1968

Optimum Movement of Feeder Calves and Feed Grains within South Dakota with Implications for Slaughter Plant Location

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OPTIMUM MOVEMENT OF FEEDER CALVES AND FEED GRAINS WITHIN SOUTH DAKOTA WITH IMPLICATIONS FOR SLAUGHTER PLANT LOCATION

BY

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A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Industrial Economics, South Dakota
State University

1968

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser Date

Head, Economics Department Date

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to Dr. Mark J. Powers, thesis advisor, without whose capable guidance and counseling this study would have been impossible.

I would also like to thank the many others who made valuable contributions and suggestions which aided me in this study. Although it is not possible to list them all, I would like to express my appreciation to Bill L. Jewett who made the initial investigation out of which this thesis evolved, and who set up the computer program used for solving the model; L. T. Smythe, who suggested the references used for the theoretical framework; Dr. Richard P. Covert, who helped in setting up the model; and Dr. Robert L. Beck, who read the manuscript and made important suggestions for the final draft.

This thesis is dedicated to my wife, Mary Jo, who not only gave me support and encouragement while writing the manuscript; but also, accepted the task of typing the final draft.

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CHAPTER I

INTRODUCTION

The basic economic activity in South Dakota is agriculture. Therefore, it is essential to the economic position of the state that information is made available which can serve as a guide in developing the agricultural industries within the state. The purpose of this study is to provide such information to the cattle feeding and beef slaughtering industries.

Livestock data indicate that a large proportion of the cattle produced in South Dakota is shipped out of the state for fattening and slaughter. Data also indicate that the state is an exporter of feed grains. It seems that if these feeder cattle and feed grains were retained within the state, South Dakota would have available potential resources to expand its beef industry. Studies have shown that there are markets available for dressed beef and slaughter cattle from South

Dakota. These studies also indicate that South Dakota has a comparative advantage in supplying these markets.[1]

Another study concludes that the structure of shipping patterns for beef from surplus regions to deficit regions is quite stable.[2] This means that the probability that South Dakota will lose its comparative advantage is slight. Also, predictions on the expansion of beef production and the expected growth of feedlots for beef, shown in Figures 1-1 and 1-2 respectively; suggest that cattle feeding should increase in South Dakota.[3] Given this information, along with favorable long-term demand prospects for beef, it becomes apparent that the cattle feeding and beef slaughtering industries in the state are operating far below their potential production. The question which arises is, how can these industries be more fully developed?

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[1] Judge, G. G., Havlicek, J., and Rizek, R. L., Spatial Structure of the Livestock Economy. 1. Spatial Analyses of the Meat Marketing Sector in 1955 and 1960, S. Dak. State University, Brookings, N. Cent. Regional Res. Bul. 157 (Expt. Sta. Bul. 520), May, 1964.

Havlicek, J., Rizek, R. L., and Judge, G. G., Spatial Structure of the Livestock Economy. II. Spatial Analyses of the Flows of Slaughter Livestock in 1955 and 1960, S. Dak. State University, Brookings, N. Cent. Regional Res. Bul. 159 (Expt. Sta. Bul. 521), July, 1964.

Rizek, R. L., Judge, G. G., and Havlicek, J., Spatial Structure of the Livestock Economy. III. Joint Spatial Analysis of Regional Slaughter and the Flows and Pricing of Livestock and Meat, S. Dak. State University, Brookings, N. Cent. Regional Res. Bul. 163 (Expt. Sta. Bul. 522), October, 1965.

[2] Crom, Richard J., Simulated Interregional Models of the Livestock-Meat Economy, Marketing Economics Division, Economic Research Service, USDA, Agricultural Economic Report No. 117, July, 1967.

[3] Pope, L. S., "Beef Industry is Facing Important Development: Pope," Beef, Webb Publishing Co., St. Paul, Minn., April, 1968, pp. 34-35.

Figure 1-1. Shifting Pattern of Beef Production

Figure 1-2. Pattern of Expected Feedlot Growth

The geography of South Dakota is such that the area west of the Missouri River is well suited for raising feeder cattle. The area east of the Missouri River is more suitable for growing small grains, including feed grains. It is possible, therefore, that a deficit of feed grains and a surplus of feeder cattle will exist in some areas of the state, while a surplus of feed grains and a deficit of feeder cattle will exist in other areas.

To identify the areas which are most efficient in feeding cattle, a study is necessary to determine a least-cost pattern for transporting cattle and feed from one area to another. The purpose of this study is to identify those regions of the state which have surpluses or deficits of feeder calves and feed grains. Once these regions have been identified it is possible to determine which of two alternatives is more economical, (1) the movement of feeder cattle to the surplus feed grains; or, (2) the movement of surplus feed grains to the feeder cattle.

If the optimum shipping patterns of feeder cattle and feed grains are known, it is possible to determine the regions which have an advantage in feeding cattle and the number of fat cattle that a region would produce. If the potential number of fat cattle produced in a region is known along with the present slaughtering capacity within each region, it is possible to discuss, in a general manner, which is more economical, (1) to ship the excess slaughter cattle of a region to available markets in the form of dressed beef; or, (2) to ship the excess slaughter cattle of a region to available markets as live animals.

A study of this nature should be of importance to farmers who produce feed grains, ranchers who produce feeder cattle, and meat packers who process fat cattle. This study should also be of interest to state policy makers who are concerned with the economic development of businesses and communities in South Dakota.

STATEMENT OF THE PROBLEM

The problem to be solved is as follows. Given that South Dakota has a comparative advantage to export fat cattle and dressed beef; also, given that some areas in the state are best suited for raising feeder cattle, while other areas are best suited for growing feed grains; what areas within the state have a surplus of feeder calves and a deficit of feed grains? What areas within the state have a surplus of feed grains and a deficit of feeder calves?

Once these areas are identified the question arises as to which is more economical, (1) the shipment of surplus feed grains to surplus feeder calves; or, (2) the shipment of surplus feeder calves to surplus feed grains.

Also, given an increased production of beef in South Dakota, there are implications with respect to the number, size and location of current and future slaughtering plants. A study on optimum plant location is beyond the scope of this thesis; however, some implications based on transportation costs are discussed in a later chapter.

OBJECTIVES

The primary objective of this study is to determine the optimum movement of feeder calves and feed grains within South Dakota. A corollary to this objective is to discuss the alternatives for handling excess slaughter cattle, assuming there is no change in present slaughtering facilities.

REVIEW OF LITERATURE

Three publications resulted from a study conducted by thirteen agricultural experiment stations in the Midwest.[4] This study, entitled "Adjustments in Livestock Marketing in the North Central States to Changing Patterns of Production and Consumption", made an extensive analysis of data on the geographical movement of livestock and meat in the United States in 1955 and 1960. The study indicated that in 1955 and 1960, using a combination of truck and rail rates, South Dakota had a comparative advantage to ship slaughter cattle to both the East and West Coast. When considering the shipment of dressed beef, South Dakota had a comparative advantage for shipping to points on the East Coast and the Butte, Montana area.

In this study North Dakota and South Dakota are considered as one region using Bismark, North Dakota as the supply and demand point. However, it is argued that the results would remain unchanged if South Dakota were considered as a separate region. This is a valid argument

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[4] Judge, Havlicek and Rizek, op. cit.

since South Dakota is in a favorable competitive position with North Dakota in producing fat cattle as is indicated in Figure 1-1 and in studies mentioned below.

Crom, using the model developed in the above study, projected livestock production to the year 1975.[5] This study indicated that the structure of shipping patterns for both cattle and beef is rather stable. This means that a low degree of flexibility exists among surplus regions as potential suppliers of deficit regions.

Another study of the movement of surplus slaughter cattle was made using different regional demarcations of the United States.[6] In this study the region, which includes North Dakota, South Dakota and Nebraska, had a comparative advantage for shipping slaughter cattle to the East Coast. This study also confirmed the widely accepted hypothesis that "location and transportation costs are important determinants of competitive market power in interregional fed beef commerce."[7] Aberdeen, South Dakota was used as the supply and demand point in this study which helps substantiate the assumption that the results would remain unchanged if South Dakota were considered separately.

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[5] Crom, op. cit.

[6] Williams, Willard F. and Dietrich, Raymond A., An Interregional Analysis of the Fed Beef Economy, U. S. Department of Agriculture Economic Research Service, Oklahoma and Texas Agricultural Experiment Stations, Agricultural Economic Report No. 88, August, 1966.

[7] Ibid., p. 1.

Judge and Wallace conducted a detailed study on the "Methodological Development and Annual Spatial Analyses of the Beef Marketing Sector".[8] Using a linear programming model, which takes into consideration regional price differentials, this study indicated that the region, including North Dakota and South Dakota, had a comparative advantage for shipping its surplus slaughter cattle to the East Coast. In particular, the destination point was the region which includes Vermont, New Hampshire, Maine, Massachusetts, Connecticut and Rhode Island. This study also indicated that if the cattle were slaughtered locally and shipped as dressed beef the region had a comparative advantage for shipping its surplus beef to all of the above mentioned states plus the state of New York. The point of supply and demand for this study was Bismark, North Dakota. However, as stated above, it can be argued that South Dakota has a similar advantage when considered separately.

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[8] Judge, G. G., and Wallace, T. D., Spatial Price Equilibrium Analyses of the Livestock Economy. I. Methodological Development and Annual Spatial Analyses of the Beef Marketing Sector, Department of Agricultural Economics, Oklahoma State University, Technical Bulletin TB-78, June, 1959.

CHAPTER II

CONCEPTS AND PROCEDURES

THEORETICAL FRAMEWORK

Basically, this study is concerned with the theory of interregional trade which incorporates the theory of comparative advantage.

Theory of interregional trade.[1] Just as individuals differ in aptitudes and natural abilities and can benefit each other through specialization and trade, so do regions differ. That is, regions differ in the amount of resources that are available for the purpose of producing a particular product. It is not difficult to see that if a region has fertile and productive land but a small amount of coal reserves, the region is best suited for agriculture. On the other hand, if a region has sandy and unproductive land but large coal reserves, the region is best suited for coal mining. Both regions would benefit if each were to specialize in producing the products which would employ local resources and then trade with the other region.

> In brief, each region is best equipped to produce the goods that require large proportions of the factors relatively abundant there; it is least fit to produce goods requiring large proportions of factors existing within its borders in small quantities or not at all.[2]

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[1] Ohlin, Bertil, Interregional and International Trade, Harvard University Press, Cambridge, Mass. (revised edition), 1967, pp. 1-41.

[2] Ibid., p. 7.

It is quite reasonable to assume that a region cannot for a long period of time produce all commodities at a lower cost. For example, if region X in the short run can produce goods more cheaply then region Y, goods will begin to flow from region X to region Y. The rate of exchange will depend on the relative costs of production in the two regions and the prices received for the goods traded.

Theory of comparative advantage.[3] The theory of comparative advantage states that if there are two regions producing two products, even though one region may be absolutely more efficient in the production of both products, both regions will benefit if each region specializes in the product for which it has a greater relative efficiency, i.e., each region produces the product for which it has a comparative advantage, and then trades with the other region. This principle holds when applied to multiple regions producing multiple products.

To illustrate these two theories, consider a region in which capital and labor are cheap (abundant) factors and land is a dear (scarce) factor. This region would manufacture goods and export them. It could be said that these goods contain much capital and labor. Consider another region in which land is a cheap factor and labor and capital are dear factors. This region would produce and export

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[3] Samuelson, Paul A., Economics: An Introductory Analysis, McGraw-Hill Book Company (7th edition), 1967, Chapter 34.

agricultural products, i.e., it would produce and export goods containing much land. It seems logical that the two regions just described would want to trade with each other.

Since commodities move from one region to another with various degrees of difficulty, chiefly depending upon transportation costs, it is necessary to minimize these costs so that trade may be carried on as efficiently as possible. Such a solution is particularly important to this study if optimum shipping patterns for feeder calves and feed grains are to be established.

HYPOTHESES

1. There are areas within South Dakota where conditions exist such that there is an absolute deficit of feed grains available for fattening cattle.

    a. There are areas within the state where conditions exist such that there is an absolute surplus of feed grains available for fattening cattle.

2. There are areas within South Dakota where conditions exist such that there is an absolute deficit of feeder cattle.

    a. There are areas within the state where conditions exist such that there is an absolute surplus of feeder cattle.

3. The transportation costs are of such a nature that it is advantageous to ship feed grains from surplus areas to deficit areas.

    a. The transportation costs are of such a nature that it is advantageous to ship feeder cattle to areas of surplus feed grains.

ASSUMPTIONS

The following assumptions pertain to this study.

1. Production within each region is concentrated around a predetermined central city. This implies that movement intraregionally is not prohibited; whereas, interregional movement is restricted by transportation costs. This assumption is necessary because a point of origin or destination within each region is needed, so that, representative transportation costs between regions can be calculated.

2. The imports (into the state) and exports (to other states) of feeder cattle and feed grains are not considered in this study because this study is limited to investigating the potential of beef production in South Dakota. In other words, all cattle produced in the state are fed within the state; and all feed grains produced in the state are used in the state.

3. All shipments of feeder cattle and feed grains are made by truck. This assumption is necessary because most points within South Dakota have no railroad connections, and nearly all shipments are made by truck.

4. The amount of feed in corn equivalents[4] necessary to fatten each animal unit is 50 bushels or 2800 pounds. The 50 bushels or 2800 pounds is the amount of feed in corn equivalents needed to feed a calf weighing 450 pounds to 1050 pounds which is considered market weight.

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[4] Corn is used as the basic feed grain and all other feed grains are converted into corn equivalent units by use of conversion factors which are explained later. A corn equivalent unit is equal to 100 pounds of corn.

5. Transportation costs are calculated on the basis of a feeder calf weighing 450 pounds. This assumption is made to maintain consistency with assumption (4).

6. In the transportation model, it is assumed that the price differential is the same as the transportation costs. This means that a perfect market is assumed. That is, no region offers higher prices to attract more trade. This assumption is made merely to simplify the model.

THE MODEL

The following transportation model is used to determine the optimum movement of feed grains and feeder cattle in South Dakota.[5]

$$\Sigma\Sigma X_{ij} C_{ij} = \text{Minimum Cost}$$

Subject to

$$\Sigma_j X_{ij} = a_i ; \; i = 1, 2, \ldots, n$$

$$\Sigma_i X_{ij} = b_j ; \; j = 1, 2, \ldots, m$$

$$\Sigma_i a_i = \Sigma_j b_j *$$

* If the supply is not equal to demand the dummy regions in Montana and Iowa are used (see procedure (3) under regional demarcations, in the basic data section).

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[5] Heady, E. O., and Candler, W., Linear Programming Methods, Iowa State University Press, Ames, Iowa, 1958, Chapter 10.

a_i = amount of feeder calves or feed grain units available for export from ith region.

b_j = amount of feeder calves or feed grain units demanded by the jth region.

C_{ij} = cost of unit transportation from region i to region j.

X_{ij} = amount of feeder calves or feed grain units flowing from i to j.

The transportation model is a special type of linear programming model used in determining the least-cost method of transferring goods from an area which has a surplus to an area which has a deficit.

Assumptions of the transportation model. 1. Resources and products must be homogeneous. This means that the resources of products must satisfy the demands of both the region from which they originate and the region to which they are destined.

2. The supply of an originating region and the demand of the region of destination must be known; and total demand must equal total supply.

3. The cost of production or the cost of moving the product from origins to destinations is known and does not depend upon the number of units produced or moved (areas of surplus are "origins", areas of deficit are "destinations").

4. There is an objective to be maximized or minimized. Usually an attempt is made to minimize costs.

5. Transportation from origins to destinations can be carried on only at non-negative levels.

6. The optimum solution is obtained through a method of sub-optimization, that is, the optimum solution is derived by optimizing two methods and choosing the better of the two. First, the supply and demand data are subjected to the costs of transporting feeder calves among regions. Secondly, these data are subjected to the costs of transporting feed grains among regions. The computer optimizes each of these methods and the optimum solution is determined as the one which has the least total cost.

BASIC DATA

Regional Demarcations. 1. In order to apply the theory of interregional trade, South Dakota must be divided into a number of regions. For the purpose of this study, the state is divided into seven regions on the basis of their natural resource and the similarities in their agricultural practices.[6] These regions are depicted in Figure 2-1.

Similar natural resources and similar agricultural practices can be demonstrated by considering the kind of crops grown in a region. The land in Region I is used primarily for rangeland. Rangeland is prevalent in Region II; however, wheat and corn are also important crops in this region. Along with grazing, spring grains, sorghum and

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[6] Westin, Fred C., Puhr, Leo F., and Buntley, George J., Soils of South Dakota, Agronomy Department, Agricultural Experiment Station, S. Dak. State University, Brookings and the Soil Conservation Service, USDA (Soil Survey Series No. 3), revised July, 1967.

Figure 2-1. Regional Demarcations Indicating the Cities which Serve as Supply and Demand Points.

winter wheat are major crops in Region III. Spring wheat and corn along with pasture are dominant crops in Region IV. The major crops in Region V are corn and oats. The land in Region VI is used for pasture and for growing various spring grains. Corn and oats are the principal crops in Region VII.[7]

2. A city nearest to the center, in each of the seven regions is selected. These cities are to be used as a basis from which out-shipments (to another region) or in-shipments (into the region) will be made. The central city of each region is shown in Table 2-1.

3. Two regions outside the state are set up to provide areas to which a state surplus could be shipped. Resources are also drawn from these regions to compensate for any deficit within the state. Transportation costs involving these regions are such that shipping to or from these regions is prohibitive, unless no other alternative is available.

Determining the number of feeder calves. 1. The data which are used in this study are taken from the South Dakota Crop and Livestock Reporting Service Bulletin.[8]

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[7] Ibid., p. 22.

[8] South Dakota Crop and Livestock Reporting Service, South Dakota Agricultural Statistics, 1950-1965.

Table 2-1. Breakdown of Regions by Counties and Central Cities which Serve as Points of Origin and Points of Destination.

Regions	Counties	Origins and Destinations
I	Butte, Corson, Dewey, Harding, Perkins, Ziebach, Haakon, Jackson, Lawrence, Meade, Pennington, Stanley, Bennett, Custer, Fall River, Shannon, Washabaugh, Jones, Lyman, Mellette, Todd.	Phillip
II	Campbell, Edmunds, Faulk, McPherson, Potter, Walworth, Hand, Hughes, Hyde, Sully.	Faulkton
III	Aurora, Brule, Buffalo, Gregory, Jerauld, Tripp.	Chamberlain
IV	Beadle, Brown, Clark, Day, Marshall, Spink.	Aberdeen
V	Bon Homme, Charles Mix, Davison, Douglas, Hanson, Hutchinson, McCook, Miner, Sanborn.	Mitchell
VI	Brookings, Codington, Deuel, Grant, Hamlin, Kingsbury.	Watertown
VII	Clay, Lake, Lincoln, Minnehaha, Moody, Turner, Union, Yankton.	Sioux Falls
VIII		Ames, Iowa
IX		Billings, Montana

2. The total number of beef and dairy cattle given for each county for the years 1950-1965 is used. The counties are then grouped so that they coincide with the predetermined seven regions. Similar treatment is given to the hog and sheep data.

3. To find the number of feeder calves produced in each region, the number of beef and dairy cattle is multiplied by the calving percentage of each year from 1950-1965. Twenty percent is subtracted from this figure for replacement purposes. The calving percentages used are given in Table 2-2.

Feed grains requirement for other livestock. 1. First, hogs and sheep are converted into beef animal units and these units are multiplied by 2800 pounds to determine the amount of feed that they consume. The 2800 pounds is the amount of feed grains in corn equivalents that is needed to feed a calf from 450 pounds to 1050 pounds which is considered market weight. The conversion factors used are given in Table 2-3.

2. To obtain the amount of feed required for the twenty percent of beef calves kept for replacement, the number of beef cattle in each region is multiplied by 2.2 units of feed grains in corn equivalents.[9]

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[9]Aanderud, Wallace G., Barber, Myron T. and Dahl, Merlyn M., Guidebook for Planning a Farm or Ranch Business, Cooperative Extension Service, S. Dak. State University and USDA, Ext. Circular 633 (revised), 1967, p. 18.

Table 2-2. Calving Percentages used to Determine the Number of Calves Produced Each Year (1950-1965) in South Dakota.

Year	Calving Percentage
1950	88
1951	90
1952	90
1953	90
1954	93
1955	93
1956	85
1957	89
1958	91
1959	91
1960	93
1961	93
1962	93
1963	91
1964	93
1965	88

Source: U. S. Department of Agriculture, Livestock and Meat Statistics, AMS, SRS, ERS, Supplement to Statistical Bulletin No. 333, 1966.

Table 2-3. Conversion Factors used in Converting Hogs, Sheep and Dairy Cattle into Beef Animal Units.

Kind of Animal	Number Per Animal Unit	Conversion Factor
Beef Cow and Calf	1	1.00
Dairy Cow	1	1.00
Feeder Lambs	20	.05
Feeder Pigs	7	.14

Source: Aanderud, Wallace G., Barber, Myron T., and Dahl, Merlyn M., Guidebook for Planning a Farm or Ranch Business, Cooperative Extension Service, S. Dak. State University and USDA, Ext. Circular 633 (revised), 1967, p. 18.

3. To determine the amount of feed grains required for replacing and maintaining dairy cattle in each region, the number of dairy cattle is multiplied by 24.32 units of feed grains in corn equivalents.[10]

4. Steps 1, 2 and 3 give the amount of feed grains needed in each region for hogs, sheep, replacement of beef cattle and the replacement and maintenance of dairy cattle.

5. The total amount of feed grains produced in each region is derived using the method described in procedure (2) under the section on determination of feeder calves. Each of the five feed grains considered (corn, oats, barley, rye and sorghum) is multiplied by a conversion factor to change it from bushels to corn equivalents in cwt. The conversion factors used are given in Table 2-4.

6. The amount of feed grains in corn equivalents needed for hogs, sheep, replacement of beef cattle and for the replacement and maintenance of dairy cattle is then subtracted from the total amount produced in each region. The amount of feed grain units in corn equivalents available for fattening feeder calves after considering all other livestock has been determined as a result of these calculations. However, to determine the true amount of feed grains available for fattening calves, it is necessary to also consider the feed grains needed for poultry.

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[10] Cooperative Extension Service, Planning for More Profitable Use of Resources, S. Dak. State University and USDA, Exp. Circular 652, 1964, p. 88.

Table 2-4. Conversion Factors used in Converting Bushels of Corn, Oats, Barley, Rye, and Sorghum into Corn Equivalents, in 100 Pound Units.

Kind of Grain	Conversion Factor
Corn	.56
Oats	.271186
Barley	.421053
Rye	.56
Sorghum	.513761

Note: The conversion factors are based on the test weight and feed value of each grain. The feed value for each grain is found on page seven in Extension Circular 633 (revised) by Aanderud, Barber and Dahl. This circular is cited in full in footnote #8.

Feed grains requirement for poultry. 1. The total number of chickens is taken as of January 1 of each year. This figure is a good estimate to use in determining the amount of feed consumed by all chickens, since at that time of year, flocks are comprised mostly of laying hens. Any pullets produced during the year are for replacement purposes.

2. The amount of feed grains used for scratch, in chick starter and in laying mashes is converted into corn equivalent units. This figure gives the total amount of feed needed for maintaining the given laying flock plus replacements. This is more feed than is required for just chickens; however, the assumption is made that the amount over-estimated is used in the production of turkeys, ducks, geese, guineas and broilers raised for on the farm consumption. The commercial production of the aforementioned is negligible in South Dakota.

3. The above calculation gives the total amount of feed in corn equivalents needed for poultry each year for the entire state. The total amount of feed in corn equivalents produced in the state for a given year is also known. By dividing the former by the latter, a percentage is determined. This percentage is a rough estimate of feed in corn equivalents needed within the state for poultry for a given year. By further calculations an average percent over the period studied, 1950-1965, is determined.

4. The percentage derived in (3) is subtracted from any surplus of feed grains in corn equivalents in those areas which are major poultry producers. This, then, gives the net surplus of feed in corn

equivalents which is available in each region for the purpose of fattening cattle.

5. Major poultry producing regions are determined in the following manner: (1) Data from the South Dakota Crop and Livestock Reporting Bulletin are treated as described in procedure (2) under the section on determination of feeder calves; (2) Data from the South Dakota Poultry Production and Marketing Bulletin are also used. These sources indicate that poultry production takes place primarily in Regions III, IV, V, VI and VII. In other words, poultry production in Regions I and II is negligible.

Transportation costs. 1. Transportation costs between the central cities of each region described under regional demarcation are calculated. The rates used are those given in the South Dakota Class B Motor Carriers Bulletin, Freight Tariff No. 16, see Tables 2-5, 2-6 and 2-7.

2. These data are then set up in a transportation model using linear programming analysis. The results will show the optimum shipping pattern of feeder cattle and feed grains within the state.

Table 2-5. Mileage Between Central Cities used to Calculate Transportation Costs.

Origin	Destination (miles)					
	II	III	IV	V	VI	VII
I	194	137	253	209	285	274
II		124	61	144	111	219
III			162	72	203	135
IV				144	100	215
V					128	70
VI						115

Source: South Dakota highway map, copyright 1963 by South Dakota State Highway Commission, Pierre, South Dakota; prepared by Rand McNally & Co.

Table 2-6. Per Unit Cost for Shipping a 450 Pound Feeder Calf Between Regions.

Origin	Destination (dollars)					
	II	III	IV	V	VI	VII
I	2.33	1.98	2.67	2.43	2.93	2.83
II		1.67	1.08	1.80	1.62	2.25
III			1.89	1.17	2.16	1.76
IV				1.80	1.58	2.25
V					1.71	1.17
VI						1.67

Source: South Dakota Class B Motor Carriers Freight Tariff No. 16, issued by the Public Utilities Commission, Pierre, South Dakota, 1956.

Table 2-7. Per Unit Cost for Shipping Feed Grain Units Between Regions.

Origin	Destination (cents)					
	II	III	IV	V	VI	VII
I	36	33	41	37	44	43
II		28	18	30	27	35
III			31	20	33	30
IV				30	26	35
V					29	20
VI						28

Source: South Dakota Class B Motor Carriers Freight Tariff No. 16, issued by the Public Utilities Commission, Pierre, South Dakota, 1956.

CHAPTER III

EMPIRICAL RESULTS

INTRODUCTION

According to previous assumptions, the producers in the regions which have a surplus of feeder calves or feed grains can dispose of their surpluses (1) by shipping the surplus feeder calves to regions which have a deficit of feeder calves, (2) by shipping the surplus feed grains to regions which have a deficit of feed grains. To determine which of these two alternatives is more economical is the main objective of this thesis.

To obtain this objective an optimum solution is obtained for each of the 16 years, 1950-1965, considered in this study; these solutions are presented in Appendices A-D. The results of this chapter are based upon the solution obtained using the average data of the 16 years. The unique characteristics of those years which deviate greatly from the average solution are discussed in Appendices B and D.

Two dummy regions, Regions VIII and IX, are discussed in Chapter II in the section on regional demarcations; however, only Region IX is used in this chapter for the following reasons. The functions of Region VIII are, (1) to absorb (demand) the surplus feeder calves which exist after the demand within South Dakota has been satisfied; (2) to supply the feed grains necessary to satisfy the demand which still exists after all surpluses of the regions within the state have been allocated. In an average year, no feeder calves are exported

(out of the state) and no feed grains are imported (into the state); therefore, the functions of Region VIII do not pertain to the analysis of this chapter, because only the average year is considered. The need for Region VIII becomes apparent when the unique characteristics of years 1955, 1956, 1959, 1964 and 1965 are discussed in Appendices B and D. On the other hand, the functions of Region IX are, (1) to absorb (demand) the surplus feed grains which exist after the demand within South Dakota has been satisfied; (2) to supply the feeder calves necessary to satisfy the demand which still exists after all surpluses of the regions within the state have been allocated. Since, in an average year, there is always a surplus of feed grains and a deficit of feeder calves within the state, the functions of Region IX pertain to the analysis of this chapter.

The optimum solution is obtained by optimizing two solutions and choosing the better of the two (see assumption (6) of the model in Chapter II). The two solutions are known as the "feeder calf solution" and the "feed grains solution"; and they will be discussed separately.

FEEDER CALF SOLUTION

The analysis is presented using a number of steps leading to the optimum solution. First, surplus and deficit regions are determined; second, per unit costs used in allocating feeder calves are shown; third, it is shown how surplus regions allocate their surpluses to regions which have a deficit; fourth, the total costs of allocating the

surpluses are discussed; and fifth, steps one through four are combined to show local demand along with the optimum allocation of surpluses.

The first step is to determine whether a particular region has a surplus or a deficit of feeder calves. The data in Table 3-1 explain how the surplus and deficit regions are determined. These regions are also depicted in Figure 3-1. According to Table 3-1 and Figure 3-1, Regions I, II and III are regions with a surplus of feeder calves and Regions IV, V, VI, and VII are regions with a deficit of feeder calves.

Table 3-1. Average Surplus or Deficit of Feeder Calf Production in South Dakota, by Regions, 1950-1965.

Region (1)	Average Feeder Calf Production (000) (2)	Average Feeder Calf Demand (000) (3)	Surplus (Supply) (000) (4)	Deficit (Demand) (000) (5)
I	385	20	365	
II	173	120	53	
III	116	67	49	
IV	122	181		59
V	136	317		181
VI	100	232		132
VII	85	332		247
IX	152[a]			

[a] The number of feeder calves imported into South Dakota, in an average year, to satisfy the demand of the regions with a surplus of feed grains.

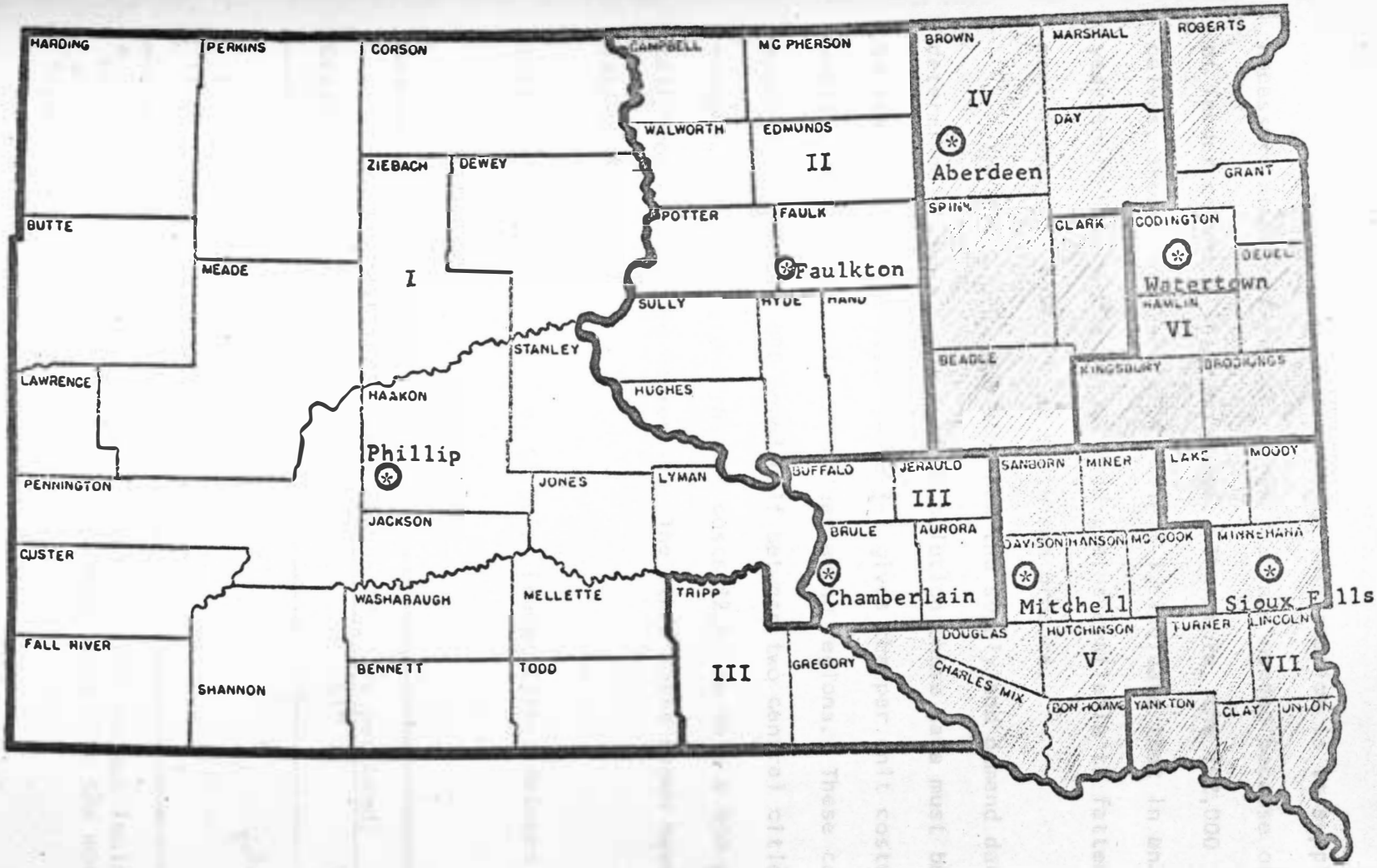

Figure 3-1. Regions with a Deficit or a Surplus of Feeder Calves. (Shaded Regions Indicate Regions with a Deficit).

The function of Region IX in this section is to supply the necessary number of feeder calves that are needed because of a deficit of feeder calves within the state. Therefore, the 152,000 feeder calves, shown in column 2 of Table 3-1, indicate that in an average year South Dakota has enough feed grains available to fatten 152,000 more feeder calves than the state can produce.

The first step explains how the supply and demand data are determined. To find the optimum solution these data must be subjected to transportation costs. Table 3-2 gives the per unit costs used in making allocations of feeder calves among regions. These costs are based on shipping a 450 pound calf between two central cities. For example, Table 3-2 shows that it costs $2.67 to ship a 450 pound feeder calf from Region I to Region IV. The other costs shown have a similar interpretation.

Table 3-2. Per Unit Cost of Shipping Feeder Calves Between Regions in South Dakota.

Origin	Destination (dollars per head)			
	IV	V	VI[a]	VII
I	2.67	2.43		2.83
II	1.08			
III		1.17		

[a] Costs of shipping from Region IX to Region VI are not included in the solution, because this study is concerned only with the movement of feeder calves within the state.

The results of the first two steps are shown in Figure 3-2 and Table 3-3. These results indicate the optimum flow of surplus feeder calves from regions with a surplus to regions with a deficit of feeder calves. According to Figure 3-2 and Table 3-3, Region I ships 6,000 head of feeder calves to Region IV, 132,000 head to Region V and 227,000 head to Region VII. This exhausts Region I's surplus of 365,000 feeder calves. Region II ships its surplus of 53,000 feeder calves to Region IV and Region III ships its surplus of 49,000 feeder calves to Region V. This completes the allocation of all surplus feeder calves. However, it is apparent that the demands of Regions VI and VII have not been fulfilled. Here, then, the need for Region IX becomes apparent. Region VI satisfies its unfulfilled demand by drawing 132,000 feeder calves from Region IX. Region VII, likewise, satisfies its remaining demand by drawing 20,000 feeder calves from Region IX.

Table 3-3. Optimum Allocation of Surplus Feeder Calf Production in South Dakota, by Regions, Average 1950-1965.

Origin	Destination (1,000 head) IV	V	VI	VII	Total Surplus
I	6	132		227	365
II	53				53
III		49			49
IX			132	20	152

Total shipments.....619,000 head.

Total shipments within South Dakota.....467,000 head.

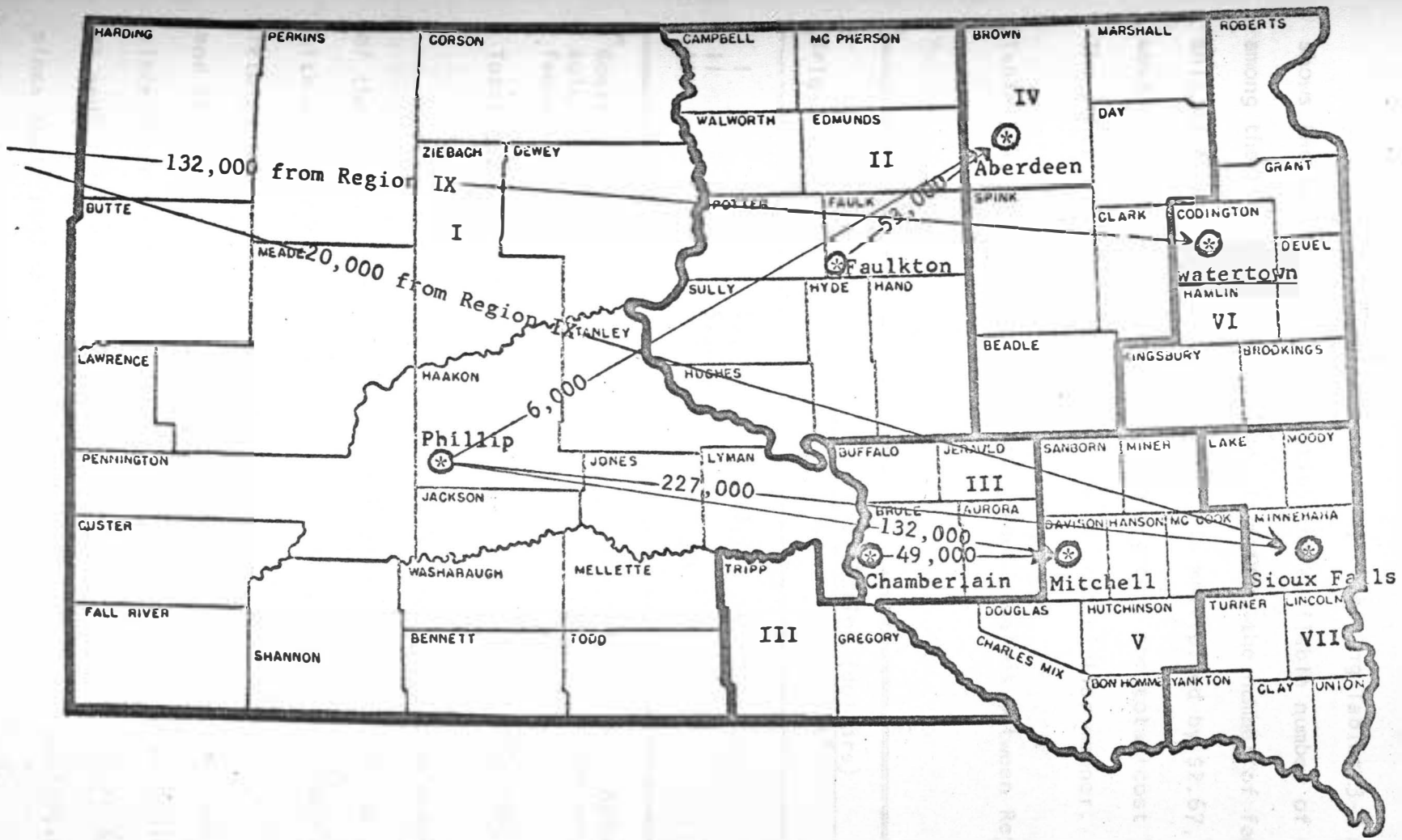

Figure 3-2. Optimum Shipping Patterns for Feeder Calves in South Dakota.

Table 3-4, which is derived by combining Tables 3-2 and 3-3, shows the total cost of allocating the available number of feeder calves among the regions. For example, if 6,000, the number of feeder calves shipped from Region I to Region IV, is multiplied by $2.67, the per unit cost of shipping between these two regions, the total cost is $16,020. The other totals shown are calculated in a similar manner.

Table 3-4. Total Cost of Shipping Feeder Calves Between Regions in South Dakota.

Origin	Destination (dollars) IV	V	VI[a]	VII
I	16,020	320,760		642,410
II	57,240			
III		57,330		

[a] Costs of shipping from Region IX to Region VI are not included in the solution, because this study is concerned only with the movement of feeder calves within the state.

Total cost of shipments within South Dakota.....$1,093,760.

Table 3-5, which includes local demand, gives an overall picture of the optimum allocation of feeder calves in South Dakota. The figures with an asterisk indicate the number of feeder calves which each region retains from its production to satisfy local demand. In Region I, II, and III this figure represents only part of the regions' calf production since these regions are exporters of feeder calves. In Regions IV, V, VI and VII this figure represents the regions' entire calf production, since these regions have to import feeder calves to satisfy all of the

local demand. For example, Region I produces 385,000 feeder calves in an average year; however, Region I can only support 20,000 feeder calves with its available feed grains. This means that there is a surplus of 365,000 feeder calves which must be shipped to regions which have a deficit of feeder calves. Table 3-5 indicates that Region I ships 6,000 feeder calves to Region IV, 132,000 feeder calves to Region V and it ships 227,000 head to Region VII. On the other hand, Region IV produces 122,000 feeder calves; however, it can support 181,000 feeder calves. Therefore, Region IV has a deficit of 59,000 feeder calves. To correct this deficit Region IV imports 6,000 feeder calves from Region I and 53,000 feeder calves from Region II.

The total cost of allocating surplus feeder calves in South Dakota is $1,093, 760. This is the least-cost solution to the transportation model using feeder calves as the supply and demand data. It is a sub-optimum solution to the main objective of this thesis.

FEED GRAINS SOLUTION

The method of presentation is similar to that used in the previous section. The main difference is that in this section the supply and demand data are expressed in terms of feed grain units instead of feeder calves.[1]

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[1] A unit of feed grains is equivalent to 100 pounds of feed grains in corn equivalents. This measurement is used because transportation rates are calculated in 100 pound units of feed grains.

Table 3-5. Optimum Allocation of Feeder Calves in South Dakota, by Regions, Average 1950-1965.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	Total Supply
I	20*			6	132		227	385
II		120*		53				173
III			67*		49			116
IV				122*				122
V					136*			136
VI						100*		100
VII							85*	85
IX						132	20	152
Total Demand	20	120	67	181	317	232	332	1269

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....467,000 head.

Total cost of shipments within South Dakota.....$1,093,760.

The analysis involves five steps. First, surplus and deficit regions are determined; second, per unit costs used in allocating feed grains are shown; third, the optimum allocation of the surpluses is shown; fourth, the total costs of allocating the surpluses are discussed; and fifth, steps one through four are combined to show local demand along with the optimum allocation of surpluses.

The data in Table 3-6 explain how surplus and deficit regions are determined. These regions are depicted in Figure 3-3. According to Table 3-6 and Figure 3-3, Regions IV, V, VI and VII are regions with a surplus of feed grains; whereas, Regions I, II and III are regions with a deficit of feed grains.

Table 3-6. Average Surplus or Deficit of Feed Grain Units in South Dakota, by Regions, 1950-1965.

Region (1)	Average Feed Grains Available (000) (2)	Average Feed Grains Demanded (000) (3)	Surplus (Supply) (000) (4)	Deficit (Demand) (000) (5)
I	567	10790		10223
II	3350	4845		1495
III	1885	3241		1356
IV	5056	3401	1655	
V	8864	3810	5054	
VI	6495	2811	3674	
VII	9290	2377	6913	
IX		4232[a]		

[a] The number of feed grain units exported from South Dakota, in an average year, because there is a deficit of feeder calves within the state.

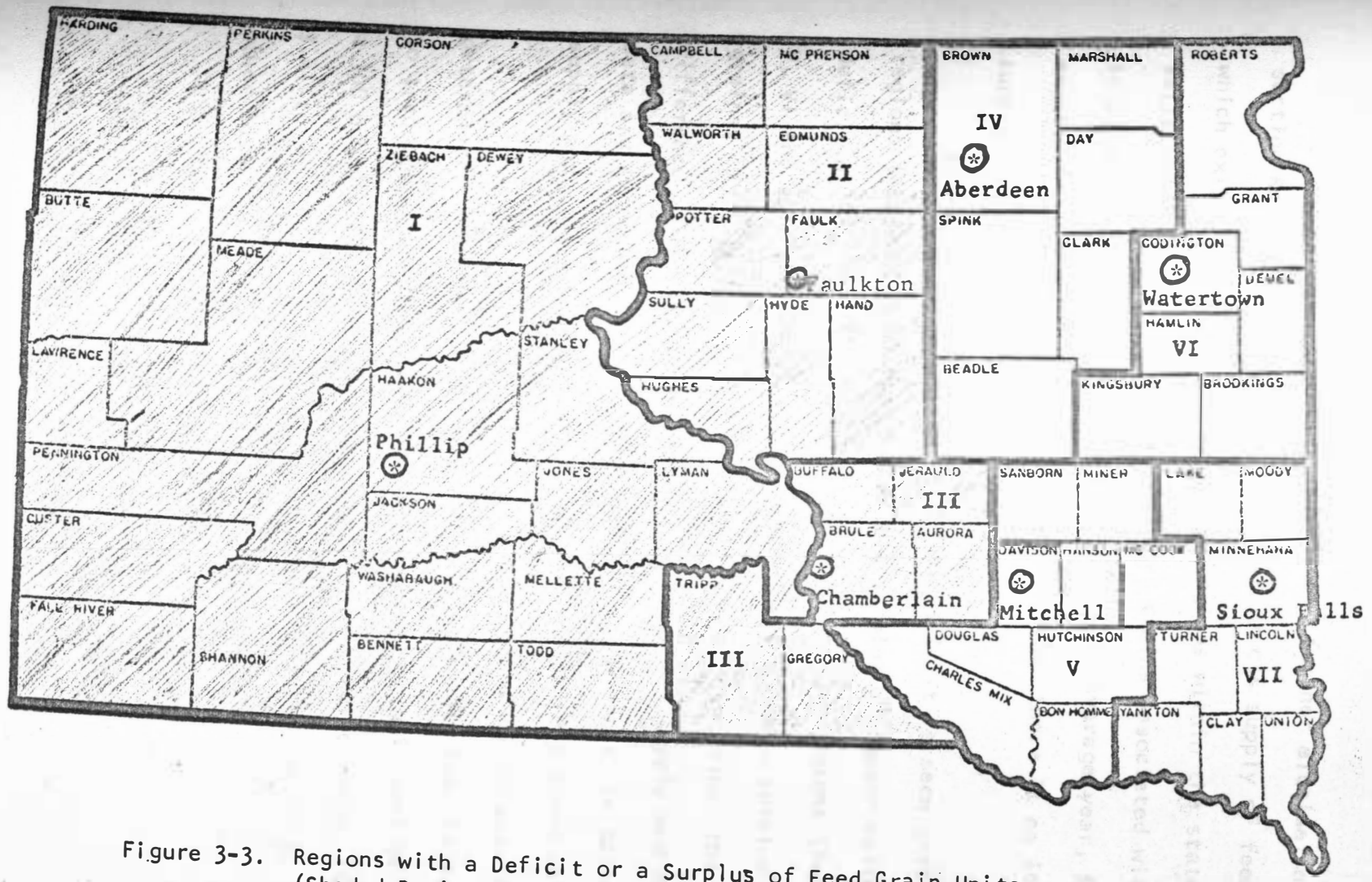

Figure 3-3. Regions with a Deficit or a Surplus of Feed Grain Units. (Shaded Regions Indicate Regions with a Deficit).

The function of Region IX may need further elucidation. In this section Region IX is used to absorb the excess supply of feed grains which exists after the demand of the regions within the state has been satisfied. The 4,232,000 units of feed grains associated with Region IX in column 3 of Table 3-6 indicate that, in an average year, South Dakota exports 4,232,000 units of feed grains because there is an insufficient supply of feeder calves within the state.

By comparing Table 3-6 with Table 3-1, it is seen that those regions (Regions I, II and III) with a surplus of feeder calves have a deficit of feed grains. On the other hand, those regions (Regions IV, V, VI and VII) with a deficit of feeder calves have a surplus of feed grains. This is all quite as it would be expected, since the only difference in the two tables is that in Table 3-1 supply and demand data are expressed in terms of feeder calves; whereas, in Table 3-6 supply and demand data are expressed in terms of feed grain units.

The first step explains how the supply and demand data are determined. To find the optimum solution these data must be subjected to transportation costs. Table 3-7 gives the per unit cost of shipping a 100 pound unit of feed grains among regions. For example, it costs $.41 to ship a unit of feed grains from Region IV to Region I. The other costs shown have a similar interpretation.

Table 3-7. Per Unit Cost of Shipping Feed Grain Units Between Regions in South Dakota.

Origin	Destination (cents per 100 pound unit)		
	I	II	III
IV	41	18	
V	37		20
VI[a]			
VII	43		

[a] Costs of shipping to Region IX from Region VI are not considered in the solution, because this study is concerned only with the movement of feed grain units within the state.

The results of the first two steps are shown in Figure 3-4 and Table 3-8. These results indicate the optimum allocation of feed grain units from regions with a surplus of feed grain units to regions which have a deficit of feed grain units. According to Figure 3-4 and Table 3-8, Region IV ships 160,000 units of feed grains to Region I and 1,495,000 units to Region II. Region V ships 3,698,000 units of feed grains to Region I and 1,356,000 units to Region III. Region VII ships 6,365,000 units of feed grains to Region I. Since Region IX absorbs the excess supply of feed grain units after the demand of the regions within the state have been satisfied, Region VII ships its remaining surplus of 548,000 units of feed grains to Region IX. Region VI ships its entire surplus of 3,684,000 units of feed grains to Region IX.

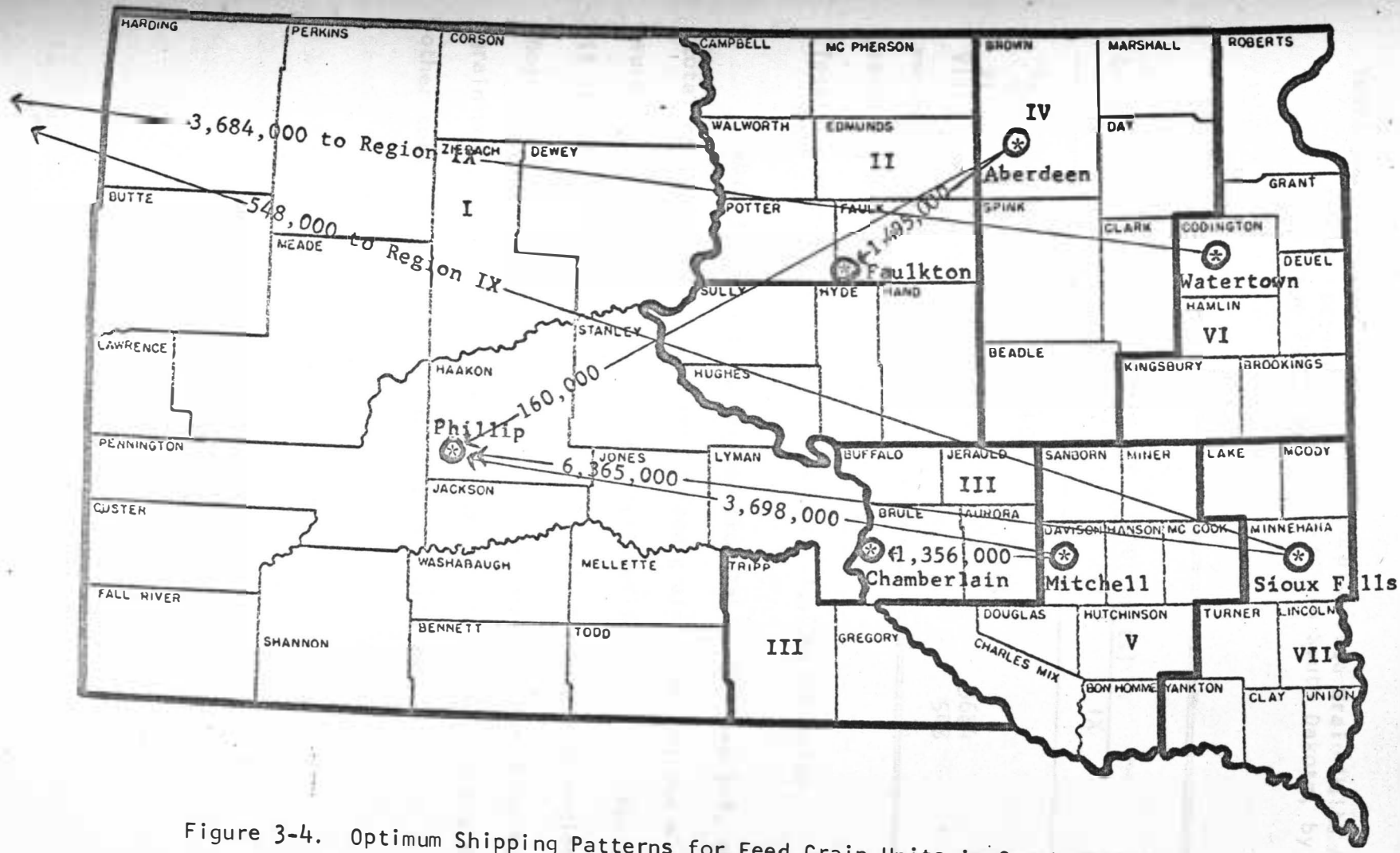

Figure 3-4. Optimum Shipping Patterns for Feed Grain Units in South Dakota.

Table 3-8. Optimum Allocation of Surplus Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, Average 1950-1965.

Origin	Destination (1,000 units)				Total Supply Available
	I	II	III	IX	
IV	160	1495			1655
V	3698		1356		5054
VI				3684	3684
VII	6365			548	6913

Total shipments.....17,306,000 units.

Total shipments within South Dakota.....13,074,000 units.

Table 3-9, which is derived from Tables 3-7 and 3-8, shows the total cost of allocating units of feed grains from regions with a surplus to regions which have a deficit of feed grains. For example, if 160,000, the number of feed grain units shipped from Region IV to Region I, is multiplied by $.41, the per unit cost of shipping feed grain units between these two regions, the total cost is $65,600. The other totals shown are calculated in a similar manner.

Table 3-9. Total Cost of Shipping Feed Grain Units Between Regions in South Dakota.

Origin	Destinations (dollars) I	II	III
IV	65,600	269,100	
V	1,368,260		271,200
VI[a]			
VII	2,736,950		

[a] Costs of shipping from Region VI to Region IX are not considered in the solution, because this study is concerned only with the movement of feed grain units within the state.

Total cost of shipments within South Dakota.....$4,711,110.

Table 3-10 gives an overall picture of the optimum allocation of feed grain units in South Dakota. The figures with an asterisk indicate the number of feed grain units retained by each region from its available supply for beef production. In Regions IV, V, VI and VII this figure represents only part of the regions' available supply of feed grain units, since these regions are exporters of feed grain units. In Regions I, II and III this figure represents the regions' entire supply of available feed grain units, since these regions have to import feed grain units to satisfy all of the local demand. For example, in an average year, Region I has available 567,000 units of feed grains for fattening cattle; however, there is a demand for 10,790,000 units of feed grains. Therefore, a deficit of feed grain units exists in Region I. To correct this deficit, Region I imports 160,000 units of feed grains from Region IV, 3,698,000 units from

Region V, and 6,365,000 units from Region VII. Another interpretation of Table 3-10 is to analyze the allocation of available feed grain units in Region IV. Region IV has available 5,056,000 units of feed grains for fattening cattle; however, it only needs 3,401,000 units. Therefore, Region IV has a surplus of 1,655,000 units of feed grains. To dispose of this surplus, Region IV ships 1,495,000 units to Region II and 160,000 units to Region I.

Table 3-10. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, Average 1950-1965.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I	567*								567
II		3350*							3350
III			1885*						1885
IV	160	1495		3401*					5056
V	3698		1356		3810*				8864
VI						2811*		3684	6495
VII	6365						2377*	548	9290
Total Demand	10790	4845	3241	3401	3810	2811	2377	4232	35507

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....13,074,000 units.

Total cost of shipments within South Dakota.....$4,711,110.

The total cost for the optimum allocation of surplus feed grain units, excluding the cost of shipping to or from dummy Region IX, is $4,711,110. Comparing this figure with the total cost of $1,093,000 for the optimum allocation of feeder calves, it is apparently less expensive to ship the surplus feeder calves from regions which have a surplus to those regions which have a deficit of feeder calves; rather than, to ship the surplus feed grain units from regions which have a surplus to those regions which have a deficit of feed grain units. This, then, is the answer to the main objective of this thesis. That is, the optimum movement of feeder calves and feed grains within South Dakota is for the surplus feeder calves to be shipped to regions which have a surplus of feed grains. The implications of this solution are discussed in the next chapter.

CHAPTER IV

IMPLICATIONS FOR SLAUGHTER PLANT LOCATION AND AREAS FOR FURTHER STUDY

IMPLICATIONS FOR SLAUGHTER PLANT LOCATION

In Chapter I reference is made to studies which indicate that potential markets exist for surplus beef from South Dakota. The results of Chapter III demonstrate that enough surplus feed grains exist within South Dakota to feed 152,000 more feeder calves to market weight than the state produces. This implies that if the surplus feed grains were used to expand the cattle feeding industry, South Dakota could feed to market weight and sell approximately 152,000 more feeder calves in an average year than it presently produces.

It would be helpful if it were known in which regions the potential increase of beef production would tend to take place. The optimum solution of the transportation model indicates that transportation costs are minimized if surplus feeder calves are shipped to regions which have a surplus of feed grains. Since Regions IV, V, VI and VII have a surplus of feed grains, the optimum solution indicates that any expansion of the cattle feeding industry would tend to take place in these regions. Assuming that these feeder calves are fed to market weight, their number also represents the number of slaughter cattle in each region.

Knowing that South Dakota produces surplus beef for which markets exist, the problem which remains to be solved is how to get the surplus

beef from its origins to potential markets, and at the same time minimize costs of transportation. The following are some questions which need to be answered. (1) Is there slaughter capacity available to handle the potential supply of slaughter cattle in those regions of the state in which beef production would be expected to increase? (2) If there is not enough slaughter capacity available, where should future slaughtering facilities be located in order to minimize transportation costs? (3) Since potential markets exist for both slaughter cattle and dressed beef, is it more economical to ship the slaughter cattle to a collection point; or, (4) is it more economical to slaughter the cattle in each region and ship the dressed beef to a collection point? Questions (3) and (4) assume that transportation costs for shipping to potential markets outside the state are minimized by shipping the cattle or beef in bulk quantities, e.g., trainloads, semi-trailer truckloads, etc. A complete answer to these questions would entail a detailed study on slaughter plant location(s) in South Dakota. That is, where in the state should slaughter plant(s) be located so as to be assured sufficient resources and minimize total transportation costs? Although such a study is beyond the scope of this thesis, this chapter considers, in a broad and general manner, some immediate implications of the optimum solution of Chapter III which relate to the questions mentioned above. It is assumed that present slaughtering plants will continue to slaughter at their present capacity.

To determine an answer to the first question, information relative to the slaughtering capacity of plants presently operating within each region, and the current proportion of total slaughter that is finished beef, was obtained by a mail questionnaire.[1] A copy of this questionnaire appears in Appendix E. The results of this questionnaire, which are summarized in Table 4-1, give the information necessary to form answers to the above questions. The data in column 4 of Table 4-1 indicate that all regions, except Region 1, have a deficit of slaughter capacity. This deficit of slaughter capacity can also be interpreted as surplus slaughter cattle as is shown in column 5. For the purpose of determining the costs of transporting beef these slaughter cattle are converted into 100 pound beef units, which are given in column 6. The conversion of slaughter cattle into beef units assumes that a 1050 pound animal will dress out at 60 percent of its live weight.

To obtain the least-cost solution, the data in columns 5 and 6, which are the supply and demand data, are subjected to the costs of

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[1] A questionnaire was sent to all meat packing plants listed in the 1967 Directory of South Dakota Manufacturers and Processors. However, those plants whose capacity kill is under seven head per hour comprised only eight-tenths of a percent of the annual kill in South Dakota over the past five years; therefore, they are disregarded.

Table 4-1. Potential Surplus and Deficit Slaughter Plant Capacity in South Dakota, by Regions, Average 1962-1966.

Region (1)	Slaughter Cattle Produced (1,000) (2)	Number of Fat Cattle Slaughtered (1,000) (3)	Surplus or Deficit Slaughter Capacity[a] (1,000) (4)	Slaughter Capacity in Terms of Cattle[b] (1,000) (5)	Slaughter Capacity in Terms of 100 lb. Beef Units (1,000) (6)
I	20	31	11	- 11	
II	120		-120	120	756
III	67		- 67	67	422
IV	181	90	- 91	91	573
V	317		-317	317	1997
VI	232	11	-221	221	1392
VII	332	292	- 40	40	252

[a] (-) indicates that a region has a deficit of slaughter capacity.

[b] (-) indicates that a region has a deficit of slaughter cattle.

Note: Column 6 is derived from column 5 by assuming that a 1050 pound animal dresses out at 60 percent of its live weight.

transporting slaughter cattle and dressed beef among regions in South Dakota. Tables 4-2[2] and 4-3[3] give the costs for shipping slaughter cattle and for shipping dressed beef, respectively.

The total cost solutions for shipping slaughter cattle and dressed beef are presented in Tables 4-4 and 4-5. The data in Table 4-4 show the total cost of shipping all excess slaughter cattle to each region. For example, if the total excess slaughter cattle shown in column 5 were shipped to Region II the total cost would be $2,871,980. The data in Table 4-5 show that if these slaughter cattle were converted into beef units and the beef units were shipped to Region II, the total cost would be $3,157,520. In every instance the cost for shipping beef units is greater than the cost for shipping slaughter cattle. These results would, therefore, indicate that in order to minimize transportation costs, slaughter cattle should be shipped to a collection point. In other words, if present costs for transporting beef in South Dakota are used as a criterion for slaughter plant location, a large plant strategically located would minimize transportation costs.

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[2]Transportation rates for shipping slaughter cattle in South Dakota were obtained from the South Dakota Class B Motor Carriers Freight Tariff No. 16 bulletin.

[3]Transportation rates for shipping dressed beef carcasses in South Dakota were obtained from All-American Transport, Inc. of Sioux Falls, South Dakota.

Table 4-2. Per Unit Cost of Shipping Fat Cattle Among Regions in South Dakota.

Origin	Destination (dollars per head)				
	III	IV	V	VI	VII
II	3.89	2.52	4.20	3.78	5.25
III		4.41	2.73	5.04	4.20
IV			4.20	3.66	5.25
V				3.99	2.73
VI					3.89

Source: South Dakota Class B Motor Carriers Freight Tariff No. 16, issued by the Public Utilities Commission, Pierre, South Dakota, 1956.

Table 4-3. Per Unit Cost of Shipping Beef Units Among Regions in South Dakota.

Origin	Destination (cents per unit)				
	III	IV	V	VI	VII
II	68	68	68	68	70
III		68	68	68	68
IV			68	68	70
V				68	68
VI					68

Source: All-American Transport, Inc., Sioux Falls, South Dakota.

Table 4-4. Total Cost of Shipping All Excess Slaughter Cattle to Each Region.

Origin	Destination (dollars) II	III	IV	V	VI	VII
All Regions	2,871,980					
All Regions		3,019,650				
All Regions			2,953,380			
All Regions				2,062,830		
All Regions					2,548,660	
All Regions						3,114,250

Note: The term "All Regions" includes Regions II-VII. Region I is not included because it has the slaughter capacity necessary to handle all the slaughter cattle it produces.

Table 4-5. Total Cost of Shipping All Excess Beef Units to Each Region.

Origin	Destination (dollars) II	III	IV	V	VI	VII
All Regions	3,157,520					
All Regions		3,379,600				
All Regions			3,281,960			
All Regions				2,308,600		
All Regions					2,720,000	
All Regions						3,521,780

Note: The term "All Regions" includes Regions II-VII. Region I is not included because it has the slaughter capacity necessary to handle all the slaughter cattle it produces.

By further examination of Table 4-4 it becomes apparent that shipping all excess slaughter cattle to Region V involves the least total cost. This implies that Mitchell, the central city of Region V, would be the collection point. Since some studies indicate that shipping dressed beef gives South Dakota a broader market (see Chapter I, Review of Literature), further investigation needs to be made as to whether Mitchell could handle a slaughtering plant large enough to process the excess slaughter cattle. A study of this nature may very well indicate that Mitchell has the necessary resources because of its location by the James River; because of the relatively small labor supply necessary to operate a large, highly mechanized kill and chill plant; and because of the accessibility to Mitchell by truck and by railroad.

Another implication derived from Table 4-1, which needs to be discussed, is the surplus slaughter capacity of Region I. The data in column 4 show that if Region I did not import any slaughter cattle, it would have the slaughter capacity necessary to slaughter approximately 11,000 more cattle per year then it presently produces. It may be assumed that slaughter cattle from regions East of the Missouri River would not be shipped to Region I to utilize this surplus capacity because of the transportation costs involved. Therefore, Region I probably gets the needed slaughter cattle from areas of Northeastern Colorado, Western Wyoming and Southeastern Montana. Testing such a

hypothesis is beyond the scope of this thesis; however, a study investigating the actual movement of slaughter cattle, if areas surrounding South Dakota are considered, may give interesting results.

It should be emphasized that the implications discussed in this chapter are general and broad in nature. This study is just a preliminary investigation to determine by how much and in what regions the cattle feeding industry might expand in South Dakota given certain assumptions.

AREAS FOR FURTHER STUDY

By relaxing some assumptions pertaining to this study other areas could be investigated. For instance, what effect would widening the boundaries of the area studied to include all or part of the surrounding states have on the optimum solution of the model? Such a study may indicate what area(s) outside the state would supply the 152,000 feeder calves needed to make up the deficit which exists in South Dakota in an average year.

The profitability of feeding surplus feed grains to livestock as compared to selling the surplus feed grains for cash could also be investigated.

A study could also be made investigating the potential feed grain production by employing irrigation, along with the potential feeder calf production by employing better range management, better herd management, etc. With such information, regression analysis could be used to predict South Dakota's potential growth of beef production.

Such a study has major policy implications in that it could indicate the future potential of one part of South Dakota's basic source of revenue, agriculture.

An interesting study, for which data may not be available in the immediate future, could be made to determine whether the use of air freight, as compared to more conventional means of transporting goods, would increase or decrease South Dakota's comparative advantage in supplying regions in the United States which have a deficit of beef production.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

Previous studies have indicated that South Dakota has a comparative advantage for shipping its surplus beef to markets on the East Coast and to western markets, including markets on the West Coast and in the Butte, Montana area. South Dakota is also included in the area for which the expansion of beef production and the growth of feedlots for cattle feeding has been predicted. These indicators imply that South Dakota could benefit economically by expanding its cattle feeding industry. Therefore, it is essential that producers of feeder calves, producers of feed grains and producers of fat cattle have some idea by how much and in which areas of the state the production of beef would most likely expand. Basically, this describes the purpose of this study.

It was hypothesized that there are regions in South Dakota in which there is a surplus of feeder calves and a deficit of feed grains. It was found that Regions I, II and III are regions with these characteristics. That is, these regions produce more feeder calves than they can support with the feed grains that are available for beef production. It was also hypothesized that there are regions in South Dakota in which there is a deficit of feeder calves and a surplus of feed grains. Regions IV, V, VI and VII are regions with such characteristics. That is, these regions can support more feeder calves

than they produce. Another hypothesis put forth raised the question whether it would be less expensive to ship surplus feed grains to regions with a surplus of feeder calves; or, whether it would be less expensive to ship surplus feeder calves to regions with a surplus of feed grains. The optimum solution shows that the latter proposition is the less expensive. This means that if transportation costs are to be minimized, Regions I, II and III should ship their surplus feeder calves to Regions IV, V, VI and VII. However, Regions I, II and III do not produce enough feeder calves to fulfill all the demand of Regions IV, V, VI and VII; therefore, Region IX, a dummy region, is used to supply the number of feeder calves necessary to satisfy the remaining demand.

The optimum solution also indicates that if the feeder calves are fed to market weight and sold as slaughter cattle, beef production would tend to expand in Regions IV, V, VI and VII. Beef production would tend to expand by 62,000 head in Region IV, by 181,000 head in Region V, by 132,000 head in Region VI, and by 247,000 head in Region VII. Regions IV and V would obtain all of the feeder calves for this expansion from domestic production, i.e., from surpluses of feeder calves which exist in Regions I, II and III. Region VII would obtain 227,000 feeder calves for its expansion from Region I; however, it must import 20,000 feeder calves from Region IX to meet all its demand. Region VI would obtain all 132,000 feeder calves for its expansion from Region IX.

It was found that slaughtering facilities presently existing within the regions do not have the capacity to process all the potential slaughter cattle which a given region could produce. A deficit of slaughter capacity exists in all regions except Region I. This means that a surplus of slaughter cattle relative to slaughter plant capacity exists in Regions II, III, IV, V, VI and VII. These surplus slaughter cattle could be shipped to the potential markets in either of two ways. (1) The cattle could be slaughtered in each region and the processed beef could be shipped to a collection point in the state from where it could be shipped to potential markets. (2) The slaughter cattle could be shipped to a collection point and then shipped to potential markets. The cattle could also be slaughtered at the collection point and the beef could be shipped to potential markets.

The results indicate that transportation costs are minimized if slaughter cattle were shipped to Mitchell, South Dakota, which is the central city of Region V. Once the slaughter cattle were at Mitchell, (1) they could be shipped to potential markets by train or truck; or, (2) the cattle could be slaughtered and the dressed beef could be shipped to potential markets. Since studies indicate that a broader market exists when dressed beef is shipped, an investigation should be made as to whether Mitchell has the resources to support a large enough slaughtering plant to handle the potential supply of slaughter cattle.

CONCLUSIONS

The following are the major conclusions of this thesis. (1) Conditions in Regions I, II and III are such that there is a surplus of feeder calves and a deficit of feed grains. (2) Conditions in Regions IV, V, VI and VII are such that there is a surplus of feed grains and a deficit of feeder calves. (3) It would be less expensive to ship the surplus feeder calves to regions which have surplus feed grains. (4) Regions IV, V, VI and VII have the resources necessary to expand beef production. (5) Assuming no change in present slaughter facilities all regions, except Region I, would have a surplus of slaughter cattle, i.e., a deficit of slaughter capacity. (6) In order to minimize transportation costs, it would be less expensive to ship the excess slaughter cattle to a collection point for shipment to potential markets; rather than, to slaughter the cattle in each region and then ship the beef to a collection point for shipment to potential markets.

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APPENDICES

Table A-1. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1950.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	Total Supply
I	4*			32	225		37	298
II		78*		48				126
III			47*		38			85
IV				86*				86
V					97*			97
VI						73*		73
VII							73*	73
IX						154	40	194
Total Demand	4	78	47	166	360	227	150	1032

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....380,000 head.

Total cost of shipments within South Dakota.....$833,200.

Table A-2. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1951.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	Total Supply
I	18*		11	106	178			313
II		125*		9				134
III			81*					81
IV				93*				93
V					103*			103
VI						78*		78
VII							72*	72
IX				1		86	42	129
Total Demand	18	125	92	209	281	164	114	1003

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....304,000 head.

Total cost of shipments within South Dakota.....$747,060.

Table A-3. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1952.

Origin	Destination (1,000 head)							Total Supply
	I	II	III	IV	V	VI	VII	
I					333		9	342
II		45*				96		141
III			91*		10			101
IV				84*		19		103
V					114*			114
VI						86*		86
VII							79*	79
IX						20	475	495
Total Demand		45	91	84	457	221	563	1461

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....467,000 head.

Total cost of shipments within South Dakota.....$1,031,900.

Table A-4. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1953.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	Total Supply
I	43*	49	19		250			361
II		160*						160
III			108*					108
IV				113*				113
V					125*			125
VI						94*		94
VII							92*	92
IX				111	42	175	308	636
Total Demand	43	209	127	224	417	269	400	1689

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....318,000 head.

Total cost of shipments within South Dakota.....$759,290.

Table A-5. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1954.

Origin	Destination (1,000 head)							Total Supply
	I	II	III	IV	V	VI	VII	
I				43	338		16	397
II		126*		53				179
III			114*		6			120
IV				124*				124
V					137*			137
VI						101*		101
VII							94*	94
IX						118	275	393
Total Demand		126	114	220	481	219	385	1545

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....456,000 head.

Total cost of shipments within South Dakota.....$1,045,690.

Table A-6. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1957.

Origin	Destination (1,000 head)							Total Supply
	I	II	III	IV	V	VI	VII	
I	116*	180	15		62			373
II		168*						168
III			111*					111
IV				119*				119
V					129*			129
VI						97*		97
VII							85*	85
IX				217	282	168	319	986
Total Demand	116	348	126	336	473	265	404	2068

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....257,000 head.

Total cost of shipments within South Dakota.....$599,760.

Table A-7. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1958.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	Total Supply
I	72*	61	5	19	238			395
II		171*						171
III			114*					114
IV				121*				121
V					133*			133
VI						98*		98
VII							80*	80
IX				135		189	279	603
Total Demand	72	232	119	275	371	287	359	1715

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....323,000 head.

Total cost of shipments within South Dakota.....$777,870.

Table A-8. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1960.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	Total Supply
I				78	257		68	403
II		126*		49				175
III			65*		60			125
IV				122*				122
V					141*			141
VI						101*		101
VII							80*	80
IX						208	500	708
Total Demand		126	65	249	458	309	648	1855

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....512,000 head.

Total cost of shipments within South Dakota.....$1,148,330.

Table A-9. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1961.

Origin	Destination (1,000 head)							Total Supply
	I	II	III	IV	V	VI	VII	
I					120		284	404
II				40		140		180
III			48*		73			121
IV				125*				125
V					145*			145
VI						105*		105
VII							82*	82
IX						23	35	58
Total Demand			48	165	338	268	401	1220

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....657,000 head.

Total cost of shipments within South Dakota.....$1,450,730.

Table A-10. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1962.

Origin	Destination (1,000 head)							Total Supply
	I	II	III	IV	V	VI	VII	
I	54*	24		84	145		84	391
II		186*						186
III			83*		41			124
IV				134*				134
V					153*			153
VI						112*		112
VII							87*	87
IX						68	227	295
Total Demand	54	210	83	218	339	180	398	1482

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....378,000 head.

Total cost of shipments within South Dakota.....$918,240.

Table A-11. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1963.

Origin	Destination (1,000 head)							Total Supply
	I	II	III	IV	V	VI	VII	
I	7*		6	50	338			401
II		149*		38				187
III			127*					127
IV				137*				137
V					155*			155
VI						113*		113
VII							85*	85
IX				57		256	369	682
Total Demand	7	149	133	282	493	369	454	1887

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....432,000 head.

Total cost of shipments within South Dakota.....$1,007,760.

APPENDIX B

INTRODUCTION

In the years 1955, 1956, 1959, 1964 and 1965 there was a surplus of feeder calves in South Dakota. In other words, the state could not support all of the feeder calves that it produced in those years. In order that a solution may be obtained for the "feeder calf solution", the surplus feeder calves must be absorbed by a dummy region. This dummy region is Region VIII, and is identified as Ames, Iowa (see Table 2-1).

The functions of Region VIII are, (1) to absorb (demand) the surplus feeder calves which exist after the demand within the state has been satisfied; (2) to supply the feed grains necessary to satisfy the demand which still exists after all surpluses of the regions within the state have been allocated.

This appendix is concerned with the optimum allocation of feeder calves; therefore, function (1) applies. For example, Table B-1 shows that Region I produced 417,000 feeder calves in 1955. Since Region I did not have any feed grains available for beef production in that year it had to ship all of its feeder calves to regions with a deficit of feeder calves. The optimum solution indicates Region I shipped 9,000 head to Region VI and the remaining 408,000 head to Region VIII. The surpluses of the other regions are allocated within the state.

The interpretation of the optimum solution of the other years considered in this appendix is similar.

Table B-1. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1955.

Origin	Destination (1,000 head)								Total Supply
	I	II	III	IV	V	VI	VII	VIII	
I						9		408	417
II		73*				109			182
III			16*		22	23	64		125
IV				119*		5			124
V					141*				141
VI						100*			100
VII							93*		93
Total Demand		73	16	119	163	246	157	408	1182

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....232,000 head.

Total cost of shipments within South Dakota.....$398,910.

Table B-2. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1956.

Origin	Destination (1,000 head)								Total Supply
	I	II	III	IV	V	VI	VII	VIII	
I								394	394
II		49*		32		91			172
III			19*					96	115
IV				120*					120
V					122*			9	131
VI						97*			97
VII						77	5*	3	85
Total Demand		49	19	152	122	265	5	502	1114

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....200,000 head.

Total cost of shipments within South Dakota.....$310,570.

Table B-3. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1959.

Origin	Destination (1,000 head)								Total Supply
	I	II	III	IV	V	VI	VII	VIII	
I								408	408
II								175	175
III							47	71	118
IV								124	124
V							136		136
VI						67*	33		100
VII							82*		82
Total Demand						67	298	778	1143

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....216,000 head.

Total cost of shipments within South Dakota.....$296,950.

Table B-4. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1964.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	VIII	Total Supply
I								437	437
II		53*						157	210
III								139	139
IV				22*		1		128	151
V					51*		82	35	168
VI						124*			124
VII							93*		93
Total Demand		53		22	51	125	175	896	1322

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....83,000 head.

Total cost of shipments within South Dakota.....$97,520.

Table B-5. Optimum Allocation of Feeder Calves in South Dakota, by Regions, 1965.

Origin	Destination (1,000 head) I	II	III	IV	V	VI	VII	VIII	Total Supply
I	9*						243	179	431
II		91*		20		102	11		224
III					91		48		139
IV				149*					149
V					169*				169
VI						127*			127
VII							96*		96
Total Demand	9	91		169	260	229	398	179	1335

* Indicates the number of feeder calves retained by each region from local production.

Total shipments within South Dakota.....515,000 head.

Total cost of shipments within South Dakota.....$1,090,230.

Table C-1. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1950.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I	112*								112
II		2186*							2186
III			1320*						1320
IV	911	1337		2399*					4647
V	6313		1053		2706*				10072
VI						2048*		4313	6361
VII	1012						2040*	1157	4209
Total Demand	8348	3523	2373	2399	2706	2048	2040	5470	28907

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....10,626,000 units.

Total cost of shipments within South Dakota.....$3,595,740.

Table C-2. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1951.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I	510*								510
II		3514*							3514
III	290		2274*						2564
IV	2991	236		2611*				13	5851
V	4981				2877*				7868
VI						2183*		2413	4596
VII							2024*	1183	3207
Total Demand	8772	3750	2274	2611	2887	2183	2024	3609	28110

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....8,498,000 units.

Total cost of shipments within South Dakota.....$3,207,460.

Table C-3. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1952.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I									
II		1253*							1253
III			2556*						2556
IV				2343*					2343
V	9348		268		3191*				12807
VI		2682		554		2405*		534	6175
VII	236						2203*	13316	15755
Total Demand	9584	3935	2824	2897	3191	2405	2203	13850	40889

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....13,088,000 units.

Total cost of shipments within South Dakota.....$4,482,020.

Table C-4. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1953.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I	1207*								1207
II	1369	4471*							5840
III	532		3012*						3544
IV				3167*				3108	6275
V	6998				3510*			1173	11681
VI						2619*		4922	7541
VII							2585*	8603	11188
Total Demand	10106	4471	3012	3167	3510	2619	2585	17806	47276

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....8,899,000 units.

Total cost of shipments within South Dakota.....$3,257,660.

Table C-5. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1954.

Origin	Destination (1,000 units)								Total Supply Available
	I	II	III	IV	V	VI	VII	IX	
I									
II		3524*							3524
III			3186*						3186
IV	1221	1488		3460*					6169
V	9466		180		3833*				13479
VI						2825*		3305	6130
VII	423						2642*	7714	10779
Total Demand	11110	5012	3366	3460	3833	2825	2642	11019	43267

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....12,778,000 units.

Total cost of shipments within South Dakota.....$4,488,760.

Table C-6. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1957.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I	3245*								3245
II	5034	4707*							9741
III	415		3100*						3515
IV				3325*				6076	9401
V	1754				3614*			7888	13256
VI						2719*		4710	7429
VII							2378*	8923	11301
Total Demand	10448	4707	3100	3325	3614	2719	2378	27597	57888

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....7,203,000 units.

Total cost of shipments within South Dakota.....$2,598,170.

Table C-7. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1958.

Origin	Destination (1,000 units)								Total Supply Available
	I	II	III	IV	V	VI	VII	IX	
I	2013*								2013
II	1710	4794*							6504
III	126		3198*						3324
IV	559			3394*				3757	7710
V	6656				3734*				10390
VI						2750*		5298	8048
VII							2252*	7798	10050
Total Demand	11064	4794	3198	3394	3734	2750	2252	16853	48039

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....9,051,000 units.

Total cost of shipments within South Dakota.....$3,349,090.

Table C-8. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1960.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I									
II		3540*							3540
III			1810*						1810
IV	1787	1366		3406*					6559
V	7175		1694		3948*				12817
VI						2833*		5833	8666
VII	2329						2250*	13551	18130
Total Demand	11291	4906	3504	3406	3948	2833	2250	19384	51522

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....14,351,000 units.

Total cost of shipments within South Dakota.....$4,973,570.

Table C-9. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1961.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I									
II		3*							3
III			1334*						1334
IV		1134		3489*					4623
V	3352		2051		4060*				9463
VI		3904				2933*		660	7497
VII	7960						2298*	980	11238
Total Demand	11312	5041	3385	3489	4060	2933	2298	1640	34158

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....18,401,000 units.

Total cost of shipments within South Dakota.....$6,331,440.

Table C-10. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1962.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	IX	Total Supply Available
I	1520*								1520
II	674	5198*							5872
III			2321*						2321
IV	2330			3760*					6090
V	4055		1158		4275*				9488
VI						3135*		1903	5038
VII	2358						2427*	6355	11140
Total Demand	10937	5198	3479	3760	4275	3135	2427	8258	41469

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....10,575,000 units.

Total cost of shipments within South Dakota.....$3,943,830.

Table C-11. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1963.

Origin	Destination (1,000 units)								Total Supply Available
	I	II	III	IV	V	VI	VII	IX	
I	207*								207
II		4175*							4175
III	170		3547*						3717
IV	1367	1074		3832*				1616	7889
V	9477				4342*				13819
VI						3170*		7159	10329
VII							2375*	10339	12714
Total Demand	11221	5249	3547	3832	4342	3170	2375	19114	52850

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....12,088,000 units.

Total cost of shipments within South Dakota.....$4,316,380.

APPENDIX D

INTRODUCTION

In the years 1955, 1956, 1959, 1964 and 1965 there was a shortage of feed grains in South Dakota. In other words, if the beef producers of the state had wanted to feed their cattle to market weight they would have had to import feed grains. In order that a solution may be obtained for the "feed grains solution", a dummy region must supply the necessary amount of feed grains. This dummy region is Region VIII, and is identified as Ames, Iowa (see Table 2-1).

The functions of Region VIII are, (1) to absorb (demand) the surplus feeder calves which exist after the demand within the state has been satisfied; (2) to supply the feed grains necessary to satisfy the demand which still exists after all surpluses of the regions within the state have been allocated.

This appendix is concerned with the optimum allocation of feed grains; therefore, function (2) applies. For example, Table D-1 shows that Region I did not have any feed grains available for beef production in 1955. However, Region I demanded 11,681,000 units of feed grains in that year. The optimum solution indicates that Region VI supplied 301,000 units toward the satisfaction of this demand, but, because the surplus feed grains of the other regions already had been allocated, Region VIII had to supply the remaining demand of 11,380,000 units of feed grains to Region I.

The interpretation of the optimum solution of the other years considered in this appendix is similar.

Table D-1. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1955.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	Total Supply Available
I								
II		2054*						2054
III			439*					439
IV				3343*				3343
V			616		3941*			4557
VI	301	3037	641	115		2800*		6894
VII			1800				2594*	4394
VIII	11380							11380
Total Demand	11681	5091	3496	3458	3941	2800	2594	33061

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....5,894,000 units.

Total cost of shipments within South Dakota.....$1,857,060.

Table D-2. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1956.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	Total Supply Available
I								
II		1369*						1369
III			535*					535
IV		880		3368*				4248
V					3424*			3424
VI		2572				2721*	2134	7427
VII							142*	142
VIII	11020		2681		251		110	14062
Total Demand	11020	4821	3216	3368	3675	2721	2386	31207

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....5,586,000 units.

Total cost of shipments within South Dakota.....$1,450,360.

Table D-3. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1959.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	Total Supply Available
I								
II								
III								
IV								
V								
VI						1868*		1868
VII			1342		3802	921	2291*	8356
VIII	11437	4886	1950	3465				21738
Total Demand	11437	4886	3292	3465	3802	2789	2291	31962

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....6,065,000 units.

Total cost of shipments within South Dakota.....$1,420,880.

Table D-4. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1964.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	Total Supply Available
I								
II		1480*						1480
III								
IV				614*				614
V					1421*			1421
VI				18		3479*		3497
VII					2303		2604*	4907
VIII	12239	4395	3896	3586	989			25105
Total Demand	12239	5875	3896	4218	4713	3479	2604	37024

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....2,321,000 units.

Total cost of shipments within South Dakota.....$465,280.

Table D-5. Optimum Allocation of Feed Grain Units Available for Fattening Feeder Calves in South Dakota, by Regions, 1965.

Origin	Destination (1,000 units) I	II	III	IV	V	VI	VII	Total Supply Available
I	252*							252
II		2543*						2543
III								
IV		566		4169*				4735
V			2549		4731*			7280
VI		2852				3569*		6421
VII	6809	302	1344				2681*	11136
VIII	5009							5009
Total Demand	12070	6263	3893	4169	4731	3569	2681	37376

* Indicates the number of feed grain units retained by each region from its available supply for beef production.

Total shipments within South Dakota.....14,422,000 units.

Total cost of shipments within South Dakota.....$4,818,490.

APPENDIX E

South Dakota State University

Questionnaire No. _____

(Confidential)

1. What is the maximum slaughtering capacity of your plant in head per hour?

_____ head per hour

2. What has been the average annual kill of cattle at your plant for the past five years?

_____ head

3. Of the average annual kill of cattle per year, what percent has been fat cattle?

_____% (excluding vealers, canners, cutters)

4. Approximately how many hours did you operate your slaughtering facilities in 1966?

_____ hours per week