer combination. More specifically, a tractor with diesel power and the forty-foot possum-belly semi-trailer is considered to be the lowest cost motor truck unit for long hauls for feeder cattle. This unit has the desirable qualities of maximum floor space for the trailer length, keeps the truck length within the legal limit in all states and makes it easier to get the maximum load weight than the straight trailer of the same length.[1] The possum-belly cattle trailer's

[1]See Appendix E for state length and weight regulations for motor trucks.

use is wide-spread in the Oklahoma area and most of the cattle haulers interviewed indicated that they needed possum-belly trailers to compete for the feeder cattle business on long hauls.

Although a specific study on backhauls was not made for this problem, their importance is considered to be a prominent factor in present competitive conditions in the transportation of feeder cattle. The firms with the larger volume and scope of business operations definitely appear to have some advantage over small operators in the struggle for the available backhauls: (1) the large firm has regular contacts at many points of destination to increase its chances of backhauls, and (2) the people providing backhauls often give first choice to regular, dependable haulers rather than those who provide these services at infrequent and irregular intervals. Backhauls were available to the surveyed truckers about one third of the time. This was reflected by an appropriate adjustment in the hauling rate.

Feedlot production of fed beef has increased rapidly, especially during the period from 1960-1965. The feedlot demand for feeder cattle increased faster than the supply of feeder cattle over this period. It is expected that by 1970 the demand for feeder cattle will exceed the supply. In other words, virtually all steer and heifer beef will pass through at least some short period of time in a feedlot operation.

At first glance, the railroads appear to have a comparative advantage over motor truck transportation of feeder cattle. If an optimum solution were obtained considering only straight one-way hauls, the cattle industry could move closer to a least-cost marketing pattern by shipping less by truck and more by railroad.

Perhaps the best explanation for the greater use of motor truck transportation for feeder cattle marketing is the impact of the recent dispersion of the feeding industry and packing plants. Twenty years ago, most cattle feeding was done in the North Central states, and feeder cattle were shipped from the South, West, and North into that area. Today, cattle feeding is widespread throughout the Western half of the United States. Packing plants are being constructed nearer these sources of supply. These new facilities tend to be more efficient than older facilities in the traditional feeding areas.[2] It has often been conceded that railroads have an advantage for hauls more than 700 to 750 miles in length, but today most hauls to feedlots or feeding areas from supply regions are within this mileage range. With generally better highways in all states, the motor truck takes much of the cattle hauling from the railroads. Truck hauling of feeder cattle has the advantages of convenience at the ranch sites, flexibility of schedule, faster service, and generally lower rates on short hauls. Railroads have advantages in rates on long hauls, grazing privileges, and market testing privileges.

## Summary of Results

The optimum distributions of Models I, II, III, and IV depicted patterns that were very similar for both the truck rate of $.60 and $.46 per mile. Since the quantity transported and the transportation charges

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[2]John W. Goodwin, Cattle Feeding - An Analysis of Oklahoma's Opportunities, Processed Series P-488, Oklahoma Agricultural Experiment Station (Stillwater, 1965), pp. 28-31.

were included in all four models, and since the optimum patterns were essentially the same for all models, the overwhelming factors for determining optimum patterns of feeder cattle distribution are the weight of the shipment and the distance between the supply region and alternative demand areas. In general, variables such as production costs and price differentials did not alter the pattern. For 1965, the optimum pattern for feeder cattle shipments is generally as follows: The Pacific Northwest, Utah, and Nevada will ship all of their export supply of feeder cattle into California feedlots. If feeder cattle were in fact homogeneous among regions, the Montana area should ship its feeder cattle by railroad into California and by truck into Colorado, but because of quality differences, this area in fact ships most of its cattle into the Nebraska and Iowa areas. The Southern Plains region was the largest supplier of feeder cattle and would be expected to ship fifty percent of its exports of feeder cattle into California, ten percent into the Arizona-New Mexico region, thirty-six percent into the Kansas-Nebraska area, and about four percent into the Western Corn-Belt region.

However, according to the study by Abel and Capener[3], more than half of the Southern Plains' outshipments of feeder cattle moved into California, Arizona, and Colorado. More than thirty percent of Texas' outshipments were shipped into California, but the remaining portion of the Southern Plains' outshipments moved North and Northeast into Kansas, Nebraska, Iowa, and Illinois.

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[3]Abel and Capener, pp. 6-16.

Both the Model solutions and actual data show that the Dakotas ship feeder cattle into Minnesota, Nebraska and the Western Corn-Belt regions. Colorado should be supplied by Montana and Wyoming. It appears however, that Colorado receives about sixty percent of its inshipments from Texas, New Mexico, and Oklahoma. For the most part, the South Central and Southeastern regions should ship feeder cattle into the Western Corn-Belt feedlots while the Mid-Atlantic and Appalachian regions should ship into the Eastern Corn-Belt feedlots. Under the 1965 conditions when supply exceeded demand, the small supply of feeder cattle in the Northeast did not have a feasible market.

## Conclusions

The main difference in the 1970 optimum pattern of distribution from the 1965 optimum pattern is that shipments from the Oklahoma-Texas area into California would be expected to virtually cease. However, estimated shipments from the Oklahoma-Texas region into the Kansas-Nebraska area would nearly double. Arizona and California may experience disadvantages in obtaining feeder cattle by 1970. The importance of the feeder cattle supply from the South Central and Southeastern states will become increasingly important to the Corn-Belt regions by 1970. With the abundant supply of local feeder cattle, large efficient feedlot operations, adequate feed grain supplies, and excellent nearby markets for both excess feeder cattle and fed beef, the Texas-Oklahoma region occupies a very prominant position in the beef sector of our eocnomy both in 1965 and 1970.

The growth of the cattle feeding industry in the Southwestern states during the last five years tends to coincide with the results of this study. According to studies made by Goodwin[4] and Uvacek[5], Oklahoma and Texas have increased their cattle feeding capabilities tremendously from 1960 to 1965, and are expected to continue to increase even more rapidly in the near future. The large supply of good feeder cattle, which were once available from the Texas-Oklahoma region for shipment into the Corn-Belt and California regions, will be greatly reduced as local feeding increases within the Texas-Oklahoma region. The Southern Plains are in an excellent location to utilize the large supplies of feed grains necessary for feeding locally produced cattle.

Implications

The results of this study show that without backhauls the motor truck carriers are hard pressed to compete with the railroads for the transportation of feeder cattle in interstate or interregional transfer. Since the cost of transportation was the major consideration for marketing costs, feeder cattle producers should ship cattle by railroad if loading facilities are nearby and if the motor truck rate is near the sixty-cent per load mile rate. The results also showed that under the present structure of railroad rates, motor trucks could very effectively compete with the railroad when the truckers were able to get backhauls one third of the time. If the truckers could get backhauls one third of the time, then they could charge a rate of $.46 per load mile and would be the cheapest source of transportation for feeder cattle on all hauls except

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[4]Goodwin, Cattle Feeding - An Analysis of Oklahoma's Opportunities, pp. 14-36.

[5]Edward Uvacek, Jr., Economic Trends of Texas Cattle Feeding (College Station: Texas Agricultural Experiment Station Bulletin B-1055, 1966), pp. 8-28.

the very long ones into California. The forty-foot possum belly trailer was the specific unit used for this study because it appears to be the most efficient type of livestock trailer for interstate transport of feeder cattle that stays within the legal length and weight regulations of all states.

Limitations

It must be kept in mind that the results of this study are estimates of the expected patterns of distribution which would optimize the returns for feeder cattle producers. The entire study has been based upon the condition that the railroad rates are held constant at their present levels. In other words, the exempt private carriers of agricultural commodities can be much more flexible with the rates they charge than the railroads.

Although the four theoretical models used in this study obtain feasible solutions quickly with the aid of the high speed computer, they are limited to the numerical data which are available. One obvious limitation is the inability to handle quality differences of feeder cattle between regions. Another restriction on the models is that information was available only on a state by state basis. In other words, feeder cattle producing regions or feeding regions which cross over state boundaries cannot be aggregated because of the lack of this type of data.

Data for the demand of feeder cattle as it existed in 1965 were not available before 1960; consequently, the short span of years of observation from 1960 to 1965 limits the degree of confidence about any long term projection. Therefore, a five-year projection to 1970 was considered to be adequate to give an indication of what directions of movement can be expected for the next few years. However, it should be pointed out that the magnitudes of changes may be either overstated or understated. The predicted results would be uncertain over very long periods of time.

Need for Further Study

There is need for additional study about the existing and expected possibilities for backhauls for interstate truck livestock haulers. More information is needed on the seasonality of backhauls by region, organization of market information concerning existing possibilities for truckers, and what modifications can be made to livestock trailers to make them more flexible to a wider range of backhaul cargo.

Another area for further study is that concerned with the losses from shrinkage enroute by truck and rail. There is some evidence that ranchers shipping cattle consider the time in transient and method of transportation more important than small differences in cost by truck or rail. The results of the models show that through the middle of the country, the cost ranges over which the transportation rate may vary are very small. Therefore, the variation of shrinkage and loss through shipping could be a very decisive factor in determining optimum patterns of distribution for feeder cattle.

Because the Southern Plains region is expected to continue to expand its cattle feeding activities substantially within the near future, a third area for further study is that concerned with the feeding and slaughtering cost variables for beef cattle. A study of this type would be an expansion of the study on optimum patterns of feeder cattle distribution. Feeding and slaughtering cost variables could be considered as modified storage and processing activites which could be adapted to theoretical models of the type used by Martin[6] in his study of the DELMARVA Poultry Industry, Leath and Martin in their transhipment problem model[7], and Hurt and Tramel[8], also with the transhipment problem model.

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[6] James E. Martin, _The Effects of Changes in Transportation Rates on the DELMARVA Poultry Industry_, Miscellaneous Publication No. 515, Maryland Agricultural Experiment Station (College Park, 1964).

[7] Mack N. Leath and James E. Martin, "The Transhipment Problem with Inequality Restraints," _Journal of Farm Economics_, Vol. 48, No. 4, Part I, (November, 1966), pp. 894-908.

[8] Verner G. Hurt and Thomas E. Tramel, "Alternative Formulations of the Transhipment Problem", _Journal of Farm Economics_, Vol. 47 (August, 1965), pp. 763-773.

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# APPENDIXES

## APPENDIX A

### RAILROAD RATES BETWEEN POINTS PER HUNDREDWEIGHT OF FEEDER CATTLE

| | Destination | | | | | | |
|---|---|---|---|---|---|---|---|
| Origin | Bakersfield | Phoenix | Denver | Omaha | St. Paul | Des Moines | Indianapolis |
| Spokane | 1.38 | 1.86 | 1.40 | 1.63 | 1.52 | 1.74 | 2.32 |
| Ogden | .92 | 1.05 | .70 | 1.24 | 1.97 | 1.48 | 2.21 |
| Billings | 1.59 | 1.75 | .97 | 1.03 | 1.04 | 1.24 | 1.92 |
| Cheyenne | 1.50 | 1.32 | .38 | .78 | 1.12 | .92 | 1.62 |
| Pierre | 2.21 | 1.63 | .84 | .67 | .68 | .76 | 1.44 |
| Oklahoma City | 1.59 | 1.28 | .82 | .68 | .88 | .74 | 1.20 |
| Jackson | 2.20 | 1.83 | 1.34 | 1.17 | 1.26 | 1.16 | 1.46 |
| Louisville | 2.61 | 2.28 | 1.73 | 1.54 | 1.64 | 1.45 | 1.46 |
| Thomasville | 2.74 | 2.37 | 1.80 | 1.59 | 1.70 | 1.56 | 1.56 |
| Roanoke | 2.87 | 2.54 | 2.34 | 1.96 | 2.25 | 2.00 | 1.12 |
| Harrisburg | 2.99 | 2.69 | 2.22 | 1.98 | 1.80 | 1.84 | 1.25 |

Based on 25,000 pounds per carload which is approximately 50 head of 500-lb. feeders.

APPENDIX B

FORTRAN STATEMENTS TO COMPUTE AND PUNCH CARDS
FOR LINEAR PROGRAMMING INPUT

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```
  0 DIMENSION X(10,20), CASH(20), PRICE(20), IMKT1(20),
  1 IMKT2(20), ISUP1(20), ISUP2(20)
    READ(5,1) ((IMKT1(I), IMKT2(I)), I=1,8)
    READ(5,1) ((ISUP1(I), ISUP2(I)), I=1, 11)
    READ(5,2) ((X(I,J), J=1,11),I=1,8)
    READ(5,5) NAME1
    READ(5,8) (PRICE(J),J=1,11)
    READ(5,8) (CASH(J), J=1,11)
1   FORMAT(12X,2A3)
2   FORMAT(16F5.0)
5   FORMAT(1A10)
6   FORMAT(6X,2A3,6H10COST,F12.6)
7   FORMAT(6X,2A3,2A3,1A10)
8   FORMAT(10F8.4)
    DO15 I=1,8
    DO15 J=1,11
    COST4=.001846*X(I,J)
    WRITE(7,6)ISUPI(J),IMKT1(I),COST4
    WRITE(7,7)ISUP1(J),IMKT1(I),IMKT1(I), IMKT2(I), NAME1
    WRITE(7,7) ISUP1(J),IMKT1(I),ISUP1(J),ISUP2(J),NAME1
    WRITE(6,6)ISUP1(J),IMKT1(I),COST4
    WRITE(6,7)ISUP1(J),IMKT1(I),IMKT1(I),IMKT2(I),NAME1
    WRITE,6,7)ISUP1(J),IMKT1(I),ISUP1(J),ISUP2(J),NAME1
15  CONTINUE
    CALL EXIT
    END
```

## APPENDIX C

## PRIVATE MOTOR CARRIERS DEFINED

Section 203(a) (17) of the Interstate Commerce Act defines private carriers as:

> . . . any person not included in the terms, "common carried by motor vehicle" or "contract carried by motor vechicle," who or which transports in interstate or foreign commerce by motor vehicle property of which such person is the owner, lessee, or bailee, when such transportation is for the purpose of sale, lease, rent, or bailment, or in furtherance of any commercial enterprise.

Section 203(c) of the Interstate Commerce Act further defines private motor carriage as transportation ". . . within the scope, and in furtherance, of a primary business enterprise (other than transportation) . . ."

Since only common and contract carriers are subject to economic regulation by the Interstate Commerce Commission, private motor carriage may be conducted without economic regulation by the Commission (5, Sec. 204(1)(2)).

Section 203(c) of the Interstate Commerce Act also states that the provisions of Section 203(b) of the Act apply to private motor carriers. Section 203(b) reads in part:

> . . . Nothing in this part, except the provisions of Section 204 relative to qualifications and maximum hours of service of employees and safety of operation or standards of equipment shall be construed to include . . . Motor vehicles used in carrying property consisting of ordinary livestock, fish (including shell fish), or agricultural (including horticultural) commodities (not including manufactured products thereof), if such motor vehicles are not used in carrying

any other property, or passengers, for compensation: Provided, That the words "property consisting of ordinary livestock, fish (including shell fish), or agricultural (including horticultural) commodities (not including manufactured products thereof)" as used herein shall include property shown as "Exempt" in the "Commodity List" incorporated in ruling numbered 107, March 19, 1958, Bureau of Motor Carriers, Interstate Commerce Commission, but shall not include property shown therein as "not exempt": Provided further, however, That notwithstanding the preceeding proviso the words "property consisting of ordinary livestock, fish (including shell fish), or agricultural (including horticultural) commodities (not including manufactured products thereof)" shall not be deemed to include frozen fruits, frozen berries, frozen vegetables, cocoa beans, coffee beans, tea, bananas, or hemp, and wool imported from any foreign country, wool tops and noil, or wool waste (carded, spun, woven, or knitted), and shall be deemed to include cooked or uncooked (including breaded) fish or shell fish when frozen or fresh (but not including fish and shell fish which have been treated for preserving, such as canned, smoked, pickled, spiced, corned, or kippered products); . . .

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Source: T. Q. Hutchinson, Private Motor Carriers of Exempt Agricultural Commodities (Washington: MED, ERS, USDA, Marketing Research Report No. 696, 1965), p. 25.

## APPENDIX D

## THE AGRICULTURAL EXEMPTION

Exemption from Economic Regulation was provided for Motor Carriers by the Congress under the Motor Carrier portion of the Interstate Commerce Act. Part II Sec. 203(b) is of particular interest to Agriculture. That Section reads in part as follows:

> (4a) Motor vehicles controlled and operated by any farmer when used in the transportation of his agricultural (including horticultural) commodities and products thereof, or in the transportation of supplies to his farm; or
> (5) motor vehicles controlled and operated by a cooperative association as defined in the Agricultural Marketing Act, approved June 15, 1929, as amended, by a federation of such cooperative associations, if such federation possesses no greater powers or purposes than cooperative associations so defined; or
> (6) motor vehicles used in carrying property consisting of ordinary livestock, fish (including shell fish), or agricultural (including horticultural) commodities (not including manufactured products thereof), if such motor vehicles are not used in carrying any other property, or passengers, for compensation: Provided, That the words "property consisting of ordinary livestock, fish (including shell fish), or agricultural (including horticultural) commodities (not including manufactured products thereof)" as used herein shall include property shown as "Exempt" in the "Commodity List" incorporated in rluing numbered 107, March 19, 1958, Bureau of Motor Carriers, Interstate Commerce Commission, but shall not include property shown therein as "Not exempt": Provided further, however, That notwithstanding the preceding proviso the words "property consisting of ordinary livestock, fish (including shell fish), or agricultural (including horticultural) commodities (not including manufactured products thereof)" shall not be deemed to include frozen fruits, frozen berries, frozen vegetables, cocoa beans, coffee beans, tea, bananas, or hemp, and wool imported from any foreign country, wool tops and noils, or wool waste (carded, spun, woven, or knitted), and shall be deemed to include cooked or uncooked (including breaded) fish or shell fish when frozen or fresh (but not including fish and shell fish which

have been treated for preserving, such as canned, smoked, pickled, spiced, corned or kippered products); . . .[1]

[1]The Interstate Commerce Act revised to October 1, 1958, page 124.

Source: Mildred R. DeWolfe, *For-Hire Motor Carriers Hauling Exempt Agricultural Commodiites--Nature and Extent of Commodities* (Washington: MED, ERS, USDA, Marketing Research Report No. 585, 1963), p. 17.

APPENDIX E, TABLE I

STATE LAWS RESTRICTING WEIGHTS OF LIVESTOCK TRUCKS

| State | Axle Load Limits Single (lbs.) | Axle Load Limits Tandem (lbs.) | Maximum Gross Weight: Tractor and semi-trailer[a] 4-Axle[b] (lbs.) | Maximum Gross Weight: Tractor and semi-trailer[a] 5-Axle[c] (lbs.) | Maximum Gross Weight: Other Combination (lbs.) |
|---|---|---|---|---|---|
| Alabama | 18,000 | 36,000 | 63,000 | 73,280 | 73,280 |
| Arizona | 18,000 | 32,000 | 59,000 | 73,000 | 76,800 |
| Arkansas | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| California | 18,000 | 32,000 | 73,280 | 73,280 | 76,800 |
| Colorado | 18,000 | 36,000 | 63,000 | 67,200 | 75,200 |
| Connecticut | 22,400 | 36,000 | 67,400 | 73,000 | 73,000 |
| Delaware | 20,000 | 36,000 | 60,000 | 73,280 | 73,280 |
| Florida | 20,000 | 40,000 | 66,610 | 66,610 | 66,610 |
| Georgia | 20,340 | 40,680 | 63,280 | 73,280 | 73,280 |
| Idaho | 18,000 | 32,000 | 59,000 | 73,280 | 76,800 |
| Illinois | 18,000 | 32,000 | 64,000 | 73,280 | 73,280 |
| Indiana | 18,000 | 32,000 | 59,000 | 72,000 | 72,000 |
| Iowa | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Kansas | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Kentucky | 18,000 | 32,000 | 59,640 | 73,280 | 73,280 |
| Louisiana | 18,000 | 32,000 | 50,000 | 64,000 | 68,000 |
| Maine | 22,000 | 36,000 | 66,300 | 73,280 | 73,280 |
| Maryland | 22,400 | 40,000 | 65,000 | 73,280 | 73,280 |
| Massachusetts | 22,400 | 36,000 | 67,400 | 73,000 | 73,000 |
| Michigan | 18,000 | 26,000 | 59,000 | 67,000 | 105,000 |
| Minnesota | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Mississippi | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Missouri | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Montana | 18,000 | 32,000 | 59,000 | 73,280 | 76,800 |
| Nebraska | 18,000 | 32,000 | 59,000 | 70,500 | 71,146 |
| Nevada | 18,000 | 32,000 | 59,000 | 73,280 | 76,800 |
| New Hampshire | 22,400 | 36,000 | 66,400 | 70,000 | 73,280 |
| New Jersey | 22,400 | 32,000 | 63,400 | 73,280 | 73,280 |
| New Mexico | 21,600 | 34,320 | 64,920 | 75,600 | 86,400 |
| New York | 22,400 | 36,000 | 67,400 | 71,000 | 71,000 |
| North Carolina | 18,000 | 36,000 | 64,000 | 70,000 | 73,280 |
| North Dakota | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Ohio | 19,000 | 24,000 | 59,500 | 72,000 | 78,000 |
| Oklahoma | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Oregon | 18,000 | 32,000 | 59,000 | 73,280 | 76,000 |
| Pennsylvania | 22,400 | 36,000 | 60,000 | 71,145 | 73,280 |
| Rhode Island | 22,400 | 36,000 | 67,400 | 73,280 | 73,280 |
| South Carolina | 20,000 | 32,000 | 65,000 | 73,280 | 73,280 |
| South Dakota | 18,000 | 32,000 | 59,000 | 72,110 | 73,280 |
| Tennessee | 18,000 | 32,000 | 59,000 | 73,280 | 73,280 |
| Texas | 18,000 | 32,000 | 58,420 | 72,000 | 72,000 |
| Utah | 18,000 | 33,000 | 60,000 | 76,500 | 79,900 |

APPENDIX E, TABLE I , (CONTINUED)

| State | Axle Load Limits | | Maximum Gross Weight | | |
|---|---|---|---|---|---|
| | | | Tractor and semi-trailer[a] | | Other |
| | Single | Tandem | 4-Axle[b] | 5-Axle[c] | Combination |
| | (lbs.) | (lbs.) | (lbs.) | (lbs.) | (lbs.) |
| Vermont | 22,400 | 36,000 | 60,000 | 60,000 | 60,000 |
| Virginia | 18,000 | 32,000 | 59,000 | 70,000 | 70,000 |
| Washington | 18,000 | 32,000 | 59,000 | 68,000 | 72,000 |
| West Virginia | 18,000 | 32,000 | 59,000 | 60,800 | 73,280 |
| Wisconsin | 19,500 | 32,000 | 67,500 | 73,000 | 73,000 |
| Wyoming | 18,000 | 36,000 | 63,000 | 72,110 | 73,950 |

[a]To permit comparison between states, maximum weights for tractor semi-trailer combinations assumes maximum over all length of 50 feet, with 44 feet between extreme axles.

[b]2-axle tractor, tandem-axle semi-trailer.

[c]3-axle tractor, tandem-axle semi-trailer.

Source: Watch Your Weight! State Size and Weight Limits for Trucks and Truck-Trailers, Truck-Trailer Manufacturers Association, Inc., 1413 K Street, N. W., Washington, D. C., 20005, January 1, 1967.

APPENDIX E, TABLE II

STATE LAWS RESTRICTING SIZES OF LIVESTOCK TRUCKS

| State | Height | Wider | Length | | | | |
|---|---|---|---|---|---|---|---|
| | | | Semi-trailer length | Full trailer length | Tractor and semi-trailer | Truck and full trailer | Tractor semi- and full trailer |
| | (ft.-in.) | (inches) | (feet) | (feet) | (feet) | (feet) | (feet) |
| Alabama | 13-6 | 96 | NS | NS | 55 | NP | NP |
| Arizona | 13-6 | 96 | NR | NR | 65 | 65 | 65 |
| Arkansas | 13-6 | 96 | NR | NR | 55 | 55 | 55 |
| California | 13-6 | 96 | 40 | 40 | 60 | 65 | 65 |
| Colorado | 13-6 | 96 | NR | NR | 65 | 65 | 65 |
| Connecticut | 13-6 | 102 | 40 | 40 | 55 | NP | NP |
| Delaware | 13-6 | 96 | 40 | 40 | 55 | 60 | 60 |
| Florida | 13-6 | 96 | NR | 35 | 55 | 55 | NP |
| Georgia | 13-6 | 96 | 55 | 55 | 55 | 55 | 55 |
| Idaho | 14-0 | 96 | NR | NR | 60 | 65 | 65 |
| Illinois | 13-6 | 96 | 42 | 42 | 55 | 60 | 65 |
| Indiana | 13-6 | 96 | NR | NR | 55 | 55 | 65 |
| Iowa | 13-6 | 96 | NR | NR | 55 | 55 | 60 |
| Kansas | 13-6 | 96 | 42.5 | 42.5 | 55 | 65 | 65 |
| Kentucky | 13-6 | 96 | NR | NR | 55 | 65 | 65 |
| Louisiana | 13-6 | 96 | NR | NR | 60 | 65 | NP |
| Maine | 13-6 | 96 | NR | NR | 55 | 55 | NP |
| Maryland | 13-6 | 96 | NR | NR | 55 | 55 | 55 |
| Massachusetts | NS | 96 | NR | 33 | 55 | NR | NP |
| Michigan | 13-6 | 96 | 40 | 40 | 55 | 55 | 65 |
| Minnesota | 13-6 | 96 | NR | 40 | 50 | 50 | NP |
| Mississippi | 13-6 | 96 | NS | NS | 55 | 55 | NP |
| Missouri | 13-6 | 96 | NR | NR | 55 | 55 | 65 |
| Montana | 13-6 | 96 | NR | NR | 60 | 60 | 65 |
| Nebraska | 13-6 | 96 | NR | 40 | 60 | 60 | 65 |
| Nevada | NR | 96 | NR | NR | NR | NR | NR |
| New Hampshire | 13-6 | 96 | NR | NR | 55 | 55 | 55 |
| New Jersey | 13-6 | 96 | NR | 35 | 55 | 55 | 55 |
| New Mexico | 13-6 | 96 | NR | NR | 65 | 65 | 65 |
| New York | 13-6 | 96 | NR | 35 | 55 | 55 | NP |
| North Carolina | 13-6 | 96 | NR | NR | 55 | 55 | NP |
| North Dakota | 13-6 | 96 | NR | NR | 60 | 60 | 65 |
| Ohio | 13-6 | 96 | 40 | 35 | 55 | 60 | 60 |
| Oklahoma | 13-6 | 96 | NR | NR | 55 | 55 | 65 |
| Oregon | 13-6 | 96 | 40 | 40 | 60 | 65 | 65 |
| Pennsylvania | 13-6 | 96 | 40 | 40 | 55 | 55 | NP |
| Rhode Island | 13-6 | 102 | NR | NR | 55 | 55 | NP |
| South Carolina | 13-6 | 96 | NR | 35 | 55 | 55 | NP |
| South Dakota | 13-6 | 96 | NR | NR | 65 | 65 | 65 |
| Tennessee | 13-6 | 96 | NR | 35 | 50 | 50 | NP |
| Texas | 13-6 | 96 | 40 | 40 | 55 | 55 | 65 |
| Utah | 14-0 | 96 | 45 | 45 | 60 | 65 | 65 |

APPENDIX E, TABLE II, (CONTINUED)

| State | Height | Wider | Length: Semi-trailer length | Length: Full trailer length | Length: Tractor and semi-trailer | Length: Truck and full trailer | Length: Tractor semi- and full trailer |
|---|---|---|---|---|---|---|---|
| | (ft.-in.) | (inches) | (feet) | (feet) | (feet) | (feet) | (feet) |
| Vermont | 14-0 | 96 | NR | NR | 55 | 55 | NP |
| Virginia | 13-6 | 96 | NR | NR | 55 | 55 | NP |
| Washington | 13-6 | 96 | 40 | 40 | 60 | 65 | 65 |
| West Virginia | 13-6 | 96 | NR | NR | 55 | 55 | NP |
| Wisconsin | 13-6 | 96 | 35 | 35 | 55 | 55 | NP |
| Wyoming | 13-6 | 96 | NR | NR | 65 | 65 | 65 |

NR - Not restricted.

NP - Not permitted.

NS - Not specified.

Source: _Watch Your Weight! State Size and Weight Limits for Trucks and Truck-Trailers_, Truck-trailer Manufacturers Association, Inc., 1413 K Street, N. W., Washington, D. C., 20005, January 1, 1967.

APPENDIX F, TABLE I

COST ANALYSIS OF MODEL I OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1965

| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Ogden | Bakersfield | 120* | 3.16 | INFINITE | UNBOUNDED | 3.61 | Ogden-Bakersfield |
| Billings | Bakersfield | 659* | -.81 | INFINITE | UNBOUNDED | -.66 | Billings-Denver* |
| Oklahoma City | Bakersfield | 944* | 1.59 | 1.44 | Billings-Denver* | 1.72 | Jackson-Bakersfield* |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.34 | Jackson-Phoenix* |
| Cheyenne | Denver | 289 | 1.13 | INFINITE | UNBOUNDED | 1.32 | Cheyenne UNUSE |
| Oklahoma City | Denver | 319* | .82 | .46 | Cheyenne-Bakersfield* | .84 | Pierre-Denver* |
| Pierre | Omaha | 138* | 1.13 | 1.05 | Jackson-St. Paul* | 1.16 | Pierre-Denver* |
| Oklahoma City | Omaha | 837 | .68 | .66 | Pierre-Denver* | .75 | Oklahoma-Des Moines* |
| Jackson | Omaha | 17* | 5.32 | 5.25 | Oklahoma-Des Moines* | 5.34 | Thomasville-Omaha* |
| Pierre | St. Paul | 610* | 1.14 | INFINITE | UNBOUNDED | 1.19 | Pierre-St. Paul |
| Louisville | Des Moines | 632 | 9.33 | 9.29 | Louisville UNUSE | 9.44 | Roanoke-Des Moines * |
| Jackson | Des Moines | 1491* | 5.31 | 5.29 | Thomasville-Omaha* | 5.38 | Oklahoma-Des Moines* |
| Thomasville | Des Moines | 513* | 5.34 | INFINITE | UNBOUNDED | 5.36 | Thomasville-Omaha* |
| Louisville | Indianapolis | 74 | 8.48 | 8.36 | Roanoke-Des Moines | 8.52 | Louisville UNUSE |
| Roanoke | Indianapolis | 179 | 8.92 | 8.88 | Louisville UNUSE | 9.04 | Roanoke-Des Moines |

*Railroad shipments

APPENDIX F, TABLE II

COST ANALYSIS OF MODEL II OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1965

| | | | | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/ cwt. ($) | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Spokane | Bakersfield | 119* | .78 | INFINITE | UNBOUNDED | 1.51 | Spokane-Bakersfield |
| Ogden | Bakersfield | 120* | .25 | INFINITE | UNBOUNDED | .70 | Ogden-Bakersfield |
| Billings | Bakersfield | 659* | 1.84 | INFINITE | UNBOUNDED | 1.99 | Billings-Denver * |
| Oklahoma City | Bakersfield | 825* | 1.59 | 1.44 | Billings-Denver | 1.78 | Jackson-Bakersfield * |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.41 | Jackson-Phoenix* |
| Cheyenne | Denver | 289 | -.45 | INFINITE | UNBOUNDED | -.26 | Cheyenne UNUSE |
| Oklahoma City | Denver | 319* | .82 | .46 | Cheyenne-Bakersfield* | .84 | Pierre-Denver* |
| Pierre | Omaha | 138* | 1.07 | .92 | Jackson-St. Paul* | 1.10 | Pierre-Denver* |
| Oklahoma City | Omaha | 854* | .68 | .66 | Pierre-Denver* | .75 | Jackson-Omaha* |
| Pierre | St. Paul | 610* | 1.08 | INFINITE | UNBOUNDED | 1.13 | Pierre-St. Paul |
| Louisville | Des Moines | 513 | .24 | -.59 | Thomasville-Des Moines | .35 | Roanoke-Des Moines |
| Oklahoma City | Des Moines | 102* | .74 | .67 | Jackson-Omaha* | .78 | Pierre-Des Moines* |
| Jackson | Des Moines | 1508* | .26 | INFINITE | UNBOUNDED | .33 | Jackson-Omaha* |
| Thomasville | Des Moines | 513* | .29 | INFINITE | UNBOUNDED | .38 | Thomasville-Omaha* |
| Louisville | Indianapolis | 193 | -.61 | -.73 | Roanoke-Des Moines | .22 | Thomasville-Indianapolis |
| Roanoke | Indianapolis | 60 | 1.86 | .28 | Pierre UNUSE | 1.98 | Roanoke-Des Moines |

*Railroad shipments

## APPENDIX F, TABLE III

### COST ANALYSIS OF MODEL I OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1965

| | | | | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/ cwt. ($) | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Ogden | Bakersfield | 120* | 3.16 | INFINITE | UNBOUNDED | 3.28 | Ogden-Bakersfield |
| Billings | Bakersfield | 340* | -.81 | -.82 | Oklahoma-Denver* | -.46 | Billings-Bakersfield |
| Oklahoma City | Bakersfield | 1263* | 1.59 | 1.24 | Ogden-Phoenix | 1.60 | Oklahoma-Denver * |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.33 | Jackson-Phoenix* |
| Billings | Denver | 319 | -1.59 | -1.94 | Cheyenne-Bakersfield* | -1.58 | Oklahoma-Denver * |
| Cheyenne | Denver | 289 | 1.08 | INFINITE | UNBOUNDED | 1.32 | Cheyenne UNUSE |
| Pierre | Omaha | 138 | 1.01 | 1.01 | Pierre-St. Paul* | 1.05 | Pierre-Denver |
| Oklahoma City | Omaha | 837 | .67 | .65 | Pierre-Denver* | .68 | Oklahoma-Omaha* |
| Jackson | Omaha | 17* | 5.32 | 5.23 | Oklahoma-Des Moines | 5.34 | Thomasville-Omaha* |
| Pierre | St. Paul | 610 | 1.02 | INFINITE | UNBOUNDED | 1.02 | Pierre-St. Paul* |
| Jackson | Des Moines | 1491 | 5.31 | 5.29 | Thomasville-Omaha * | 5.31 | Jackson-Des Moines* |
| Louisville | Des Moines | 632 | 9.08 | 8.75 | Thomasville-Indianapolis | 9.17 | Roanoke-Des Moines |
| Thomasville | Des Moines | 513 | 5.28 | INFINITE | UNBOUNDED | 5.34 | Thomasville UNUSE |
| Louisville | Indianapolis | 74 | 8.43 | 8.34 | Roanoke-Des Moines | 8.73 | Louisville UNUSE |
| Roanoke | Indianapolis | 179 | 8.73 | 8.43 | Louisville UNUSE | 8.81 | Roanoke-Des Moines |

*Railroad shipments

APPENDIX F, TABLE IV

COST ANALYSIS OF MODEL II OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1965

| | | | | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/cwt. ($) | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Spokane | Bakersfield | 119* | .78 | INFINITE | UNBOUNDED | 1.02 | Spokane-Bakersfield |
| Ogden | Bakersfield | 120* | .25 | INFINITE | UNBOUNDED | .37 | Ogden-Bakersfield |
| Billings | Bakersfield | 340* | 1.84 | 1.83 | Oklahoma-Denver* | 2.19 | Billings-Bakerfield |
| Oklahoma City | Bakersfield | 1144* | 1.59 | 1.24 | Ogden-Phoenix | 1.60 | Oklahoma-Denver* |
| Oklahoma City | Phoenix | 247* | 1.28 | INFINITE | UNBOUNDED | 1.40 | Oklahoma-Phoenix |
| Billings | Denver | 319 | 1.06 | .72 | Cheyenne-Bakersfield* | 1.07 | Oklahoma-Denver* |
| Cheyenne | Denver | 289 | -.50 | INFINITE | UNBOUNDED | -.26 | Cheyenne UNUSE |
| Pierre | Omaha | 138 | .95 | .95 | Pierre-St. Paul* | .99 | Pierre-Denver |
| Oklahoma City | Omaha | 854 | .67 | .65 | Pierre-Denver* | .68 | Oklahoma-Omaha* |
| Pierre | St. Paul | 610 | .96 | INFINITE | UNBOUNDED | .96 | Pierre-St. Paul* |
| Jackson | Des Moines | 1508 | .26 | INFINITE | UNBOUNDED | .26 | Jackson UNUSE |
| Louisville | Des Moines | 513 | -.01 | -.34 | Thomasville-Indianapolis | .08 | Roanoke-Des Moines |
| Thomasville | Des Moines | 513 | .23 | INFINITE | UNBOUNDED | .29 | Thomasville UNUSE |
| Oklahoma City | Des Moines | 102* | .74 | .66 | Jackson-Omaha* | .76 | Pierre-Des Moines* |
| Louisville | Indianapolis | 193 | -.66 | -.75 | Roanoke-Des Moines | -.33 | Thomasville-Indianapolis |
| Roanoke | Indianapolis | 60 | 1.67 | .50 | Pierre UNUSE | 1.75 | Roanoke-Des Moines |

*Railroad shipments

APPENDIX F, TABLE V

COST ANALYSIS OF MODEL I OPTIMUM SOLUTION WITH TRUCK RATE
OF $.60 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1000 head) | Trans-fer-Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged | | | |
|---|---|---|---|---|---|---|---|
| | | | | Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Billings-Omaha* | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | 12.44 | INFINITE | UNBOUNDED | 12.92 | Spokane-Phoenix* |
| Ogden | Bakersfield | 161* | 3.16 | INFINITE | UNBOUNDED | 3.52 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | -.81 | -.96 | Oklahoma-Denver* | -.76 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.84 | Oklahoma-Denver* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.26 | Roanoke-Omaha* | 1.34 | Jackson-Phoenix* |
| Billings | Denver | 498* | -1.43 | -1.75 | Cheyenne-Phoenix* | -1.34 | Billings-Denver |
| Cheyenne | Denver | 363 | 1.13 | INFINITE | UNBOUNDED | 1.32 | Cheyenne UNUSE |
| Pierre | Omaha | 153* | 1.13 | 1.08 | Billings-St. Paul* | 1.18 | Pierre-Omaha |
| Oklahoma City | Omaha | 1553 | .68 | .62 | Jackson-Phoenix* | .71 | Roanoke-Omaha* |
| Jackson | Omaha | 407* | 5.32 | 5.27 | Harrisburg-Des Moines* | 5.34 | Thomasville-Omaha* |
| Pierre | St. Paul | 610* | 1.14 | 1.09 | Harrisburg-Des Moines* | 1.19 | Pierre-St. Paul |
| Harrisburg | St. Paul | 74* | 11.92 | INFINITE | UNBOUNDED | 11.98 | Harrisburg-Des Moines* |
| Jackson | Des Moines | 1353* | 5.31 | 5.29 | Thomasville-Omaha* | 5.36 | Harrisburg-Des Moines* |
| Louisville | Des Moines | 926 | 9.33 | INFINITE | UNBOUNDED | 9.44 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311* | 5.34 | INFINITE | UNBOUNDED | 5.36 | Thomasville-Omaha* |
| Roanoke | Des Moines | 317 | 9.88 | 9.76 | Louisville-Indianapolis | 9.98 | Roanoka-St. Paul |
| Roanoke | Indianapolis | 242 | 8.92 | INFINITE | UNBOUNDED | 9.04 | Louisville-Indianapolis |

*Railroad shipments

APPENDIX F, TABLE VI

COST ANALYSIS OF MODEL II OPTIMUM SOLUTION WITH TRUCK RATE OF $.60 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1,000 head) | Transfer Cost/ cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Billings-Omaha* | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | .78 | INFINITE | UNBOUNDED | 1.26 | Spokane-Phoenix* |
| Ogden | Bakersfield | 161* | .25 | INFINITE | UNBOUNDED | .61 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | 1.84 | 1.68 | Oklahoma-Denver* | 1.88 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.84 | Oklahoma-Denver* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.26 | Roanoke-Omaha* | 1.34 | Jackson-Phoenix* |
| Billings | Denver | 498* | 1.22 | .90 | Cheyenne-Phoenix* | 1.31 | Billings-Denver* |
| Cheyenne | Denver | 363 | -.45 | INFINITE | UNBOUNDED | -.26 | Cheyenne UNUSE |
| Pierre | Omaha | 153 | 1.07 | 1.02 | Billings-St. Paul* | 1.12 | Pierre-Omaha |
| Oklahoma City | Omaha | 1553* | .68 | .62 | Jackson-Phoenix* | .71 | Roanoke-Omaha* |
| Jackson | Omaha | 407* | .27 | .22 | Harrisburg-Des Moines* | .29 | Thomasville-Omaha* |
| Pierre | St. Paul | 610* | 1.08 | 1.03 | Harrisburg-Des Moines* | 1.13 | Pierre-St. Paul |
| Harrisburg | St. Paul | 74* | 2.84 | INFINITE | UNBOUNDED | 2.88 | Harrisburg-Des Moines* |
| Jackson | Des Moines | 1353* | .26 | .24 | Thomasville-Omaha* | .31 | Harrisburg-Des Moines* |
| Louisville | Des Moines | 926 | .24 | INFINITE | UNBOUNDED | .35 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311* | .29 | INFINITE | UNBOUNDED | .31 | Thomasville-Omaha* |
| Roanoke | Des Moines | 317 | 2.82 | 2.70 | Louisville-Indianapolis | 2.92 | Roanoke-St. Paul |
| Roanoke | Indianapolis | 242 | 1.86 | INFINITE | UNBOUNDED | 1.98 | Louisville-Indianapolis |

*Railroad shipments

APPENDIX F, TABLE VII

COST ANALYSIS OF MODEL I OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1,000 head) | Transfer Cost/ cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Ogden-Phoenix | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | 12.44 | INFINITE | UNBOUNDED | 12.68 | Spokane-Bakersfield |
| Ogden | Bakersfield | 161* | 3.16 | INFINITE | UNBOUNDED | 3.21 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | -.81 | -1.12 | Oklahoma-Denver* | -.75 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.69 | Oklahoma-Bakersfield* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.23 | Billings-Omaha* | 1.33 | Jackson-Phoenix* |
| Billings | Denver | 498 | -1.59 | -1.75 | Cheyenne-Phoenix* | -1.43 | Billings-Denver* |
| Cheyenne | Denver | 363 | 1.08 | INFINITE | UNBOUNDED | 1.32 | Cheyenne UNUSE |
| Pierre | Omaha | 153 | 1.01 | 1.01 | Pierre-St. Paul* | 1.05 | Harrisburg-Indianapolis |
| Oklahoma City | Omaha | 1553 | .67 | .62 | Jackson-Phoenix* | .68 | Oklahoma-Omaha* |
| Jackson | Omaha | 407* | 5.32 | 5.28 | Harrisburg-Indianapolis | 5.34 | Thomasville-Omaha* |
| Pierre | St. Paul | 610 | 1.02 | .98 | Harrisburg-Indianapolis | 1.02 | Pierre-St. Paul* |
| Harrisburg | St. Paul | 74 | 11.62 | INFINITE | UNBOUNDED | 11.66 | Harrisburg-Indianapolis |
| Jackson | Des Moines | 1353 | 5.31 | 5.29 | Thomasville-Omaha | 5.31 | Jackson-Des Moines |
| Louisville | Des Moines | 926 | 9.08 | INFINITE | UNBOUNDED | 9.17 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311 | 5.28 | INFINITE | UNBOUNDED | 5.34 | Thomasville UNUSE |
| Roanoke | Des Moines | 317 | 9.46 | 9.42 | Harrisburg-Indianapolis | 9.51 | Roanoke-Phoenix* |
| Roanoke | Indianapolis | 242 | 8.73 | 8.68 | Roanoke-Phoenix* | 8.77 | Harrisburg-Indianapolis |

*Railroad shipments

APPENDIX F, TABLE VIII

COST ANALYSIS OF MODEL II OPTIMUM SOLUTION WITH TRUCK RATE OF $.46 PER MILE, 1970

| Origin | Destination | Quantity Shipped (1000 head) | Transfer Cost/cwt. ($) | Cost Range Over Which Optimum Solution Remains Unchanged: Lower Limit ($) | Incoming Vector at Lower Limit | Upper Limit ($) | Incoming Vector at Upper Limit |
|---|---|---|---|---|---|---|---|
| Dummy Supply | Bakersfield | 1693 | 9999.00 | 9998.95 | Ogden-Phoenix | 9999.00 | Dummy-Bakersfield* |
| Spokane | Bakersfield | 113* | .78 | INFINITE | UNBOUNDED | 1.02 | Spokane-Bakersfield |
| Ogden | Bakersfield | 161* | .25 | INFINITE | UNBOUNDED | .30 | Ogden-Phoenix |
| Billings | Bakersfield | 293* | 1.84 | 1.53 | Oklahoma-Denver* | 1.90 | Billings-Omaha* |
| Dummy Supply | Phoenix | 211 | 9999.00 | 9998.69 | Oklahoma-Bakersfield* | 9999.00 | Dummy-Phoenix* |
| Oklahoma City | Phoenix | 326* | 1.28 | 1.23 | Billings-Omaha* | 1.33 | Jackson-Phoenix* |
| Billings | Denver | 498 | 1.06 | .90 | Cheyenne-Phoenix* | 1.22 | Billings-Denver* |
| Cheyenne | Denver | 363 | -.50 | INFINITE | UNBOUNDED | -.26 | Cheyenne UNUSE |
| Pierre | Omaha | 153 | .95 | .95 | Pierre-St. Paul* | .99 | Harrisburg-Indianapolis |
| Oklahoma City | Omaha | 1553 | .67 | .62 | Jackson-Phoenix* | .68 | Oklahoma-Omaha* |
| Jackson | Omaha | 407* | .27 | .23 | Harrisburg-Indianapolis | .29 | Thomasville-Omaha* |
| Pierre | St. Paul | 610 | .96 | .92 | Harrisburg-Indianapolis | .96 | Pierre-St. Paul* |
| Harrisburg | St. Paul | 74 | 2.53 | INFINITE | UNBOUNDED | 2.57 | Harrisburg-Indianapolis |
| Jackson | Des Moines | 1353 | .26 | .24 | Thomasville-Omaha* | .26 | Jackson-Des Moines* |
| Louisville | Des Moines | 926 | -.01 | INFINITE | UNBOUNDED | .08 | Louisville-Indianapolis |
| Thomasville | Des Moines | 311 | .23 | INFINITE | UNBOUNDED | .29 | Thomasville UNUSE |
| Roanoke | Des Moines | 317 | 2.40 | 2.36 | Harrisburg-Indianapolis | 2.45 | Roanoke-Phoenix* |
| Roanoke | Indianapolis | 242 | 1.67 | 1.62 | Roanoke-Phoenix* | 1.71 | Harrisburg-Indianapolis |

*Railroad shipments

# APPENDIX G

The following code information will interpret the numerical and alphabetical regional designations of Appendix G tables on the shadow prices for the optimum model solutions for this study. Any three-digit number beginning with a "three" will indicate a rail supply shipment. A three-digit number beginning with a "two" will indicate a truck supply shipment. All three-digit numbers beginning with a "one" will indicate a demand region. An asterisk to the left of a shipment will indicate that activity is in the optimum solution. The plus signs preceeding the shipment designations indicate the slack activity for for each of the supply regions. A slack which has an asterisk preceeding it shows that all of that region's supply was shipped.

Demand Regions

| Code Name | Region |
|---|---|
| 101 | Bakersfield |
| 102 | Phoenix |
| 103 | Denver |
| 104 | Omaha |
| 105 | St. Paul |
| 106 | Des Moines |
| 107 | Indianapolis |

Supply Regions

| | | |
|---|---|---|
| Truck | 201 or 201SPK | Spokane |
| | 202 or 202 OGD | Ogden |
| | 203 or 203BIL | Billings |
| | 204 or 204CHE | Cheyenne |
| | 205 or 205PIE | Pierre |
| | 206 or 206OKC | Oklahoma City |

Supply Regions (Continued)

| | Code Name | Region |
|---|---|---|
| | 207 or 207JAC | Jackson |
| | 208 or 208LOU | Louisville |
| | 209 or 209THM | Thomasville |
| | 210 or 210ROA | Roanoke |
| | 211 or 211HAR | Harrisburg |
| Rail | 301 or 301SPK | Spokane |
| | 302 or 203OGD | Ogden |
| | 303 or 303BIL | Billings |
| | 304 or 304CHE | Cheyenne |
| | 305 or 305PIE | Pierre |
| | 306 or 306OKC | Oklahoma City |
| | 307 or 307JAC | Jackson |
| | 308 or 308LOU | Louisville |
| | 309 or 309THM | Thomasville |
| | 310 or 310ROA | Roanoke |
| | 311 or 311HAR | Harrisburg |

For example: 201101 2.36929000

This states that an additional truck shipment from Spokane to Bakersfield would add $2.36929, per hundredweight of feeder cattle shipped, to the optimum least cost solution.

APPENDIX G, TABLE I

SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL I ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | 2.48934800 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.19968200 |
| 205101 | 1.31083600 | 206101 | .89471600 | 207101 | 1.27233600 | 208101 | 1.91176400 |
| 209101 | 1.67719200 | 210101 | 2.51540600 | 211101 | 4.28696600 | 201102 | 3.20600600 |
| 202102 | .66396600 | 203102 | .89881800 | 204102 | 1.04502800 | 205102 | 1.20048600 |
| 206102 | .53884800 | 207102 | .88324000 | 208102 | 1.55220400 | 209102 | 1.28071200 |
| 210102 | 1.68511600 | 211102 | 3.92730600 | 201103 | 3.17812400 | 202103 | .80037800 |
| 203103 | .24145000 | * 204103 | . | 205103 | .15361200 | 206103 | .31713600 |
| 207103 | .89597000 | 208103 | .86899200 | 209103 | 1.17529800 | 210103 | 1.22711600 |
| 211103 | 3.19435200 | 201104 | 3.85900200 | 202104 | 1.73046600 | 203104 | .86325600 |
| 204104 | .86178600 | 205104 | .04994000 | 206104 | .18762000 | 207104 | .43232800 |
| 208104 | .21521200 | 209104 | .57320600 | 210104 | .21705800 | 211104 | 2.43535000 |
| 201105 | 3.76593200 | 202105 | 2.20042600 | 203105 | .77018600 | 204105 | 1.41850800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .76014600 | 208105 | .22736400 |
| 209105 | .69427200 | 210105 | .21259600 | 211105 | 2.29243800 | 201106 | 4.17913000 |
| 202106 | 1.95275600 | 203106 | 1.18338400 | 204106 | 1.12099600 | 205106 | .24823200 |
| 206106 | .37299000 | 207106 | .35002800 | * 208106 | . | 209106 | .39676000 |
| 210106 | .11629800 | 211106 | 3.29635600 | 201107 | 5.74269200 | 202107 | 3.63077000 |
| 203107 | 2.74694600 | 204107 | 2.79901000 | 205107 | 1.94101400 | 206107 | 1.55443000 |
| 207107 | .87983000 | * 208107 | . | 209107 | .82687800 | * 210107 | . |
| 211107 | 2.22752200 | 301101 | 1.76067800 | * 302101 | . | * 303101 | . |
| 304101 | .35500000 | 305101 | .63000000 | * 306101 | . | 307101 | .12500000 |
| 308101 | .23600000 | 309101 | .265000000 | 310101 | .27567800 | 311101 | 2.42407800 |
| 301102 | 2.53567800 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .47500000 |
| 305102 | .35500000 | * 306102 | . | 307102 | .05500000 | 308102 | .21100000 |
| 309102 | .19500000 | 310102 | .25067800 | 311102 | 2.42987800 | 301103 | 2.55067800 |
| 302103 | .53700000 | 303103 | .15000000 | * 304103 | . | 305103 | .02500000 |
| * 306103 | . | 307103 | .03000000 | 308103 | .12600000 | 309103 | .09000000 |
| 310103 | .51567800 | 311103 | 2.43067800 | 301104 | 2.91567800 | 302104 | 1.18100000 |
| 303104 | .35000000 | 304104 | .54000000 | * 305104 | . | * 306104 | . |
| * 307104 | . | 308104 | .07600000 | 309104 | .02000000 | 310104 | .28067800 |
| 311104 | 2.32567800 | 301105 | 2.79567800 | 302105 | 1.89800000 | 303105 | .35500000 |
| 304105 | .87000000 | * 305105 | . | 306105 | .19000000 | 307105 | .08000000 |
| 308105 | .17100000 | 309105 | .12000000 | 310105 | .55567800 | 311105 | 2.14067800 |
| 301106 | 3.04067800 | 302106 | 1.42500000 | 303106 | .57000000 | 304106 | .69000000 |
| 305106 | .10500000 | 306106 | .07000000 | * 307106 | . | * 308106 | . |
| * 309106 | . | 310106 | .33067800 | 311106 | 2.19067800 | 301107 | 4.46614600 |
| 302107 | 3.00646800 | 303107 | 2.10046800 | 304107 | 2.24046800 | 305107 | 1.62546800 |
| 306107 | 1.37546800 | 307107 | 1.15046800 | 308107 | .84646800 | 309107 | .85046800 |
| 310107 | .29114600 | 311107 | 2.45114600 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .19170800 | * +205PIE | . | * +206OKC | . |
| * +207JAC | . | +208LOU | .39808800 | * +209THM | . | * +210ROA | . |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311 HAR | . |

## APPENDIX G, TABLE II

### SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL II ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .72867000 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.19968200 |
| 205101 | 1.31083600 | 206101 | .89471600 | 207101 | 1.34233600 | 208101 | 1.98176400 |
| 209101 | 1.74719200 | 210101 | 2.58540600 | 211101 | 2.32696600 | 201102 | 1.44532800 |
| 202102 | .66396600 | 203102 | .89881800 | 204102 | 1.04502800 | 205102 | 1.20048600 |
| 206102 | .53884800 | 207102 | .95324000 | 208102 | 1.62220400 | 209102 | 1.35071200 |
| 210102 | 1.75511600 | 211102 | 1.96740600 | 201103 | 1.41744600 | 202103 | .80037800 |
| 203103 | .24145000 | * 204103 | . | 205103 | .15361200 | 206103 | .31713600 |
| 207103 | .96597000 | 208103 | .93899200 | 209103 | 1.24529800 | 210103 | 1.29711600 |
| 211103 | 1.23435200 | 201104 | 2.09832400 | 202104 | 1.73046600 | 203104 | .86325600 |
| 204104 | .86178600 | 205104 | .04994000 | 206104 | .18762000 | 207104 | .50232800 |
| 208104 | .28521200 | 209104 | .64320600 | 210104 | .28705800 | 211104 | .47535000 |
| 201105 | 2.00525400 | 202105 | 2.20042600 | 203105 | .77018600 | 204105 | 1.41850800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .83014600 | 208105 | .29736400 |
| 209105 | .76427200 | 210105 | .28259600 | 211105 | .33243800 | 201106 | 2.34845200 |
| 202106 | 1.88275600 | 203106 | 1.11338400 | 204106 | 1.05099600 | 205106 | .17823200 |
| 206106 | .30299000 | 207106 | .35002800 | * 208106 | . | 209106 | .39676000 |
| 210106 | .11629800 | 211106 | 1.26635600 | 201107 | 3.91201400 | 202107 | 3.56077000 |
| 203107 | 2.67694600 | 204107 | 2.72901000 | 205107 | 1.87101400 | 206107 | 1.48443000 |
| 207107 | .87983000 | * 208107 | . | 209107 | .82687800 | * 210107 | . |
| 211107 | .19752200 | * 301101 | . | * 302101 | . | * 303101 | . |
| 304101 | .35500000 | 305101 | .63000000 | * 306101 | . | 307101 | .19500000 |
| 308101 | .30600000 | 309101 | .33500000 | 310101 | .34567800 | 311101 | .46407800 |
| 301102 | .77500000 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .47500000 |
| 305102 | .35500000 | * 306102 | . | 307102 | .12500000 | 308102 | .28100000 |
| 309102 | .26500000 | 310102 | .32067800 | 311102 | .46987800 | 301103 | .79000000 |
| 302103 | .53700000 | 303103 | .15000000 | * 304103 | . | 305103 | .02500000 |
| * 306103 | . | 307103 | .10000000 | 308103 | .19600000 | 309103 | .16000000 |
| 310103 | .58567800 | 311103 | .47067800 | 301104 | 1.15500000 | 302104 | 1.18100000 |
| 303104 | .35000000 | 304104 | .54000000 | * 305104 | . | * 306104 | . |
| 307104 | .07000000 | 308104 | .14600000 | 309104 | .09000000 | 310104 | .35067800 |
| 311104 | .36567800 | 301105 | 1.03500000 | 302105 | 1.89800000 | 303105 | .35500000 |
| 304105 | .87000000 | * 305105 | . | 306105 | .19000000 | 307105 | .15000000 |
| 308105 | .24100000 | 309105 | .19000000 | 310105 | .62567800 | 311105 | .18067800 |
| 301106 | 1.21000000 | 302106 | 1.35500000 | 303106 | .50000000 | 304106 | .62000000 |
| 305106 | .03500000 | * 306106 | . | * 307106 | . | * 308106 | . |
| * 309106 | . | 310106 | .33067800 | 311106 | .16067800 | 301107 | 2.63546800 |
| 302107 | 2.93646800 | 303107 | 2.03046800 | 304107 | 2.17046800 | 305107 | 1.55546800 |
| 306107 | 1.30546800 | 307107 | 1.15046800 | 308107 | .84646800 | 309107 | .85046800 |
| 310107 | .29114600 | 311107 | .42114600 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .19170800 | * +205PIE | . | * +206OKC | . |
| * +207JAC | . | +208LOU | .39808800 | * +209THM | . | * +210ROA | . |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

## APPENDIX G, TABLE III

### SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL III ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | 2.70775800 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.19968200 |
| 205101 | 1.31083600 | 206101 | .89471600 | 207101 | 1.27233600 | 208101 | 1.91176400 |
| 209101 | 1.67719200 | 210101 | 2.39910800 | 211101 | 2.87537600 | 201102 | 2.42441600 |
| 202102 | .66396000 | 203102 | .89881800 | 204102 | 1.04502800 | 205102 | 1.20048600 |
| 206102 | .53884800 | 207102 | .88324000 | 208102 | 1.55220400 | 209102 | 1.28071200 |
| 210102 | 1.56881800 | 211102 | 2.51581600 | 201103 | 3.39653400 | 202103 | .80037800 |
| 203103 | .24145000 | * 204103 | . | 205103 | .15361200 | 206103 | .31713600 |
| 207103 | .89597000 | 208103 | .86899200 | 209103 | 1.17529800 | 210103 | 1.11081800 |
| 211103 | 1.78276200 | 201104 | 4.07741200 | 202104 | 1.73046600 | 203104 | .86325600 |
| 204104 | .86178600 | 205104 | .04994000 | 206104 | .18762000 | 207104 | .43232800 |
| 208104 | .21512120 | 209104 | .57320600 | 210104 | .10076000 | 211104 | 1.02376000 |
| 201105 | 3.98434200 | 202105 | 2.20042600 | 203105 | .77018600 | 204105 | 1.41850800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .76014600 | 208105 | .22736400 |
| 209105 | .69427200 | 210105 | .09629800 | 211105 | .88084800 | 201106 | 4.39754000 |
| 202106 | 1.95275600 | 203106 | 1.18338400 | 204106 | 1.12099600 | 205106 | .24823200 |
| 206106 | .37299000 | 207106 | .35002800 | * 208106 | . | 209106 | .39676000 |
| * 210106 | . | 211106 | 1.88476600 | 201107 | 6.07740000 | 202107 | 3.74706800 |
| 203107 | 2.86324400 | 204107 | 2.91530800 | 205107 | 2.05731200 | 206107 | 1.67072800 |
| 207107 | .99612800 | 208107 | .21629800 | 209107 | .94317600 | * 210107 | . |
| 211107 | .93223000 | 301101 | 1.97908800 | * 302101 | . | * 303101 | . |
| 304101 | .35500000 | 305101 | .63000000 | * 306101 | . | 307101 | .12500000 |
| 308101 | .63408800 | 309101 | .26500000 | 310101 | .02500000 | 311101 | 1.01248800 |
| 301102 | 2.75408800 | 302102 | .787000000 | 303102 | .46500000 | 304102 | .47500000 |
| 305102 | .35500000 | * 306102 | . | 307102 | .05500000 | 308102 | .60908800 |
| 309102 | .19500000 | * 310102 | . | 311102 | 1.01828800 | 301103 | 2.76908800 |
| 302103 | .53700000 | 303103 | .15000000 | * 304103 | . | 305103 | .02500000 |
| * 306103 | . | 307103 | .03000000 | 308103 | .52408800 | 309103 | .09000000 |
| 310103 | .26500000 | 311103 | 1.01908800 | 301104 | 3.13408800 | 302104 | 1.18100000 |
| 303104 | .35000000 | 304104 | .54000000 | * 305104 | . | * 306104 | . |
| * 307104 | . | 308104 | .47408800 | 309104 | .02000000 | 310104 | .03000000 |
| 311104 | .91408800 | 301105 | 3.01408800 | 302105 | 1.89800000 | 303105 | .35500000 |
| 304105 | .87000000 | * 305105 | . | 306105 | .19000000 | 307105 | .08000000 |
| 308105 | .56908800 | 309105 | .12000000 | 310105 | .30500000 | 311105 | .72908800 |
| 301106 | 3.25908800 | 302106 | 1.42500000 | 303106 | .57000000 | 304106 | .69000000 |
| 305106 | .10500000 | 306106 | .87000000 | * 307106 | . | 308106 | .39808800 |
| * 309106 | . | 310106 | .08000000 | 311106 | .77908800 | 301107 | 4.80085400 |
| 302107 | 3.12276600 | 303107 | 2.21676600 | 304107 | 2.35676600 | 305107 | 1.74176600 |
| 306107 | 1.49176600 | 307107 | 1.26676600 | 308107 | 1.36085400 | 309107 | .96676600 |
| 310107 | .15676600 | 311107 | 1.15585400 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .19170800 | * +205PIE | . | * +206OKC | . |
| * +207JAC | . | * +208LOU | . | * +209THM | . | +210ROA | .13438000 |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

## APPENDIX G, TABLE IV

## SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL IV ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .72867000 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.19968200 |
| 205101 | 1.31083600 | 206101 | .89471600 | 207101 | 1.34233600 | 208101 | 11.98176400 |
| 209101 | 1.74719200 | 210101 | 2.58540600 | 211101 | 2.32696600 | 201102 | 1.44532800 |
| 202102 | .66396600 | 203102 | .89881800 | 204102 | 1.04502800 | 205102 | 1.20048600 |
| 206102 | .53884800 | 207102 | .95324000 | 208102 | 1.62220400 | 209102 | 1.35071200 |
| 210102 | 1.75511600 | 211102 | 1.96740600 | 201103 | 1.41744600 | 202103 | .80037800 |
| 203103 | .24145000 | * 204103 | . | 205103 | .15361200 | 206103 | .31713600 |
| 207103 | .96597000 | 208103 | .93899200 | 209103 | 1.24529800 | 210103 | 1.29711600 |
| 211103 | 1.23435200 | 201104 | 2.09832400 | 202104 | 1.73046600 | 203104 | .86325600 |
| 204104 | .86178600 | 205104 | .04994000 | 206104 | .18762000 | 207104 | .50232800 |
| 208104 | .28521200 | 209104 | .64320600 | 210104 | .28705800 | 211104 | .47535000 |
| 201105 | 2.00525400 | 202105 | 2.20042600 | 203105 | .77018600 | 204105 | 1.41850800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .83014600 | 208105 | .29736400 |
| 209105 | .76427200 | 210105 | .28259600 | 211105 | .33243800 | 201106 | 2.34845200 |
| 202106 | 1.88275600 | 203106 | 1.11338400 | 204106 | 1.05099600 | 205106 | .17823200 |
| 206106 | .30299000 | 207106 | .35002800 | * 208106 | . | 209106 | .39676000 |
| 210106 | .11629800 | 211106 | 1.26635600 | 201107 | 3.91201400 | 202107 | 3.56077000 |
| 203107 | 2.67694600 | 204107 | 2.72901000 | 205107 | 1.87101400 | 206107 | 1.48443000 |
| 207107 | .87983000 | * 208107 | . | 209107 | .82687800 | * 210107 | . |
| 211107 | .19752200 | * 301101 | . | * 302101 | . | * 303101 | . |
| 304101 | .35500000 | 305101 | .63000000 | * 306101 | . | 307101 | .19500000 |
| 308101 | .30600000 | 309101 | .33500000 | 310101 | .34567800 | 311101 | .46407800 |
| 301102 | .77500000 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .47500000 |
| 305102 | .35500000 | * 306102 | . | 307102 | .12500000 | 308102 | .28100000 |
| 309102 | .26500000 | 310102 | .32067800 | 311102 | .46987800 | 301103 | .79000000 |
| 302103 | .53700000 | 303103 | .15000000 | * 304103 | . | 305103 | .02500000 |
| 306103 | . | 307103 | .10000000 | 308103 | .19600000 | 309103 | .16000000 |
| 310103 | .58567800 | 311103 | .47067800 | 301104 | 1.15500000 | 302104 | 1.18100000 |
| 303104 | .35000000 | 304104 | .54000000 | * 305104 | . | * 306104 | .. |
| 307104 | .07000000 | 308104 | .14600000 | 309104 | .09000000 | 310104 | .35067800 |
| 311104 | .36567800 | 301105 | 1.03500000 | 302105 | 1.89800000 | 303105 | .35500000 |
| 304105 | .87000000 | * 305105 | . | 306105 | .19000000 | 307105 | .15000000 |
| 308105 | .24100000 | 309105 | .19000000 | 310105 | .62567800 | 311105 | .18067800 |
| 301106 | 1.21000000 | 302106 | 1.35500000 | 303106 | .50000000 | 304106 | .62000000 |
| 305106 | .03500000 | * 306106 | . | * 307106 | . | * 308106 | . |
| * 309106 | . | 310106 | .33067800 | 311106 | .16067800 | 301107 | 2.63546800 |
| 302107 | 2.93646800 | 303107 | 2.03046800 | 304107 | 2.17046800 | 305107 | 1.55546800 |
| 306107 | 1.30546800 | 307107 | 1.15046800 | 308107 | .84646800 | 309107 | .85046800 |
| 310107 | .29114600 | 311107 | .42114600 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .19170800 | * +205PIE | . | * +206OKC | . |
| * +207JAC | . | +208LOU | .39808800 | * +209THM | . | * +210ROA | . |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

## APPENDIX G, TABLE V

**SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL I ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | 2.36929000 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | .73909000 | 206101 | .31459000 | 207101 | .47469000 | 208101 | 1.23313000 |
| 209101 | .74920000 | 210101 | 1.69583500 | 211101 | 3.52773500 | 201102 | 2.98983500 |
| 202102 | .35321500 | 203102 | .38894500 | 204102 | .68609500 | 205102 | .72571500 |
| 206102 | .11302000 | 207102 | .24765000 | 208102 | 1.02873000 | 209102 | .51650000 |
| 210102 | 1.13061000 | 211102 | 3.32333500 | 201103 | 3.08340500 | 202103 | .57272000 |
| * 203103 | . | * 204103 | . | 205103 | .03820500 | 206103 | .05801500 |
| 207103 | .37235000 | 208103 | .61997500 | 209103 | .55064000 | 210103 | .89448500 |
| 211103 | 2.87637500 | 201104 | 3.64657500 | 202104 | 1.32691500 | 203104 | .51789000 |
| 204104 | .70184000 | * 205104 | . | * 206104 | . | 207104 | .05822000 |
| 208104 | .16010000 | 209104 | .13038500 | 210104 | .16151500 | 211104 | 2.33584500 |
| 201105 | 3.57865500 | 202105 | 1.69057000 | 203105 | .44997000 | 204105 | 1.13200000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .31292000 | 208105 | .17283500 |
| 209105 | .22660500 | 210105 | .16151500 | 211105 | 2.22972000 | 201106 | 3.89682500 |
| 202106 | 1.50217000 | 203106 | .76814000 | 204106 | .90539500 | 205106 | .15686000 |
| 206106 | .14695500 | * 207106 | . | * 208106 | . | * 209106 | . |
| 210106 | .08914500 | 211106 | 3.00069000 | 201107 | 5.09533000 | 202107 | 2.78840500 |
| 203107 | 1.96664500 | 204107 | 2.19163000 | 205107 | 1.45441500 | 206107 | 1.05255500 |
| 207107 | .40610500 | * 208107 | . | 209107 | .32969500 | * 210107 | . |
| 211107 | 2.18140500 | 301101 | 2.13411500 | * 302101 | . | * 303101 | . |
| 304101 | .34862500 | 305101 | .61505000 | * 306101 | . | 307101 | .11005000 |
| 308101 | .56911500 | 309101 | .24752000 | 310101 | .64911500 | 311101 | 2.79751500 |
| 301102 | 2.90911500 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .46862500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .04005000 | 308102 | .54411500 |
| 309102 | .17752000 | 310102 | .62411500 | 311102 | 2.80331500 | 301103 | 2.93049000 |
| 302103 | .54337500 | 303103 | .15637500 | * 304103 | . | 305103 | .01642500 |
| 306103 | .00637500 | 307103 | .02142500 | 308103 | .46549000 | 309103 | .07889500 |
| 310103 | .89549000 | 311103 | 2.81049000 | 301104 | 3.30406500 | 302104 | 1.19595000 |
| 303104 | .36495000 | 304104 | .54857500 | * 305104 | . | 306104 | .01495000 |
| * 307104 | . | 308104 | .42406500 | 309104 | .01747000 | 310104 | .66906500 |
| 311104 | 2.71406500 | 301105 | 3.18982000 | 302105 | 1.91870500 | 303105 | .37570500 |
| 304105 | .88433000 | 305105 | .00575500 | 306105 | .21070500 | 307105 | .08575500 |
| 308105 | .52482000 | 309105 | .12322500 | 310105 | .94982000 | 311105 | 2.53482000 |
| 301106 | 3.43159500 | 302106 | 1.44248000 | 303106 | .58748000 | 304106 | .70110500 |
| 305106 | .10753000 | 306106 | .08748000 | 307106 | .00253000 | 308106 | .35059500 |
| * 309106 | . | 310106 | .72159500 | 311106 | 2.58159500 | 301107 | 4.65966500 |
| 302107 | 2.82655000 | 303107 | 1.92055000 | 304107 | 2.05417500 | 305107 | 1.43060000 |
| 306107 | 1.19555000 | 307107 | .95560000 | 308107 | .99966500 | 309107 | .65307000 |
| 310107 | .48466500 | 311107 | 2.64466500 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .23567000 | +205PIE | .11815000 | * +206OKC | . |
| * +207JAC | . | +208LOU | .29402500 | +209THM | .06010000 | * +210ROA | . |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

## APPENDIX G, TABLE VI

### SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL II ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .23517500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | .73909000 | 206101 | .31459000 | 207101 | .56217000 | 208101 | 1.32061000 |
| 209101 | .83668000 | 210101 | 1.78331500 | 211101 | 1.58521500 | 201102 | .85572000 |
| 202102 | .35321500 | 203102 | .38894500 | 204102 | .68609500 | 205102 | .72571500 |
| 206102 | .11302000 | 207102 | .33513000 | 208102 | 1.11621000 | 209102 | .60398000 |
| 210102 | 1.21809000 | 211102 | 1.38081500 | 201103 | .94929000 | 202103 | .57272000 |
| * 203103 | . | * 204103 | . | 205103 | .03820500 | 206103 | .05801500 |
| 207103 | .45983000 | 208103 | .70745500 | 209103 | .63812000 | 210103 | .98196500 |
| 211103 | .93385500 | 201104 | 1.51246000 | 202104 | 1.32691500 | 203104 | .51789000 |
| 204104 | .70184000 | * 205104 | . | * 206104 | . | 207104 | .14570000 |
| 208104 | .24758000 | 209104 | .21786500 | 210104 | .24899500 | 211104 | .39332500 |
| 201105 | 1.44454000 | 202105 | 1.69057000 | 203105 | .44997000 | 204105 | 1.13200000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .40040000 | 208105 | .26031500 |
| 209105 | .31408500 | 210105 | .24899500 | 211105 | .28720000 | 201106 | 1.67523000 |
| 202106 | 1.41469000 | 203106 | .68066000 | 204106 | .81791500 | 205106 | .06938000 |
| 206106 | .05947500 | * 207106 | . | * 208106 | . | * 209106 | . |
| 210106 | .08914500 | 211106 | .97069000 | 201107 | 2.87373500 | 202107 | 2.70092500 |
| 203107 | 1.87916500 | 204107 | 2.14150000 | 205107 | 1.36693500 | 206107 | .96507500 |
| 207107 | .40610500 | * 208107 | . | 209107 | .32969500 | * 210107 | . |
| 211107 | .15140500 | * 301101 | . | * 302101 | . | * 303101 | . |
| 304101 | .34862500 | 305101 | .61505000 | * 306101 | . | 307101 | .19500000 |
| 308101 | .30600000 | 309101 | .33500000 | 310101 | .73659500 | 311101 | .85499500 |
| 301102 | .77500000 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .46862500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .12500000 | 308102 | .28100000 |
| 309102 | .26500000 | 310102 | .71159500 | 311102 | .86079500 | 301103 | .79637500 |
| 302103 | .54337500 | 303103 | .15637500 | * 304103 | . | 305103 | .01642500 |
| 306103 | .00637500 | 307103 | .10637500 | 308103 | .20237500 | 309103 | .11637500 |
| 310103 | .98297000 | 311103 | .86797000 | 301104 | 1.16995000 | 302104 | 1.19595000 |
| 303104 | .36495000 | 304104 | .54857500 | * 305104 | . | 306104 | .01495000 |
| 307104 | .08495000 | 308104 | .16095000 | 309104 | .10495000 | 310104 | .75654500 |
| 311104 | .77154500 | 301105 | 1.05570500 | 302105 | 1.91870500 | 303105 | .37570500 |
| 304105 | .88433000 | 305105 | .00575500 | 306105 | .21070500 | 307105 | .17070500 |
| 308105 | .26170500 | 309105 | .21070500 | 310105 | 1.03730000 | 311105 | .59230000 |
| 301106 | 1.21000000 | 302106 | 1.35500000 | 303106 | .50000000 | 304106 | .61362500 |
| 305106 | .02005000 | * 306106 | . | * 307106 | . | * 308106 | . |
| * 309106 | . | 310106 | .72159500 | 311106 | .55159500 | 301107 | 2.43807000 |
| 302107 | 2.739070000 | 303107 | 1.833070000 | 304107 | 1.96669500 | 305107 | 1.34312000 |
| 306107 | 1.10807000 | 307107 | .95307000 | 308107 | .64907000 | 309107 | .65307000 |
| 310107 | .48466500 | 311107 | .61466500 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .23567000 | +205PIE | .11815000 | * +206OKC | . |
| +207JAC | .00253000 | +208LOU | .64462000 | +209THM | .06010000 | * +210ROA | . |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

APPENDIX G, TABLE VII

SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL III ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | 2.44331500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | .73909000 | 206101 | .31459000 | 207101 | .47469000 | 208101 | 1.23313000 |
| 209101 | .74920000 | 210101 | 1.60669000 | 211101 | 1.97176000 | 201102 | 3.06386000 |
| 202102 | .35321500 | 203102 | .38894500 | 204102 | .68609500 | 205102 | .72571500 |
| 206102 | .11302000 | 207102 | .24765000 | 208102 | 1.02873000 | 209102 | .51650000 |
| 210102 | 1.04146500 | 211102 | 1.7673600 | 201103 | 3.15743000 | 202103 | .57272000 |
| * 203103 | . | * 204103 | . | 205103 | .03820500 | 206103 | .05801500 |
| 207103 | .37235000 | 208103 | .61997500 | 209103 | .55064000 | 210103 | .80534000 |
| 211103 | 1.32040000 | 201104 | 3.72060000 | 202104 | 1.32691500 | 203104 | .51789000 |
| 204104 | .70184000 | * 205104 | . | * 206104 | . | 207104 | .05822000 |
| 208104 | .16010000 | 209104 | .13038500 | 210104 | .07237000 | 211104 | .77987000 |
| 201105 | 3.65268000 | 202105 | 1.69057000 | 203105 | .44997000 | 204105 | 1.13200000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .31292000 | 208105 | .17283500 |
| 209105 | .22660500 | 210105 | .07237000 | 211105 | .67374500 | 201106 | 3.97085000 |
| 202106 | 1.50217000 | 203106 | .76814000 | 204106 | .90539500 | 205106 | .15686000 |
| 206106 | .14695500 | * 207106 | . | * 208106 | . | * 209106 | . |
| * 210106 | . | 211106 | 1.44471500 | 201107 | 5.25850000 | 202107 | 2.87755000 |
| 203107 | 2.05579000 | 204107 | 2.28077500 | 205107 | 1.54356000 | 206107 | 1.14170000 |
| 207107 | .49525000 | 208107 | .08914500 | 209107 | .41884000 | * 210107 | . |
| 211107 | .71457500 | 301101 | 2.20814000 | * 302101 | . | * 303101 | . |
| 304101 | .34862500 | 305101 | .61505000 | * 306101 | . | 307101 | .11005000 |
| 308101 | .86314000 | 309101 | .24752000 | 310101 | .07530500 | 311101 | 1.24154000 |
| 301102 | 2.98314000 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .46862500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .04005000 | 308102 | .83814000 |
| 309102 | .17752000 | 310102 | .05030500 | 311102 | 1.24734000 | 301103 | 3.00451500 |
| 302103 | .54337500 | 303103 | .15637500 | * 304103 | . | 305103 | .01642500 |
| 306103 | .00637500 | 307103 | .02142500 | 308103 | .75951500 | 309103 | .07889500 |
| 310103 | .32168000 | 311103 | 1.25451500 | 301104 | 3.37809000 | 302104 | 1.19595000 |
| 303104 | .36495000 | 304104 | .54857500 | * 305104 | . | 306104 | .01495000 |
| * 307104 | . | 308104 | .71809000 | 309104 | .01747000 | 310104 | .09525500 |
| 311104 | 1.15809000 | 301105 | 3.26384500 | 302105 | 1.91870500 | 303105 | .37570500 |
| 304105 | .88433000 | 305105 | .00575500 | 306105 | .21070500 | 307105 | .08575500 |
| 308105 | .81884500 | 309105 | .12322500 | 310105 | .37601000 | 311105 | .97884500 |
| 301106 | 3.50562000 | 302106 | 1.44248000 | 303106 | .58748000 | 304106 | .70110500 |
| 305106 | .10753000 | 306106 | .08748000 | 307106 | .00253000 | 308106 | .64462000 |
| * 309106 | . | 310106 | .14778500 | 311106 | 1.02562000 | 301107 | 4.82283500 |
| 302107 | 2.91569500 | 303107 | 2.00969500 | 304107 | 2.14332000 | 305107 | 1.51974500 |
| 306107 | 1.28469500 | 307107 | 1.04474500 | 308107 | 1.38283500 | 309107 | .74221500 |
| * 310107 | . | 311107 | 1.17783500 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .23567000 | +205PIE | .11815000 | * +206OKC | . |
| * +207JAC | . | * +208LOU | . | +209THM | .06010000 | +210ROA | .48466500 |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

## APPENDIX G, TABLE VIII

SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL IV ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1965

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .23517500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | .73909000 | 206101 | .31459000 | 207101 | .56217000 | 208101 | 1.32061000 |
| 209101 | .83668000 | 210101 | 1.69417000 | 211101 | 1.36872000 | 201102 | .85572000 |
| 202102 | .35321500 | 203102 | .38894500 | 204102 | .68609500 | 205102 | .72571500 |
| 206102 | .11302000 | 207102 | .33513000 | 208102 | 1.11621000 | 209102 | .60398000 |
| 210102 | 1.12894500 | 211102 | 1.16432000 | 201103 | .94929000 | 202103 | .57272000 |
| * 203103 | . | * 204103 | . | 205103 | .03820500 | 206103 | .05801500 |
| 207103 | .45983000 | 208103 | .70745500 | 209103 | .63812000 | 210103 | .89282000 |
| 211103 | .71736000 | 201104 | 1.51246000 | 202104 | 1.32691500 | 203104 | .51789000 |
| 204104 | .70184000 | * 205104 | . | * 206104 | . | 207104 | .14570000 |
| 208104 | .24758000 | 209104 | .21786500 | 210104 | .15985000 | 211104 | .17683000 |
| 201105 | 1.44454000 | 202105 | 1.69057000 | 203105 | .44997000 | 204105 | 1.13200000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .40040000 | 208105 | .26031500 |
| 209105 | .31408500 | 210105 | .15985000 | 211105 | .07070500 | 201106 | 1.67523000 |
| 202106 | 1.41469000 | 203106 | .68066000 | 204106 | .81791500 | 205106 | .06938000 |
| 206106 | .05944750 | * 207106 | . | * 208106 | . | * 209106 | . |
| * 210106 | . | 211106 | .75419500 | 201107 | 2.96288000 | 202107 | 2.79007000 |
| 203107 | 1.96831000 | 204107 | 2.19329500 | 205107 | 1.45608000 | 206107 | 1.05422000 |
| 207107 | .49525000 | 208107 | .08914500 | 209107 | .41884000 | * 210107 | . |
| 211107 | .02405500 | * 301101 | . | * 302101 | . | * 303101 | . |
| 304101 | .34862500 | 305101 | .61505000 | * 306101 | . | 307101 | .19500000 |
| 308101 | .30600000 | 309101 | .39510000 | 310101 | .52010000 | 311101 | .63850000 |
| 301102 | .77500000 | 302102 | .78700000 | 303102 | .46500000 | 304102 | .46862500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .12500000 | 308102 | .28100000 |
| 309102 | .32510000 | 310102 | .49510000 | 311102 | .64430000 | 301103 | .79637500 |
| 302103 | .54337500 | 303103 | .15637500 | * 304103 | . | 305103 | .01642500 |
| 306103 | .00637500 | 307103 | .10637500 | 308103 | .20237500 | 309103 | .22647500 |
| 310103 | .76647500 | 311103 | .65147500 | 301104 | 1.16995000 | 302104 | 1.19595000 |
| 303104 | .36495000 | 304104 | .54857500 | * 305104 | . | 306104 | .01495000 |
| 307104 | .08495000 | 308104 | .16095000 | 309104 | .16505000 | 310104 | .54005000 |
| 311104 | .55505000 | 301105 | 1.05570500 | 302105 | 1.91870500 | 303105 | .37570500 |
| 304105 | .88433000 | 305105 | .00575500 | 306105 | .21070500 | 307105 | .17070500 |
| 308105 | .26170500 | 309105 | .27080500 | 310105 | .82080500 | 311105 | .37580500 |
| 301106 | 1.21000000 | 302106 | 1.35500000 | 303106 | .50000000 | 304106 | .61362500 |
| 305106 | .02005000 | * 306106 | . | * 307106 | . | * 308106 | . |
| 309106 | .06010000 | 310106 | .50510000 | 311106 | .33510000 | 301107 | 2.52721500 |
| 302107 | 2.82821500 | 303107 | 1.92221500 | 304107 | 2.05584000 | 305107 | 1.43226500 |
| 306107 | 1.19721500 | 307107 | 1.04221500 | 308107 | .73821500 | 309107 | .80231500 |
| 310107 | .35731500 | 311107 | .48731500 | * +201SPK | . | * +202OGD | . |
| * +203BIL | . | +204CHE | .23567000 | +205PIE | .11815000 | * +206OKC | . |
| +207JAC | .00253000 | +208LOU | .64462000 | * +209THM | . | +210ROA | .12735000 |
| * +211HAR | . | * +301SPK | . | * +302OGD | . | * +303BIL | . |
| * +304CHE | . | * +305PIE | . | * +306OKC | . | * +307JAC | . |
| * +308LOU | . | * +309THM | . | * +310ROA | . | * +311HAR | . |

## APPENDIX G, TABLE IX

## SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL I ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .72867000 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.34968200 |
| 205101 | 1.61583600 | 206101 | 1.19971600 | 207101 | 1.57733600 | 208101 | 2.21676400 |
| 209101 | 1.98219200 | 210101 | 2.70410800 | 211101 | 2.45128800 | * 301101 | . |
| * 302101 | . | * 303101 | . | 304101 | .50500000 | 305101 | .93500000 |
| 306101 | .30500000 | 307101 | .43000000 | 308101 | .54100000 | 309101 | .57000000 |
| 310101 | .33000000 | 311101 | .58840000 | * 212101 | . | 312101 | . |
| 201102 | 1.14032800 | 202102 | .35896600 | 203102 | .59381800 | 204102 | .89002800 |
| 205102 | 1.20048600 | 206102 | .53884800 | 207102 | .88324000 | 208102 | 1.55220400 |
| 209102 | 1.28071200 | 210102 | 1.56881800 | 211102 | 1.78672800 | 301102 | .47000000 |
| 302102 | .48200000 | 303102 | .16000000 | 304102 | .32000000 | 305102 | .35500000 |
| * 306102 | . | 307102 | .05500000 | 308102 | .21100000 | 309102 | .19500000 |
| * 310102 | . | 311102 | .28920000 | * 212102 | . | 312102 | . |
| 201103 | 1.26744600 | 202103 | .65037800 | 203103 | .09145000 | * 204103 | . |
| 205103 | .30861200 | 206103 | .47213600 | 207103 | 1.05097000 | 208103 | 1.02399200 |
| 209103 | 1.33029800 | 210103 | 1.26581800 | 211103 | 1.20867400 | 301103 | .64000000 |
| 302103 | .38700000 | * 303103 | . | * 304103 | . | 305103 | .18000000 |
| 306103 | .15500000 | 307103 | .18500000 | 308103 | .28100000 | 309103 | .24500000 |
| 310103 | .42000000 | 311103 | .44500000 | 212103 | .62000000 | 312103 | .62000000 |
| 201104 | 1.79332400 | 202104 | 1.42546600 | 203104 | .55825600 | 204104 | .70678600 |
| 205104 | .04994000 | 206104 | .18762000 | 207104 | .43232800 | 208104 | .21521200 |
| 209104 | .57320600 | 210104 | .10076000 | 211104 | .29467200 | 301104 | .85000000 |
| 302104 | .87600000 | 303104 | .04500000 | 304104 | .38500000 | * 305104 | . |
| * 306104 | . | * 307104 | . | 308104 | .07600000 | 309104 | .02000000 |
| 310104 | .03000000 | 311104 | .18500000 | 212104 | .60500000 | 312104 | .60500000 |
| 201105 | 1.70025400 | 202105 | 1.89542600 | 203105 | .46518600 | 204105 | 1.26350800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .76014600 | 208105 | .22736400 |
| 209105 | .69427200 | 210105 | .09629800 | 211105 | .15176000 | 301105 | .73000000 |
| 302105 | 1.59300000 | 303105 | .05000000 | 304105 | .71500000 | * 305105 | . |
| 306105 | .19000000 | 307105 | .08000000 | 308105 | .17100000 | 309105 | .12000000 |
| 310105 | .30500000 | * 311105 | . | 212105 | .59500000 | 312105 | .59500000 |
| 201106 | 2.11345200 | 202106 | 1.64775600 | 203106 | .87838400 | 204106 | .96599600 |
| 205106 | .24823200 | 206106 | .37299000 | 207106 | .35002800 | * 208106 | . |
| 209106 | .39676000 | * 210106 | . | 211106 | 1.15567800 | 301106 | .97500000 |
| 302106 | 1.12000000 | 303106 | .26500000 | 304106 | .53500000 | 305106 | .10500000 |
| 306106 | .07000000 | * 307106 | . | * 308106 | . | * 309106 | . |
| 310106 | .08000000 | 311106 | .05000000 | 212106 | .61500000 | 312106 | .61500000 |
| 201107 | 3.79331200 | 202107 | 3.44206800 | 203107 | 2.55824400 | 204107 | 2.76030800 |
| 205107 | 2.05731200 | 206107 | 1.67072800 | 207107 | .99612800 | 208107 | .11629800 |
| 209107 | .94317600 | * 210107 | . | 211107 | .20314200 | 301107 | 2.51676600 |
| 302107 | 2.81776600 | 303107 | 1.91176600 | 304107 | 2.20176600 | 305107 | 1.74176600 |
| 306107 | 1.49176600 | 307107 | 1.26676600 | 308107 | .96276600 | 309107 | .96676600 |
| 310107 | .15676600 | 311107 | .42676600 | 212107 | 1.57676600 | 312107 | 1.57676600 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .19170800 |
| * +205PIE | . | * +206OKC | . | * +207JAC | . | +208LOU | .39808800 |
| * +209THM | . | +210ROA | .13438000 | * +211HAR | . | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | * +311HAR | . | * +312DUM | . |

## APPENDIX G., TABLE X

## SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL II ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .72867000 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.34968200 |
| 205101 | 1.61583600 | 206101 | 1.19971600 | 207101 | 1.57733600 | 208101 | 2.21676400 |
| 209101 | 1.98219200 | 210101 | 2.70410800 | 211101 | 2.45128800 | * 301101 | . |
| * 302101 | . | * 303101 | . | 304101 | .50500000 | 305101 | .93500000 |
| 306101 | .30500000 | 307101 | .43000000 | 308101 | .54100000 | 309101 | .57000000 |
| 310101 | .33000000 | 311101 | .58840000 | * 212101 | . | 312101 | . |
| 201102 | 1.14032800 | 202102 | .35896600 | 203102 | .59381800 | 204102 | .89002800 |
| 205102 | 1.20048600 | 206102 | .53884800 | 207102 | .88324000 | 208102 | 1.55220400 |
| 209102 | 1.28071200 | 210102 | 1.56881680 | 211102 | 1.78672800 | 301102 | .47000000 |
| 302102 | .48200000 | 303102 | .16000000 | 304102 | .320000000 | 305102 | .35500000 |
| * 306102 | . | 307102 | .05500000 | 308102 | .21100000 | 309102 | .19500000 |
| * 310102 | . | 311102 | .289200000 | * 212102 | . | 312102 | . |
| 201103 | 1.26744600 | 202103 | .65037800 | 203103 | .09145000 | * 204103 | . |
| 205103 | .30861200 | 206103 | .47213600 | 207103 | 1.05097000 | 208103 | 1.02399200 |
| 209103 | 1.33029800 | 210103 | 1.26581800 | 211103 | 1.20867400 | 301103 | .64000000 |
| 302103 | .38700000 | * 303103 | . | * 304103 | . | 305103 | .18000000 |
| 306103 | .15500000 | 307103 | .18500000 | 308103 | .28100000 | 309103 | .24500000 |
| 310103 | .42000000 | 311103 | .44500000 | 212103 | .62000000 | 312103 | .62000000 |
| 201104 | 1.79332400 | 202104 | 1.42546600 | 203104 | .55825600 | 204104 | .70678600 |
| 205104 | .04994000 | 206104 | .18762000 | 207104 | .43232800 | 208104 | .21521200 |
| 209104 | .57320600 | 210104 | .10076000 | 211104 | .29467200 | 301104 | .85000000 |
| 302104 | .87600000 | 303104 | .04500000 | 304104 | .38500000 | * 305104 | . |
| * 306104 | . | * 307104 | . | 308104 | .07600000 | 309104 | .02000000 |
| 310104 | .03000000 | 311104 | .18500000 | 212104 | .60500000 | 312104 | .60500000 |
| 201105 | 1.70025400 | 202105 | 1.89542600 | 203105 | .46518600 | 204105 | 1.26350800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .76014600 | 208105 | .22736400 |
| 209105 | .69427200 | 210105 | .09629800 | 211105 | .15176000 | 301105 | .73000000 |
| 302105 | 1.59300000 | 303105 | .05000000 | 304105 | .71500000 | * 305105 | . |
| 306105 | .19000000 | 307105 | .08000000 | 308105 | .17100000 | 309105 | .12000000 |
| 310105 | .30500000 | * 311105 | . | 212105 | .59500000 | 312105 | .59500000 |
| 201106 | 2.11345200 | 202106 | 1.64775600 | 203106 | .87838400 | 204106 | .96599600 |
| 205106 | .24823200 | 206106 | .37299000 | 207106 | .35002800 | * 208106 | . |
| 209106 | .39676000 | * 210106 | . | 211106 | 1.15567800 | 301106 | .97500000 |
| 302106 | 1.12000000 | 303106 | .26500000 | 304106 | .53500000 | 305106 | .10500000 |
| 306106 | .07000000 | * 307106 | . | * 308106 | . | * 309106 | . |
| 310106 | .08000000 | 311106 | .05000000 | 212106 | .61500000 | 312106 | .61500000 |
| 201107 | 3.79331200 | 202107 | 3.44206800 | 203107 | 2.55824400 | 204107 | 2.76030800 |
| 205107 | 2.05731200 | 206107 | 1.67072800 | 207107 | .99612800 | 208107 | .11629800 |
| 209107 | .94317600 | * 210107 | . | 211107 | .20314200 | 301107 | 2.51676600 |
| 302107 | 2.81776600 | 303107 | 1.91176600 | 304107 | 2.20176600 | 305107 | 1.74176600 |
| 306107 | 1.49176600 | 307107 | 1.26676600 | 308107 | .96276600 | 309107 | .96676600 |
| 310107 | .15676600 | 311107 | .42676600 | 212107 | 1.57676600 | 312107 | 1.57676600 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .19170800 |
| * +205PIE | . | * +206OKC | . | * +207JAC | . | +208LOU | .39808800 |
| * +209THM | . | +210ROA | .13438000 | * +211HAR | . | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | * +311HAR | . | * +312DUM | . |

## APPENDIX G, TABLE XI

## SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL III ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .72867000 | * 301101 | . | 202101 | .44388200 | * 302101 | . |
| 203101 | .93717400 | * 303101 | . | 204101 | 1.34968200 | 304101 | .50500000 |
| 205101 | 1.57035800 | 305101 | .93500000 | 206101 | 1.01209600 | 306101 | .30500000 |
| 207101 | 1.22730800 | 307101 | .43000000 | 208101 | 2.21676400 | 308101 | .54100000 |
| 209101 | 1.98219200 | 309101 | .57000000 | 210101 | 2.70410800 | 310101 | .46438000 |
| 211101 | 2.29952800 | 311101 | .588400000 | * 212101 | . | 312101 | . |
| 201102 | 1.14032800 | 301102 | .47000000 | 202102 | .35896600 | 302102 | .48200000 |
| 203102 | .59381800 | 303102 | .16000000 | 204102 | .89002800 | 304102 | .32000000 |
| 205102 | 1.15500800 | 305102 | .35500000 | 206102 | .35122800 | * 306102 | . |
| 207102 | .53321200 | 307102 | .05500000 | 208102 | 1.55220400 | 308102 | .21100000 |
| 209102 | 1.28071200 | 309102 | .19500000 | 210102 | 1.56881800 | 310102 | .13438000 |
| 211102 | 1.63496800 | 311102 | .28920000 | * 212102 | . | 312102 | . |
| 201103 | 1.26744600 | 301103 | .64000000 | 202103 | .65037800 | 302103 | .38700000 |
| 203103 | .09145000 | * 303103 | . | * 204103 | . | * 304103 | . |
| 205103 | .26313400 | 305103 | .18000000 | 206103 | .28451600 | 306103 | .15500000 |
| 207103 | .70094200 | 307103 | .18500000 | 208103 | 1.02399200 | 308103 | .28100000 |
| 209103 | 1.33029800 | 309103 | .24500000 | 210103 | 1.26581800 | 310103 | .55438000 |
| 211103 | 1.05691400 | 311103 | .44500000 | 212103 | .62000000 | 312103 | .62000000 |
| 201104 | 1.78332400 | 301104 | .85000000 | 202104 | 1.42546600 | 302104 | .87600000 |
| 203104 | .55825600 | 303104 | .04500000 | 204104 | .70678600 | 304104 | .38500000 |
| 205104 | .00446200 | * 305104 | . | * 206104 | . | * 306104 | . |
| 207104 | .08230000 | * 307104 | . | 208104 | .21521200 | 308104 | .07600000 |
| 209104 | .57320600 | 309104 | .02000000 | 210104 | .10076000 | 310104 | .16438000 |
| 211104 | .14291200 | 311104 | .18500000 | 212104 | .60500000 | 312104 | .60500000 |
| 201105 | 1.70025400 | 301105 | .73000000 | 202105 | 1.89542600 | 302105 | 1.59300000 |
| 203105 | .46518600 | 303105 | .05000000 | 204105 | 1.26350800 | 304105 | .71500000 |
| * 205105 | . | * 305105 | . | 206105 | .63056200 | 306105 | .19000000 |
| 207105 | .41011800 | 307105 | .08000000 | 208105 | .22736400 | 308105 | .17100000 |
| 209105 | .69427200 | 309105 | .12000000 | 210105 | .09629800 | 310105 | .43938000 |
| * 211105 | . | * 311105 | . | 212105 | .59500000 | 312105 | .59500000 |
| 201106 | 2.11345200 | 301106 | .97500000 | 202106 | 1.64775600 | 302106 | 1.12000000 |
| 203106 | .87838400 | 303106 | .26500000 | 204106 | .96599600 | 304106 | .53500000 |
| 205106 | .20275400 | 305106 | .10500000 | 206106 | .18537000 | 306106 | .07000000 |
| * 207106 | . | * 307106 | . | * 208106 | . | * 308106 | . |
| 209106 | .39676000 | * 309106 | . | * 210106 | . | 310106 | .21438000 |
| 211106 | 1.00391800 | 311106 | .05000000 | 212106 | .61500000 | 312106 | .61500000 |
| 201107 | 3.79331200 | 301107 | 2.51676600 | 202107 | 3.44206800 | 302107 | 2.81776600 |
| 203107 | 2.55824400 | 303107 | 1.91176600 | 204107 | 2.76030800 | 304107 | 2.20176600 |
| 205107 | 2.01183400 | 305107 | 1.74176600 | 206107 | 1.48310800 | 306107 | 1.49176600 |
| 207107 | .64610000 | 307107 | 1.26676600 | 208107 | .11629800 | 308107 | .96276600 |
| 209107 | .94317600 | 309107 | .96676600 | * 210107 | . | 310107 | .29114600 |
| 211107 | .05138200 | 311107 | .42676600 | 212107 | 1.57676600 | 312107 | 1.57676600 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .19170800 |
| * +205PIE | . | * +206OKC | . | * +207JAC | . | +208LOU | .39808800 |
| * +209THM | . | * +210ROA | . | * +211HAR | . | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| +305PIE | .04547800 | +306OKC | .18762000 | +307JAC | .35002800 | * +308LOU | . |
| * +309THM | . | * +310ROA | . | +311HAR | .15176000 | * +312DUM | . |

## APPENDIX G, TABLE XII

## SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL IV ESTIMATED COSTS WITH TRUCK RATE OF $.60 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .72867000 | 202101 | .44388200 | 203101 | .93717400 | 204101 | 1.34968200 |
| 205101 | 1.61583600 | 206101 | 1.19971600 | 207101 | 1.57733600 | 208101 | 2.21676400 |
| 209101 | 1.98219200 | 210101 | 2.70410800 | 211101 | 2.29952800 | * 212101 | . |
| 201102 | 1.14032800 | 202102 | .35896600 | 203102 | .59381800 | 204102 | .89002800 |
| 205102 | 1.20048600 | 206102 | .53884800 | 207102 | .88324000 | 208102 | 1.55220400 |
| 209102 | 1.28071200 | 210102 | 1.56881800 | 211102 | 1.63496800 | * 212102 | . |
| 201103 | 1.26744600 | 202103 | .65037800 | 203103 | .09145000 | * 204103 | . |
| 205103 | .30861200 | 206103 | .47213600 | 207103 | 1.05097000 | 208103 | 1.02399200 |
| 209103 | 1.33029800 | 210103 | 1.26581800 | 211103 | 1.05691400 | 212103 | .62000000 |
| 201104 | 1.79332400 | 202104 | 1.42546600 | 203104 | .55825600 | 204104 | .70678600 |
| 205104 | .04994000 | 206104 | .18762000 | 207104 | .43232800 | 208104 | .21521200 |
| 209104 | .57320600 | 210104 | .10076000 | 211104 | .14291200 | 212104 | .60500000 |
| 201105 | 1.70025400 | 202105 | 1.89542600 | 203105 | .46518600 | 204105 | 1.26350800 |
| 205105 | .04547800 | 206105 | .81818200 | 207105 | .76014600 | 208105 | .22736400 |
| 209105 | .68427200 | 210105 | .09629800 | * 211105 | . | 212105 | .59500000 |
| 201106 | 2.11345200 | 202106 | 1.64775600 | 203106 | .87838400 | 204106 | .96599600 |
| 205106 | .24823200 | 206106 | .37299000 | 207106 | .35002800 | * 208106 | . |
| 209106 | .39676000 | * 210106 | . | 211106 | 1.00391800 | 212106 | .61500000 |
| 201107 | 3.79331200 | 202107 | 3.44206800 | 203107 | 2.55824400 | 204107 | 2.76030800 |
| 205107 | 2.05731200 | 206107 | 1.67072800 | 207107 | .99612800 | 208107 | .11629800 |
| 209107 | .94317600 | * 210107 | . | 211107 | .05138200 | 212107 | 1.57676600 |
| * 301101 | . | * 302101 | . | * 303101 | . | 304101 | .50500000 |
| 305101 | .93500000 | 306101 | .30500000 | 307101 | .43000000 | 308101 | .54100000 |
| 309101 | .57000000 | 310101 | .33000000 | 311101 | .58840000 | 312101 | . |
| 301102 | .47000000 | 302102 | .48200000 | 303102 | .16000000 | 304102 | .32000000 |
| 305102 | .35500000 | * 306102 | . | 307102 | .05500000 | 308102 | .21100000 |
| 309102 | .19500000 | * 310102 | . | 311102 | .28920000 | 312102 | . |
| 301103 | .64000000 | 302103 | .38700000 | * 303103 | . | * 304103 | . |
| 305103 | .18000000 | 306103 | .15500000 | 307103 | .18500000 | 308103 | .28100000 |
| 309103 | .24500000 | 310103 | .42000000 | 311103 | .44500000 | 312103 | .62000000 |
| 301104 | .85000000 | 302104 | .87600000 | 303104 | .04500000 | 304104 | .38500000 |
| * 305104 | . | * 306104 | . | * 307104 | . | 308104 | .07600000 |
| 309104 | .02000000 | 310104 | .03000000 | 311104 | .18500000 | 312104 | .60500000 |
| 301105 | .73000000 | 302105 | 1.59300000 | 303105 | .05000000 | 304105 | .71500000 |
| * 305105 | . | 306105 | .19000000 | 307105 | .08000000 | 308105 | .17100000 |
| 309105 | .12000000 | 310105 | .30500000 | * 311105 | . | 312105 | .59500000 |
| 301106 | .97500000 | 302106 | 1.12000000 | 303106 | .26500000 | 304106 | .53500000 |
| 305106 | .10500000 | 306106 | .07000000 | * 307106 | . | * 308106 | . |
| * 309106 | . | 310106 | .08000000 | 311106 | .50000000 | 312106 | .61500000 |
| 301107 | 2.51676600 | 302107 | 2.81776600 | 303107 | 1.91176600 | 304107 | 2.20176600 |
| 305107 | 1.74176600 | 306107 | 1.49176600 | 307107 | 1.26676600 | 308107 | .96276600 |
| 309107 | .96676600 | 310107 | .15676600 | 311107 | .42676600 | 312107 | 1.57676600 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .19170800 |
| * +205PIE | . | * +206OKC | . | * +207JAC | . | +208LOU | .39808800 |
| * +209THM | . | +210ROA | .13438000 | * +211HAR | . | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | +311HAR | .15176000 | * +312DUM | . |

## APPENDIX G, TABLE XIII

### SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL I ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .23517500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | 1.04409000 | 206101 | .61959000 | 207101 | .77969000 | 208101 | 1.53813000 |
| 209101 | 1.05420000 | 210101 | 1.91169000 | 211101 | 1.60301500 | * 212101 | . |
| 201102 | .55072000 | 202102 | .04821500 | 203102 | .08394500 | 204102 | .38109500 |
| 205102 | .72571500 | 206102 | .11302000 | 207102 | .24765000 | 208102 | 1.02873000 |
| 209102 | .51650000 | 210102 | 1.04146500 | 211102 | 1.09361500 | * 212102 | . |
| 201103 | .94929000 | 202103 | .57272000 | * 203103 | . | * 204103 | . |
| 205103 | .34320500 | 206103 | .36301500 | 207103 | .67735000 | 208103 | .92497500 |
| 209103 | .85564000 | 210103 | 1.11034000 | 211103 | .95165500 | 212103 | .77637500 |
| 201104 | 1.20746000 | 202104 | 1.02191500 | 203104 | .21289000 | 204104 | .39684000 |
| * 205104 | . | * 206104 | . | 207104 | .05822000 | 208104 | .16010000 |
| 209104 | .13038500 | 210104 | .07237000 | 211104 | .10612500 | 212104 | .61995000 |
| 201105 | 1.13954000 | 202105 | 1.38557000 | 203105 | .14497000 | 204105 | .82700000 |
| * 205105 | . | 206105 | .48376000 | 207105 | .31292000 | 208105 | .17283500 |
| 209105 | .22660500 | 210105 | .07237000 | * 211105 | . | 212105 | .61570500 |
| 201106 | 1.45771000 | 202106 | 1.19717000 | 203106 | .46314000 | 204106 | .60039500 |
| 205106 | .15686000 | 206106 | .14695500 | * 207106 | . | * 208106 | . |
| * 209106 | . | * 210106 | . | 211106 | .77097000 | 212106 | .63248000 |
| 201107 | 2.74536000 | 202107 | 2.57255000 | 203107 | 1.75079000 | 204107 | 1.97577500 |
| 205107 | 1.54356000 | 206107 | 1.14170000 | 207107 | .49525000 | 208107 | .08914500 |
| 209107 | .41884000 | * 210107 | . | 211107 | .04083000 | 212107 | 1.36969500 |
| * 301101 | . | * 302101 | . | * 303101 | . | 304101 | .34862500 |
| 305101 | .92005000 | 306101 | .30500000 | 307101 | .41505000 | 308101 | .52352000 |
| 309101 | .55252000 | 310101 | .38030500 | 311101 | .56769500 | 312101 | . |
| 301102 | .47000000 | 302102 | .48200000 | 303102 | .16000000 | 304102 | .16362500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .04005000 | 308102 | .19352000 |
| 309102 | .17752000 | 310102 | .05030500 | 311102 | .26849500 | 312102 | . |
| 301103 | .79637500 | 302102 | .54337500 | 303103 | .15637500 | * 304103 | . |
| 305103 | .32142500 | 306103 | .31137500 | 307103 | .32642500 | 308103 | .41989500 |
| 309103 | .38389500 | 310103 | .62668000 | 311103 | .58067000 | 312103 | .77637500 |
| 301104 | .86495000 | 302104 | .89095000 | 303104 | .05995000 | 304104 | .24357500 |
| * 305104 | . | 306104 | .01495000 | * 307104 | . | 308104 | .07347000 |
| 309104 | .01747000 | 310104 | .09525500 | 311104 | .17924500 | 312104 | .61995000 |
| 301105 | .75070500 | 302105 | 1.61370500 | 303105 | .07070500 | 304105 | .57933000 |
| 305105 | .00575500 | 306105 | .21070500 | 307105 | .08575500 | 308105 | .17422500 |
| 309105 | .12322500 | 310105 | .37601000 | * 311105 | . | 312105 | .61570500 |
| 301106 | .99248000 | 302106 | 1.13748000 | 303106 | .28248000 | 304106 | .39610500 |
| 305106 | .10753000 | 306106 | .08748000 | 307106 | .00253000 | * 308106 | . |
| * 309106 | . | 310106 | .14778500 | 311106 | .04677500 | 312106 | .63248000 |
| 301107 | 2.30969500 | 302107 | 2.61069500 | 303107 | 1.70469500 | 304107 | 1.83832000 |
| 305107 | 1.51974500 | 306107 | 1.28469500 | 307107 | 1.04474500 | 308107 | .73821500 |
| 309107 | .74221500 | * 310107 | . | 311107 | .19899000 | 312107 | 1.36969500 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .23567000 |
| +205PIE | .11815000 | * +206OKC | . | * +207JAC | . | +208LOU | .64462000 |
| +209THM | .06010000 | +210ROA | .48466500 | +211HAR | .30510000 | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | * +311HAR | . | * +312DUM | . |

## APPENDIX G, TABLE XIV

## SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL II ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .23517500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | 1.04409000 | 206101 | .61959000 | 207101 | .77969000 | 208101 | 1.53813000 |
| 209101 | 1.05420000 | 210101 | 1.91169000 | 211101 | 1.60301500 | * 212101 | . |
| 201102 | .55072000 | 202102 | .04821500 | 203102 | .08394500 | 204102 | .38109500 |
| 205102 | .72571500 | 206102 | .11302000 | 207102 | .24765000 | 208102 | 1.02873000 |
| 209102 | .51650000 | 210102 | 1.04146500 | 211102 | 1.09361500 | * 212102 | . |
| 201103 | .94929000 | 202103 | .57272000 | * 203103 | . | * 204103 | . |
| 205103 | .34320500 | 206103 | .36301500 | 207103 | .67735000 | 208103 | .92497500 |
| 209103 | .85564000 | 210103 | 1.11034000 | 211103 | .95165500 | 212103 | .77637500 |
| 201104 | 1.20746000 | 202104 | 1.02191500 | 203104 | .21289000 | 204104 | .39684000 |
| * 205104 | . | * 206104 | . | 207104 | .05822000 | 208104 | .16010000 |
| 209104 | .13038500 | 210104 | .07237000 | 211104 | .10612500 | 212104 | .61995000 |
| 201105 | 1.13954000 | 202105 | 1.38557000 | 203105 | .14497000 | 204105 | .82700000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .31292000 | 208105 | .17283500 |
| 209105 | .22660500 | 210105 | .07237000 | * 211105 | . | 212105 | .61570500 |
| 201106 | 1.45771000 | 202106 | 1.19717000 | 203106 | .46314000 | 204106 | .60039500 |
| 205106 | .15686000 | 206106 | .14695500 | * 207106 | . | * 208106 | . |
| * 209106 | . | * 210106 | . | 211106 | .77097000 | 212106 | .63248000 |
| 201107 | 2.74536000 | 202107 | 2.57255000 | 203107 | 1.75079000 | 204107 | 1.97577500 |
| 205107 | 1.54356000 | 206107 | 1.14170000 | 207107 | .49525000 | 208107 | .08914500 |
| 209107 | .41884000 | * 210107 | . | 211107 | .04083000 | 212107 | 1.36969500 |
| * 301101 | . | * 302101 | . | * 303101 | . | 304101 | .34862500 |
| 305101 | .92005000 | 306101 | .30500000 | 307101 | .41505000 | 308101 | .52352000 |
| 309101 | .55252000 | 310101 | .38030500 | 311101 | .56769500 | 312101 | . |
| 301102 | .47000000 | 302102 | .48200000 | 303102 | .16000000 | 304102 | .16362500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .04005000 | 308102 | .19352000 |
| 309102 | .17752000 | 310102 | .05030500 | 311102 | .26849500 | 312102 | . |
| 301103 | .79637500 | 302103 | .54337500 | 303103 | .15637500 | * 304103 | . |
| 305103 | .32142500 | 306103 | .31137500 | 307103 | .32642500 | 308103 | .41989500 |
| 309103 | .38389500 | 310103 | .62668000 | 311103 | .58067000 | 312103 | .77637500 |
| 301104 | .86495000 | 302104 | .89095000 | 303104 | .05995000 | 304104 | .24357500 |
| * 305104 | . | 306104 | .01495000 | * 307104 | . | 308104 | .07347000 |
| 309104 | .01747000 | 310104 | .09525500 | 311104 | .17924500 | 312104 | .61995000 |
| 301105 | .75070500 | 302105 | 1.61370500 | 303105 | .07070500 | 304105 | .57933000 |
| 305105 | .00575500 | 306105 | .21070500 | 307105 | .08575500 | 308105 | .17422500 |
| 309105 | .12322500 | 310105 | .37601000 | * 311105 | . | 312105 | .61570500 |
| 301106 | .99248000 | 302106 | 1.13748000 | 303106 | .28248000 | 304106 | .39610500 |
| 305106 | .10753000 | 306106 | .08748000 | 307106 | .00253000 | * 308106 | . |
| * 309106 | . | 310106 | .14778500 | 311106 | .04677500 | 312106 | .63248000 |
| 301107 | 2.30969500 | 302107 | 2.61069500 | 303107 | 1.70469500 | 304107 | 1.83832000 |
| 305107 | 1.51974500 | 306107 | 1.28469500 | 307107 | 1.04474500 | 308107 | .73821500 |
| 309107 | .74221500 | * 310107 | . | 311107 | .19899000 | 312107 | 1.36969500 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .23567000 |
| +205PIE | .11815000 | * +206OKC | . | * +207JAC | . | +208LOU | .64462000 |
| +209THM | .06010000 | +210ROA | .48466500 | +211HAR | .30510000 | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | * +311HAR | . | * +312DUM | . |

## APPENDIX G, TABLE XV

SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL III ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .23517500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | 1.04409000 | 206101 | .61959000 | 207101 | .77969000 | 208101 | 1.53813000 |
| 209101 | 1.05420000 | 210101 | 1.91169000 | 211101 | 1.60301500 | * 212101 | . |
| 201102 | .55072000 | 202102 | .04821500 | 203102 | .08394500 | 204102 | .38109500 |
| 205102 | .72571500 | 206102 | .11302000 | 207102 | .24765000 | 208102 | 1.02873000 |
| 209102 | .51650000 | 210102 | 1.04146500 | 211102 | 1.09361500 | * 212102 | . |
| 201103 | .94929000 | 202103 | .57272000 | * 203103 | . | * 204103 | . |
| 205103 | .34320500 | 206103 | .36301500 | 207103 | .67735000 | 208103 | .92497500 |
| 209103 | .85564000 | 210103 | 1.11034000 | 211103 | .95165500 | 212103 | .77637500 |
| 201104 | 1.20746000 | 202104 | 1.02191500 | 203104 | .21289000 | 204104 | .39684000 |
| * 205104 | . | * 206104 | . | 207104 | .05822000 | 208104 | .16010000 |
| 209104 | .13038500 | 210104 | .07237000 | 211104 | .10612500 | 212104 | .61995000 |
| 201105 | 1.13954000 | 202105 | 1.38557000 | 203105 | .14497000 | 204105 | .82700000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .31292000 | 208105 | .17283500 |
| 209105 | .22660500 | 210105 | .07237000 | * 211105 | . | 212105 | .61570500 |
| 201106 | 1.45771000 | 202106 | 1.19717000 | 203106 | .46314000 | 204106 | .60039500 |
| 205106 | .15686000 | 206106 | .14695500 | * 207106 | . | * 208106 | . |
| * 209106 | . | * 210106 | . | 211106 | .77097000 | 212106 | .63248000 |
| 201107 | 2.74536000 | 202107 | 2.57255000 | 203107 | 1.75079000 | 204107 | 1.97577500 |
| 205107 | 1.54356000 | 206107 | 1.1417000 | 207107 | .49525000 | 208107 | .08914500 |
| 209107 | .41884000 | * 210107 | . | 211107 | .04083000 | 212107 | 1.36969500 |
| * 301101 | . | * 302101 | . | * 303101 | . | 304101 | .34862500 |
| 305101 | .92005000 | 306101 | .30500000 | 307101 | .41505000 | 308101 | .52352000 |
| 309101 | .55252000 | 310101 | .38030500 | 311101 | .56769500 | 312101 | . |
| 301102 | .47000000 | 302102 | .48200000 | 303102 | .16000000 | 304102 | .16362500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .04005000 | 308102 | .19352000 |
| 309102 | .17752000 | 310102 | .05030500 | 311102 | .26849500 | 312102 | . |
| 301103 | .79637500 | 302103 | .54337500 | 303103 | .15637500 | * 304103 | . |
| 305103 | .32142500 | 306103 | .31137500 | 307103 | .32642500 | 308103 | .41989500 |
| 309103 | .38389500 | 310103 | .62668000 | 311103 | .58067000 | 312103 | .77637500 |
| 301104 | .86495000 | 302104 | .89095000 | 303104 | .05995000 | 304104 | .24357500 |
| * 305104 | . | 306104 | .01495000 | * 307104 | . | 308104 | .07347000 |
| 309104 | .01747000 | 310104 | .09525500 | 311104 | .17924500 | 312104 | .61995000 |
| 301105 | .75070500 | 302105 | 1.61370500 | 303105 | .07070500 | 304105 | .57933000 |
| 305105 | .00575500 | 306105 | .21070500 | 307105 | .08575500 | 308105 | .17422500 |
| 309105 | .12322500 | 310105 | .37601000 | * 311105 | . | 312105 | .61570500 |
| 301106 | .99248000 | 302106 | 1.13748000 | 303106 | .28248000 | 304106 | .39610500 |
| 305106 | .10753000 | 306106 | .08748000 | 307106 | .00253000 | * 308106 | . |
| * 309106 | . | 310106 | .14778500 | 311106 | .04677500 | 312106 | .63248000 |
| 301107 | 2.30969500 | 302107 | 2.61069500 | 303107 | 1.70469500 | 304107 | 1.83832000 |
| 305107 | 1.51974500 | 306107 | 1.28469500 | 307107 | 1.04474500 | 308107 | .73821500 |
| 309107 | .74221500 | * 310107 | . | 311107 | .19899000 | 312107 | 1.36969500 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .23567000 |
| +205PIE | .11815000 | * +206OKC | . | * +207JAC | . | +208LOU | .64462000 |
| +209THM | .06010000 | +210ROA | .48466500 | +211HAR | .30510000 | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | * +311HAR | . | * +312DUM | . |

APPENDIX G, TABLE XVI

SHADOW PRICES FOR OPTIMUM SHIPMENTS OF FEEDER CATTLE FROM SUPPLY TO DEMAND REGIONS USING MODEL IV ESTIMATED COSTS WITH TRUCK RATE OF $.46 PER MILE, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 201101 | .23517500 | 202101 | .11330500 | 203101 | .34713500 | 204101 | .73343000 |
| 205101 | 1.04409000 | 206101 | .61959000 | 207101 | .77969000 | 208101 | 1.53813000 |
| 209101 | 1.05420000 | 210101 | 1.91169000 | 211101 | 1.60301500 | * 212101 | . |
| 201102 | .55072000 | 202102 | .04821500 | 203102 | .08394500 | 204102 | .38109500 |
| 205102 | .72571500 | 206102 | .11302000 | 207102 | .24765000 | 208102 | 1.02873000 |
| 209102 | .51650000 | 210102 | 1.04146500 | 211102 | 1.09361500 | * 212102 | . |
| 201103 | .94929000 | 202103 | .57272000 | * 203103 | . | * 204103 | . |
| 205103 | .34320500 | 206103 | .36301500 | 207103 | .67735000 | 208103 | .92497500 |
| 209103 | .85564000 | 210103 | 1.11034000 | 211103 | .95165500 | 212103 | .77637500 |
| 201104 | 1.20746000 | 202104 | 1.02191500 | 203104 | .21289000 | 204104 | .39684000 |
| * 205104 | . | * 206104 | . | 207104 | .05822000 | 208104 | .16010000 |
| 209104 | .13038500 | 210104 | .07237000 | 211104 | .10612500 | 212104 | .61995000 |
| 201105 | 1.13954000 | 202105 | 1.38557000 | 203105 | .14497000 | 204105 | .82700000 |
| * 205105 | . | 206105 | .48676000 | 207105 | .31292000 | 208105 | .17283500 |
| 209105 | .22660500 | 210105 | .07237000 | * 211105 | . | 212105 | .61570500 |
| 201106 | 1.45771000 | 202106 | 1.19717000 | 203106 | .46314000 | 204106 | .60039500 |
| 205106 | .15686000 | 206106 | .14695500 | * 207106 | . | * 208106 | . |
| * 209106 | . | * 210106 | . | 211106 | .77097000 | 212106 | .63248000 |
| 201107 | 2.74536000 | 202107 | 2.57255000 | 203107 | 1.75079000 | 204107 | 1.97577500 |
| 205107 | 1.54356000 | 206107 | 1.14170000 | 207107 | .49525000 | 208107 | .08914500 |
| 209107 | .41884000 | * 210107 | . | 211107 | .04083000 | 212107 | 1.36969500 |
| * 301101 | . | * 302101 | . | * 303101 | . | 304101 | .34862500 |
| 305101 | .92005000 | 306101 | .30500000 | 307101 | .41505000 | 308101 | .52352000 |
| 309101 | .55252000 | 310101 | .38030500 | 311101 | .56769500 | 312101 | . |
| 301102 | .47000000 | 302102 | .48200000 | 303102 | .16000000 | 304102 | .16362500 |
| 305102 | .34005000 | * 306102 | . | 307102 | .04005000 | 308102 | .19352000 |
| 309102 | .17752000 | 310102 | .05030500 | 311102 | .26849500 | 312102 | . |
| 301103 | .79637500 | 302103 | .54337500 | 303103 | .15637500 | * 304103 | . |
| 305103 | .32142500 | 306103 | .31137500 | 307103 | .32642500 | 308103 | .41989500 |
| 309103 | .38389500 | 310103 | .62668000 | 311103 | .58067000 | 312103 | .77637500 |
| 301104 | .86495000 | 302104 | .89095000 | 303104 | .05995000 | 304104 | .24357500 |
| * 305104 | . | 306104 | .01495000 | * 307104 | . | 308104 | .07347000 |
| 309104 | .01747000 | 310104 | .09525500 | 311104 | .17924500 | 312104 | .61995000 |
| 301105 | .75070500 | 302105 | 1.61370500 | 303105 | .07070500 | 304105 | .57933000 |
| 305105 | .00575500 | 306105 | .21070500 | 307105 | .08575500 | 308105 | .17422500 |
| 309105 | .12322500 | 310105 | .37601000 | * 311105 | . | 312105 | .61570500 |
| 301106 | .99248000 | 302106 | 1.13748000 | 303106 | .28248000 | 304106 | .39610500 |
| 305106 | .10753000 | 306106 | .08748000 | 307106 | .00253000 | * 308106 | . |
| * 309106 | . | 310106 | .14778500 | 311106 | .04677500 | 312106 | .63248000 |
| 301107 | 2.30969500 | 302107 | 2.61069500 | 303107 | 1.70469500 | 304107 | 1.83832000 |
| 305107 | 1.51974500 | 306107 | 1.28469500 | 307107 | 1.04474500 | 308107 | .73821500 |
| 309107 | .74221500 | * 310107 | . | 311107 | .19899000 | 312107 | 1.36969500 |
| * +201SPK | . | * +202OGD | . | * +203BIL | . | +204CHE | .23567000 |
| +205PIE | .11815000 | * +206OKC | . | * +207JAC | . | +208LOU | .64462000 |
| +209THM | .06010000 | +210ROA | .48466500 | +211HAR | .30510000 | * +212DUM | . |
| * +301SPK | . | * +302OGD | . | * +303BIL | . | * +304CHE | . |
| * +305PIE | . | * +306OKC | . | * +307JAC | . | * +308LOU | . |
| * +309THM | . | * +310ROA | . | * +311HAR | . | * +312DUM | . |

APPENDIX H, TABLE I

DEMAND REGRESSION EQUATIONS FOR 1970

| Region | $\alpha$ | $\beta$ | $s_\beta$ | t |
|---|---|---|---|---|
| 1. Spokane | 533.800000 | 32.057143 | 4.279424 | 7.490995** |
| 2. Bakersfield | 1439.066667 | 130.742857 | 11.465275 | 11.403377** |
| 3. Ogden | 142.733333 | 4.171429 | 3.086420 | 1.351543 |
| 4. Phoenix | 533.000000 | 49.285714 | 4.379451 | 11.253857** |
| 5. Billings | 98.533333 | 4.942857 | 3.647457 | 1.355152 |
| 6. Cheyenne | 84.133333 | -4.371429 | .778451 | -5.615548** |
| 7. Denver | 635.866667 | 72.942857 | 12.700549 | 5.743284** |
| 8. Pierre | 538.266667 | 39.971429 | 16.909346 | 2.363866 |
| 9. Omaha | 1731.933333 | 240.114286 | 29.722792 | 8.078457** |
| 10. Oklahoma City | 440.466667 | 160.914286 | 7.912652 | 20.336328** |
| 11. St. Paul | 921.133333 | 22.485714 | 6.967993 | 3.227000* |
| 12. Des Moines | 4096.533333 | 100.800000 | 23.000041 | 4.382601** |
| 13. Jackson | -12.500000 | 28.700000 | 4.705670 | 6.099025** |
| 14. Indianapolis | 558.133333 | 14.200000 | 4.513683 | 3.145990* |
| 15. Louisville | 169.000000 | -14.000000 | NA | NA |
| 16. Thomasville | -43.100000 | 65.500000 | 13.224598 | 4.952892** |
| 17. Roanoke | NA | NA | NA | NA |
| 18. Harrisburg | 154.200000 | -6.342857 | 1.027778 | 6.171427** |
| United States | 11,727.4000000 | 981.600000 | 81.214109 | 12.086570** |

Years included in estimates -- 1960-65.

*Significant at .05 level.

**Significant at .01 level.

APPENDIX H, TABLE II

SUPPLY REGRESSION EQUATIONS FOR 1970

| Region | $\alpha$ | $\beta$ | $s_\beta$ | t |
|---|---|---|---|---|
| 1. Spokane | 284.335779 | 27.755022 | 1.467673 | 18.910903** |
| 2. Bakersfield | 319.953096 | 12.122492 | 1.231057 | 9.847222** |
| 3. Ogden | 229.846978 | 4.683683 | .743739 | 6.297482** |
| 4. Phoenix | 567.393763 | -.828665 | 38.808911 | -.679263 |
| 5. Billings | 409.920814 | 20.594809 | 1.559056 | 13.209794** |
| 6. Cheyenne | 235.920749 | 6.288684 | .799081 | 7.869896** |
| 7. Denver | 342.326218 | 9.402663 | 1.044226 | 9.004433** |
| 8. Pierre | 481.352454 | 48.749531 | 2.177465 | 22.388204** |
| 9. Omaha | 1094.423519 | 45.984243 | 5.116358 | 8.987691** |
| 10. Oklahoma City | 2125.910384 | 76.226939 | 7.830925 | 9.734091** |
| 11. St. Paul | 79.725711 | 15.866948 | 1.046840 | 15.156994** |
| 12. Des Moines | 850.389988 | 57.023780 | 4.795946 | 11.889996** |
| 13. Jackson | 492.134364 | 60.571274 | 4.715693 | 12.844618** |
| 14. Indianapolis | 123.487717 | 13.598625 | 1.260425 | 10.788920** |
| 15. Louisville | 17.832848 | 35.545625 | 3.666019 | 9.695974** |
| 16. Thomasville | 260.062331 | 28.206092 | 2.386485 | 11.819095** |
| 17. Roanoke | 88.094617 | 18.134637 | 1.132720 | 16.009814** |
| 18. Harrisburg | 28.881931 | 5.028484 | .467833 | 10.748459** |
| United States | 8100.095567 | 481.592152 | 31.278197 | 15.397056** |

Years included in estimates -- 1945-67.

*Significant at .05 level.

**Significant at .01 level.

VITA

Max Furnia Bowser

Master of Science

Thesis: OPTIMUM PATTERNS OF DISTRIBUTION FOR FEEDER CATTLE

Major Field: Agricultural Economics

Biographical:

Personal Data: Born near Accident, Maryland, July 17, 1939, the son of Freeman E. and A. Auburn Bowser.

Education: Graduated from Northern Garrett County Junior-Senior High School in 1957; received the Bachelor of Science degree from the University of Maryland, with a major in Agricultural Economics in February, 1965; engaged in graduate study toward the Master of Science degree at Oklahoma State University from June, 1965 to May, 1967.

Professional Experience: Research Assistant in the Department of Agricultural Economics, Oklahoma State University, from June, 1965 to May, 1967. Served in the United States Marine Corps from June, 1957 to June, 1961.