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Title: ECONOMIC CONSIDERATIONS FOR EXPANDED FEEDING OF LIVESTOCK IN THE PACIFIC NORTHWEST

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Several agricultural and related industry groups in the Pacific Coast states have expressed concern about the competitive position of these states in the production of feed grains and livestock products. This study was directed toward the investigation of these concerns.

In order to permit the real world situation, with its accompanying multivariable reality, to be reduced to workable size, a linear programming model was designed. The 48 contiguous states were divided into five regions with smaller regions in the western United States to permit a more detailed analysis of the West.

The quantities of feed grains produced in each state were determined and summed for the states in a region. The quantities of fed beef, pork, broilers, turkeys, eggs, and milk (the products of the major grain consuming classes of livestock) demanded in each state were computed.

A matrix of transportation costs between regions was developed for feed grains and for the livestock products of the model. Regional

weighted average prices received by farmers for each feed grain and for each livestock product were determined.

The model was then utilized to indicate production of all the livestock products required for consumption by region at the least cost of producing the products.

Optimal solutions were obtained using 1968 and 1969 relative prices and these solutions were analyzed. The analysis indicates that generally the states which are deficit in beef, pork, broiler, and egg production have a slight economic advantage in producing these products for local consumption until the locally produced feed supply is utilized. Each region in the model produced the milk consumed in that region. Region I (Oregon and Washington) has traditionally been self-sufficient in turkey production, and Region III (California) has been a turkey exporting state. According to the model, both of these regions should import the turkey consumed in the region to derive optimum economic benefits. These conclusions are based on the relative prices and transportation costs that existed in 1968 and 1969.

After the solutions were obtained, the price of wheat in Region I was varied using a parametric procedure available with the linear programming package. Results of this analysis using 1968 and 1969 relative prices were described. The parametric analysis indicated that at the 1968 price of wheat in Region I more than twice the quantity of wheat allocated to livestock feeding in the basic model could have been economically utilized and would have reduced costs of producing the livestock products consumed in Region I.

The 1969 wheat price in Region I was sufficiently low that the parametric analysis indicated an allocation of over four times the quantity used in the basic model for livestock feeding. The basic model utilized 1,043,000 tons of wheat for livestock feeding.

It can be concluded from the analysis that Region I could have utilized much larger quantities of wheat for livestock feeding than was allocated for feeding in the basic model. Based on the relative feed ingredient costs that existed in 1968, Region I producers of pork, broilers, eggs, and milk are competitive with other regions in supplying the quantities of these products demanded for regional consumption.

The 1969 relative prices made Region I even more competitive in producing pork, broilers, eggs, and milk, and added beef production as an economically advantageous alternative.

These conclusions are based only on feed ingredient and transportation costs. If non-feed costs and relative feeder cattle costs for beef production are included, Region I producers appear to have a slight margin for producing beef for local consumption until locally produced feed supplies are exhausted.

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Economic Considerations for Expanded Feeding of Livestock in the Pacific Northwest

by

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TABLE OF CONTENTS

ECONOMIC CONSIDERATIONS FOR EXPANDED FEEDING OF LIVESTOCK IN THE PACIFIC NORTHWEST

CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

The present and future competitive position of the livestock-feed grain economy of the Pacific Coast States is of constant concern to grain producers, livestock feeders and other industry groups. Several factors give rise to their interest.

Oregon, Washington and California are all deficit producers of meats and, according to U.S.D.A.'s classification (32), these three states are also deficit in feed grain production. These states import[1] significant quantities of beef, pork, and poultry products to satisfy the total consumption requirements of their populations. In 1968 the only exception to this situation was turkey production in Oregon and California and egg production in California. Oregon exported about the same quantity of turkey that Washington imported. California exported about 97,387,000 pounds of live weight turkey in 1968, while egg production in that state exceeded consumption by 178,000 dozen eggs.

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[1]Imports and exports, as defined in this publication, refer to shipments between states rather than movements between countries, unless otherwise indicated.

Washington, Oregon and California have consistently been deficit feed producing states. In 1968, according to U.S.D.A. (33), Oregon livestock producers fed 415,000 tons more feed grains than were produced in that state, while Washington feeders fed 727,000 tons more than were produced. California feeders fed 4,026,000 tons more feed grains than were produced in that state during the same year. The above figures do not include wheat, as U.S.D.A. does not consider it to be a feed grain.

According to estimates of per capita consumption of beef in 1968, Oregon producers fed about 45 percent of the beef consumed in the state, while about 85 percent of the beef consumed was slaughtered in the state (see Table 1). If it is assumed that about 72 percent of the beef consumed was fed beef, it logically follows that about 27 percent of the fed beef consumed by Oregon residents was imported either in live or carcass form. The 72 percent figure above was computed from slaughter figures released by U.S.D.A. and is based on steer and heifer slaughter as a percent of total slaughter.

Pork consumption indicates even larger imports. Oregon hog raisers produced slightly less than 24 percent of the state's pork consumption in 1968. From this it can be concluded that over 75 percent of the pork consumed in Oregon in 1968 was imported in either live or carcass form.

Per capita consumption in the state of Washington for 1968 was quite similar to Oregon. Washington feeders fed about 50 percent of the beef consumed in 1968, while about 90 percent of the beef consumed

TABLE 1. PRODUCTION-CONSUMPTION BALANCE OF FED BEEF, PORK, AND TURKEYS IN OREGON, WASHINGTON, AND CALIFORNIA, 1968[1]

ITEM	OREGON	WASHINGTON	CALIFORNIA	3-STATE TOTAL
FED BEEF				
No. Head Consumed	407,422	641,622	3,779,110	4,828,154
No. Head Slaughtered	347,440	592,500	2,919,000	3,858,900
Slaughter Surplus (Deficit)	(60,022)	(49,122)	(860,110)	(969,254)
No. Fed Cattle Marketed	181,000	332,000	2,068,000	2,581,000
Production-Consumption Surplus (Deficit)	(226,442)	(309,622)	(1,711,110)	(2,247,174)
PORK				
No. Head Consumed	779,214	1,282,413	7,458,772	9,520,399
No. Head Slaughtered	268,300	793,000	1,628,000	2,689,300
Slaughter Surplus (Deficit)	(510,914)	(489,413)	(5,830,772)	(6,831,099)
No. Head Marketed	183,000	122,000	230,000	535,000
Production-Consumption Surplus (Deficit)	(596,214)	(1,160,413)	(7,228,772)	(8,985,399)
TURKEYS				
No. Birds Consumed	1,034,613	1,822,933	9,453,478	12,311,024
No. Birds Produced	1,921,000	577,000	14,312,000	16,810,000
Production-Consumption Surplus (Deficit)	886,387	(1,245,933)	4,858,522	4,498,976
Number Marketed	1,940,000	589,000	14,337,000	16,866,000
Marketing-Consumption Surplus (Deficit)	905,387	(1,233,933)	4,883,522	4,554,976

[1]Source: Computed by the author, based on data obtained from Livestock and Meat Statistics; Chicken and Poultry; May, 1969, National Food Situation; Bureau of Census Population Report, 1968.

was slaughtered in the state. If it is assumed that 72 percent of the beef consumed was fed beef, then about 22 percent of the fed beef consumption was imported in either live or carcass form.

Washington hog producers raised about 15 percent of the pork consumed; thus, nearly 85 percent of the total pork consumed by the population of that state in 1968 was imported in either live or carcass form.

Beef production in California totaled 2,068,000 head in 1968, or just over 53 percent of the beef consumed. Numbers of cattle fed have declined from this level in both 1969 and 1970.

Another interesting facet of the situation is the production of wheat for export to foreign countries. Historically, about 80 percent of the Pacific Northwest soft white wheat has moved through export channels to foreign countries, with some 60 percent of the total export volume moving under government programs, chiefly Public Law 480. In 1968 the export market for soft white wheat was partially lost. Because of this market decline and a recognition of the heavy dependence on government food aid programs, the need for a market development program for wheat became self-evident. This situation, coupled with the need for market development, made it imperative to investigate the economic feasibility of alternative markets for utilizing the grain producing potential of the Pacific area. Through this approach the wheat industry could reduce its dependence on government-created export outlets and pursue the development of a more reliable market.

Actions to initiate a domestic market development program have been taken by several groups, including the Washington Wheat Commission and the Washington Associated Wheat Growers. The Washington Wheat Commission and Washington Associated Wheat Growers Committee on Wheat Utilization made the following recommendation at their meeting of May 13, 1970, as recorded by Clinesmith (8,1-4):

> ". . . The Committee recommends that the Wheat Commission undertake a pilot operation in the area of domestic market development which will have as its purpose facilitating additional consumption of Washington produced wheat in the livestock and animal products, industrial utilization and food products industries."
>
> . . . .
>
> "It was generally agreed that the barrier to further wheat feeding is not technical feasibility nor the absence of utilization information; in short, that there was no great need for additional fundamental research. . ." "A few quick calculations were made on costs, using wheat, barley, corn, and protein quotations of the past year; and it was concluded that wheat had been very competitive throughout much of that period. . ." ". . . Unit cost is the overriding determinant to cattle feeders. . ."
>
> ". . . The matter of farm prices and their relationship to equalizing regional freight rates should not be forgotten, . . . since this often negates the apparent or natural advantage Washington grain producers should have in servicing coastal markets for feed grains."
>
> ". . . It was observed that wheat price and supply fluctuations cool most feed grain users in the Pacific Northwest. It was felt the industry should concentrate on properly servicing these markets on a continuous and realistic basis, which also protects our food grain price structure."
>
> . . . .
>
> ". . . there is some merit in avoiding the situation which would likely result from excessively cheap feed and massive expansion of Washington's feeding industry, since by comparison, this would continue to be a high cost producing area. . ."

The consumption of livestock products in the form of meats, poultry, eggs and milk in the Pacific Northwest states has been described as generally exceeding production of these products in these states. Feed grain utilization by livestock and poultry has also been shown to exceed production. If it is found feasible to utilize soft white wheat in quantity as a feed grain, it follows that the present demand for meat, poultry, eggs, and milk in Oregon and Washington could be satisfied by feeding grains produced in these states.

The quantity of wheat utilized as a feed grain will depend on the price of wheat exported to foreign countries and the relative price of wheat compared with prices of other feed grains, taking into account the comparative feeding values for particular classes of livestock. Production of different livestock products in any state or region is dependent on comparative costs. The production costs of livestock products within the consuming region must be less than or equal to the relative costs of producing that product in another region and transporting it to the region of consumption.

It is conceivable that present wheat producers might desire to produce another feed grain that could be produced with lower costs than wheat or a grain that could be developed with similar costs and higher yields with qualities at least as desirable for livestock or poultry feeding as wheat. For example, if a new feed grain with comparable energy and protein feeding values, similar costs of production, and yields exceeding those of wheat by 30 percent could be developed, this feed grain could be substituted at an economic advantage for wheat presently produced. Also, if a new feed grain could be developed with higher energy levels, similar protein levels, and similar yields, but costing less to produce per acre, it would follow that this feed grain could replace the present wheat acreage at an economic advantage to the producer.

Broadly conceived, the problem or problems described thus far represent a statement of the situation in the livestock-feed grain economy of the Pacific Northwest.

OBJECTIVES OF THE STUDY

There are two over-all objectives of this study. The first broad objective is to estimate the present demand for feed grains in the Pacific Northwest. Specific objectives under this subject include:

1. Estimate the present and potential size of markets for feed grains and livestock products in the Pacific Northwest and California.

2. Determine the quantities of livestock products and/or feed grains shipped into these markets from other areas.

3. Develop an interregional model that will relate feed grain-livestock product prices among regions of the United States.

4. Determine the transportation costs of moving feed grains, livestock, and livestock products between regions of the United States.

5. Analyze the competitive position of livestock production in the Pacific Northwest as selected costs are varied.

The second broad objective is to evaluate the economic feasibility of utilizing a new high-energy feed grain in the Pacific Northwest. Specific objectives could include:

1. Determine at what prices a new high-energy feed grain would need to sell to compete on a feed value basis with other feed grains produced in the region or imported from other regions.

2. Determine the nutritive characteristics that would make this feed grain at least as desirable on a cost basis as other feed grains, including wheat.

PROCEDURE

In order to fulfill successfully the objectives of this study it was necessary to construct a detailed interregional model of the livestock-feed grain economy. Components of this model included consumption levels of the different livestock products, utilization of feed grains by region in the production of livestock products, and interregional transportation costs for products and feed grains.

PLAN OF THESIS

Chapter I includes a statement of the problem, the objectives of the study and the procedure necessary to achieve these objectives.

The second chapter covers a review of literature dealing with location theory and with the application of location theory to the livestock-feed economy.

In Chapter III the model utilized to analyze the livestock-feed economy is developed and described.

Chapter IV covers the analysis of the data generated with the model. An analysis of the demand for wheat in the Pacific Northwest is developed and the results of this analysis interpreted.

Chapter V covers the results and conclusions of the study.

CHAPTER II

LITERATURE REVIEW

The literature related to this problem can be broadly divided into two categories. These include the literature of location theory as it relates to economic activities and that related to the analysis of the location of the livestock-feed sector of the economy.

LOCATION THEORY

Von Thunen is credited by many authors with the development of the theory of the isolated state. This theory is considered basic to or underlying present-day theory of spatial economic analysis. Location theory has been studied and written about many times in terms of its relation to trade theory and location of industry. Early writers were mainly cost-oriented, while later ones have been demand and equilibrium-oriented. Changes in transportation, industrialization of countries, and standard of living have added many variables to the analysis of location theory.

Alfred Weber (42) and Von Thunen both analyzed location problems based on production and transportation costs as the overriding determinants. They assumed demands for products to be fixed, with no interdependence among the product market area, the location of processing plants, and the location of factor supply areas.

Miller and King (20) have summarized the important variables used in location theory analysis. Their major headings include:

(1) area, (2) transportation, (3) nonquantitative, (4) traditional, and (5) generality. The area variables include differences associated with the physical attributes of the geographic regions encompassed in the study. The types of transportation facilities and services available comprise the transportation variables. The nonquantitative variables include the nonmonetary elements of location plus public policy influences on both factors and products. The traditional variables include the economic considerations of size, demand, supply, rent, etc. The term generality includes variables external to the firm, such as time, uncertainty or risk, welfare, and the number of factors and products. The methodology used to study a particular problem will differ according to the relative importance attached to each of the variables. Exclusion of certain variables in a particular analysis should be viewed by the investigator in terms of the effect exclusion may have on the outcome of the analysis.

Bressler and King (5) tie much of the previous theory together and apply it to the markets of today:

> "The basic ideas of specialization and trade grow out of the concept of the market in space, form and time dimensions. The essential question is whether, given a number of points in space-form-time, they constitute a single, multiple price market or a number of competing markets."

As a preliminary definition they state that if such points are interconnected by trade they then constitute a single market.

A simple case of a two-region model may be used to analyze the situation in which a single product is being produced and consumed in each region. In the absence of trade, supply and demand curves determine the price in each region. If we assume a higher price exists in Region X than in Region Y and further assume no transfer costs, the high priced Region X would receive product from Region Y until a price was reached which would equate price between Region X and Region Y. This price would be lower than the original price in Region X and higher than the original price in Region Y. Trade would occur until an equilibrium price was obtained and would be maintained at the level of the equilibrium price.

If the situation is modified and transfer costs are considered, trade will not completely equalize costs, but rather the product prices in the two regions will move toward each other until they differ by the amount of the transfer costs. An extension of this argument indicates that trade will occur between two regions only if prices in isolation differ by more than the transfer costs. Distance and expensive transportation costs tend to reduce trade, while technological developments that reduce transportation costs could be expected to increase trade.

The simple two region-one product model can now be readily expanded into a multiple region-multiple product model in which a given quantity of each product could be produced for all regions in such a way as to minimize total production costs. An example of a two region-one product model could be illustrated by a situation in which Region X has a lower production cost and only part of the feed available is utilized in producing Product A. Feed, in this situation, is considered to be an input in the production of Product A. Region Y utilizes all of its available feed in producing Product A and imports Product A from Region X to supply the rest of the quantity demanded. Expansion of this model into a multiregion-multiproduct model can be demonstrated by adding Region Z, which produces all of its required A and also B, a product that competes with A for the available feed inputs. Region Z has a relative cost of producing Product A which is less than that of Region X. If it is now assumed that Region Z has an equal or lower cost of transporting Product A to Region Y than does Region X, it follows that Region Z will supply the quantity of Product A necessary to meet the quantity demanded in Region Y. This model can now be expanded by having both Region X and Region Z produce Product B. When B production is added, more feed inputs would be required and, depending on relative prices of feeds and quantities available in each region and the relative feeding values of feed available when fed to produce Products A and B, and further considering the relative transportation costs of moving both products between regions, it can be determined which region would supply Region Y with Products A and B to minimize total costs of producing both products for all consumption regions.

LIVESTOCK-FEED ECONOMY

Many studies have been made of the livestock-feed sectors of the United States economy. The scope of these studies varies greatly. Some have looked at the production of feed grains and the allocation of land resources to the production of various crops. Other studies have looked at the allocation of livestock and poultry production to various regions of the United States. Still others have developed rather complex multi-regional, multi-product models of production and allocation.

All models developed to allocate feeds to the production of various classes of livestock products have the problem of converting feeds to product on a consistent and realistic basis without making unrealistic assumptions. Different techniques have been attempted by different authors. Four methods of handling this problem are: (1) classifying all feeds as energy, protein or roughage and assuming that each class of livestock or poultry consumes a given quantity of feed per unit of gain; (2) the use of a common or typical ration composed of the same feeds for all regions; (3) the use of animal units, in which one class of livestock is selected as the base which is given a value, then feed consumption of the other classes of livestock is compared on a common denominator basis to the class selected as the base; or (4) use of energy, protein and all minor nutrient values of feeds, coupled with specification of nutrient requirements for each class of livestock.

Witt (44) developed a multi-regional model in which the total nutrient requirements of the various classes of livestock considered in the model were fed feeds as specified by the model to obtain a least-cost formulation of the various diets. An effort was made to determine the optimum location in which to produce the five classes of livestock in the study by determining the least-cost formulation of diets through an iterative procedure. The procedure was not converging at a satisfactory rate toward a stable solution and was terminated after four iterations. On the basis of the information obtained, the conclusion of the author was that to the extent that locally produced feedstuffs were available, livestock producers in deficit feed producing areas appeared to have an advantage over producers in surplus feed producing regions in supplying the products consumed in the deficit regions. Once the locally produced supplies of feedstuffs were utilized, ration costs increased rapidly in the deficit feedstuff producing regions.

Judge and Wallace (15) utilized a spatial price equilibrium model based on an analysis of a single product, beef (and at a later date a similar analysis was made of pork), for 21 regions of the United States. Equilibrium prices and quantities were determined through the use of parametric and iterative procedures based on price-dependent regional demand functions for beef and pork.

Brokken and Heady (6) utilized a multi-regional crop producing model coupled with a multi-class livestock producing model to determine location of crop and livestock production throughout the United States.

Livestock producing and consuming regions were identical, but feed producing regions were specified according to a different set of criteria. Thus, crop production areas could be determined independently of the livestock producing areas.

Fox (13) utilized a spatial equilibrium model in which feed production and livestock numbers were assumed as given. Demand for feed was assumed to be functionally related to the variables in the livestock sector. An equilibrium solution was determined for regional feed prices and feed utilization by livestock classes. The model was then utilized to evaluate policy decisions in the livestock-feed grain economy.

Williams and Dietrich (43) utilized a spatial analysis to determine demand differences, transportation costs, slaughter costs, and wage rates, but they did not analyze feeder cattle costs and feed costs. This study showed that production location and transportation costs are important determinants in interregional analysis of the fed beef market. Failure to include feed costs, a cost item of great importance in the fed beef economy, leaves a question about the results of the study.

King and Schrader (17) utilized a spatial equilibrium model to determine the location of cattle feeding. They assumed as given regional feeder cattle supplies, nonfeed costs of feed lot operations, feed conversion ratios by region, regional demand, and transfer costs. They pointed out that one of the weaknesses of the study was that the beef sector was considered to be independent of other livestock production.

Chuang and Judge (7) grouped livestock into grain and grain-and-roughage consuming classifications. They also grouped feeds according to six major groups. They assumed that N pounds of a certain feedstuff would furnish the same nutrients as N pounds of another feedstuff when fed to a particular class of livestock. This assumption resulted in eliminating the problem of reducing feeds to a common denominator, but it also reduced the validity of results occurring when different feeds are available for feeding different classes of livestock. The size of the potential error above may be illustrated by comparing the mega calories of metabolizable energy of different feeds when fed to the same class of livestock. One ton of barley fed to beef would furnish 2423 Mcal ME (mega cals of metabolizable energy); corn would furnish 2566 Mcal ME per ton; and wheat would furnish 2598 Mcal ME per ton.

McPherson and Witt (19) studied the feed cost relationship between the midwest and Florida using "optimum" nutrient specifications for each class of livestock to obtain the least cost diet in each region. The classes of livestock studied were considered to be independent of each other in drawing from the available supply of feed grains.

It is recognized that each of the studies referred to here has had its own objectives, hypotheses and techniques. They all contribute to general knowledge of the livestock-feed grain economy and are thus contributing to future research by creating an awareness of problems in this area.

A meaningful model, to contribute to the information and knowledge already in existence, should analyze in some detail the livestock and feed sectors in a concurrent or simultaneous manner. An attempt is made to develop such a model in Chapter III.

CHAPTER III

MODEL DEVELOPMENT

THE MODEL SPECIFICATION

The model utilized in this study is a linear programming model. It was developed to minimize the total national costs of feeding livestock and poultry a ration of feed grains, roughage in the case of beef and dairy cows, and protein supplements necessary to balance the rations and supply the energy and protein required for the production of meat or other products. Beef, hogs, broilers, turkeys, laying hens, and milk cows consume the bulk of the feed grains fed to livestock. According to the U.S.D.A. (33), horses and mules, sheep and lambs, goats, other cattle, and heifers and heifer calves kept for milk, which make up all livestock other than those included in the model, consumed only 15,234,140 tons of feed grain in 1968. This is only 11.00 percent of the total feed grains consumed in the United States. Product prices are the prices received by farmers for steers and heifers, hogs, broilers, turkeys, eggs, and milk in each state, or the weighted average price when the region has more than one state. Transportation costs of moving feed grains or any of the livestock products are the least cost means of transporting feed grains or livestock products available (on a carcass equivalent cost basis) whether by truck or rail. Because all points in a region cannot be considered, key locations or cities have been chosen within the region as the basing point for transportation costs. In most cases these key points are logical points of origin or destination. The key points are Portland, Oregon, for Region I; Denver, Colorado, for Region II; Los Angeles, California, for Region III; Omaha, Nebraska, for Region IV; and Chicago, Illinois for Region V.

The model is specified in the following manner:

Objective Function: The objective function minimizes the cost of feeding the jth feed to the ith class of livestock in the kth region, summed for all feeds fed to all classes of livestock for all regions. This is accomplished by multiplying the quantity (R_{jik}) of the jth feed available for feeding to the ith class of livestock in the kth region by the cost (C_{jik}) of the jth feed fed to the ith livestock in the kth region. Interregional movements of feeds are allowed if costs can be reduced by transporting feeds from one region to another for feeding. The unit cost (Y_{jkg}) of transporting the jth feed grain from region k to g times the quantity (S_{jkg}) of the jth feed grain transported from region k to g, summed for the jth feeds moved between regions, results in cost minimization. Interregional movement of livestock products is also permitted if transporting products reduces total cost. The unit cost (Z_{ikg}) of transporting the ith product from region k to g multiplied by the quantity (T_{ikg}) of the ith product transported from k to g minimizes cost of producing products. The objective function and constraints can be written mathematically in the following manner:

<u>Minimize</u> <u>Cost</u>:

$$\sum_{j}\sum_{i}\sum_{k} C_{jik} R_{jik} + \sum_{j}\sum_{kg} Y_{jkg} S_{jkg} + \sum_{i}\sum_{kg} Z_{ikg} T_{ikg} \qquad (1)$$

In words, equation (1) minimizes the costs of feeding the jth feed grain to the ith class of livestock in the kth region summed for feeding all of the jth feed grains to all of the ith livestock classes for all of the kth regions. This is accomplished by multiplying the unit cost "C" of feeding the jth feed grain to the ith class of livestock in the kth region by the quantity "R" of the jth feed grain available for feeding the ith class of livestock in the kth region summed for all feeds fed to all classes of livestock in all regions. The model next determines whether or not the cost of producing a livestock product for the kth region summed for all k regions can be reduced by transporting the jth feed grain from region k (the region of origin) to region g (the region of destination). This is accomplished by multiplying the unit cost "Y" of transporting the jth feed grain from region k to g by the quantity "S" of the jth feed grain transported from k to g and summing this quantity for all of the jth feeds transported between regions and adding this to the total cost described above. Alternately, if total cost can be reduced by transporting livestock products between regions rather than transporting feed grains, the model accomplishes this by multiplying the unit cost "Z" of transporting the ith livestock product from region k (the region of origin) to region g (the region of destination) by the quantity

"T" of the ith livestock product transported from k to g summed for all livestock products transported between regions. This minimizes the cost of feeding the quantities of feed required to produce the quantity of products consumed summed for all regions.

<u>Subject to the Following Constraints</u>:

$$R_{jk} \leqq A_{jk} + \sum_{gk} S_{jgk} \quad \sum_{kg} S_{jkg} \text{ for all j and k.} \tag{2}$$

Equations (2) through (5) describe the constraints of the model.

Verbally described, equation (2) indicates that the quantity "R" of the jth feed grain available for feeding in the kth region must be less than or equal to "A", the quantity of the jth feed grain produced in region k, plus "S", the quantity of the jth feed grain imported to region g from k where k is the region of origin and g is the region of destination, minus "S", the quantity of the jth feed grain exported from k to g where k is the region of origin and g is the region of destination. Simply, the quantity of a feed grain available for feeding in a region is less than or equal to production plus imports less exports for all feed grains for all regions.

$$D_{ik} = L_{ik} + \sum_{gk} T_{igk} - \sum_{kg} T_{ikg} \tag{3}$$

The quantity "D" of the ith livestock product demanded (consumed) in the kth region is equal to the quantity "L" of the ith livestock product produced in region k plus the quantity "T" of the ith product imported into the region minus the quantity "T" of the ith livestock product exported from the region summed for all livestock products and all regions.

$$\sum_j \sum_k E_{jik} R_{jk} \geqq \sum_i \sum_k F_{ik} L_{ik} \text{ for all i and k.} \quad (4)$$

Equation (4) converts feed grains to metabolizable energy and expresses livestock requirements for production of products in terms of metabolizable energy.

The metabolizable energy furnished by the jth feed grain in region k multiplied by the quantity "R" of the jth feed grain available for feeding in region k, summed for all the feed grains fed in each of the regions, is greater than or equal to the quantity "F" of energy required by the ith class of livestock produced in the kth region multiplied by the quantity "L" of the ith livestock product produced in the kth region, summed for all of the products produced in all regions.

$$\sum_j \sum_k N_{jik} R_{jk} \geqq \sum_i \sum_k M_{ik} L_{ik} \text{ for all i and k.} \quad (5)$$

This inequality insures that the protein content of the feed grains when fed to a selected class of livestock is sufficiently high to meet the protein requirements of that class of livestock.

The digestible protein supplied "N" per unit of the jth feed grain, when fed to the ith class of livestock in the kth region, multiplied by the quantity of the jth feed grain available for feeding in the kth region, must be greater than or equal to the digestible protein required "M" by the ith class of livestock in the kth region, multiplied by the quantity of the ith livestock product produced in the kth region, summed for all products produced in all regions.

The equations of the model can be summarized as follows:

Cost Minimization Equations:

$$\sum_j \sum_i \sum_k C_{jik} R_{jik} + \sum_j \sum_{kg} Y_{jkg} S_{jkg} + \sum_k \sum_{kg} Z_{ikg} T_{ikg} \quad (1)$$

Constraint Equations:

$$R_{jk} \leqq A_{jk} + \sum_{gk} S_{jgh} - \sum_{gk} S_{jkg} \quad \text{for all j and k.} \quad (2)$$

$$D_{ik} = L_{ik} + \sum_{gk} T_{igk} - \sum_{kg} T_{ikg} \quad (3)$$

$$\sum_j \sum_k E_{jik} R_{jk} \geqq \sum_i \sum_k F_{ik} L_{ik} \quad \text{for all i and k.} \quad (4)$$

$$\sum_j \sum_k N_{jik} R_{jk} \geqq \sum_i \sum_k M_{ik} L_{ik} \quad \text{for all i and k.} \quad (5)$$

Each of the terms of the above equations will now be defined.

Definition of Terms:

C_{jik}: The per unit cost of feeding the jth feed grain to the ith class of livestock in region k.

R_{jk} : Quantity of the jth feed grain available for feeding in the kth region.

Y_{jkg}: The unit cost of transporting the jth feed grain from region k to g, where k is the region of origin and g is the region of destination.

S_{jkg}: Quantity of the jth feed grain transported between region k and region g, where k is the region of origin and g is the region of destination.

Z_{ikg}: The unit cost of transporting the ith livestock product from region k to g, where region k is the region of origin and g is the region of destination.

T_{ikg}: Quantity of the ith livestock product transported between region k and g, where k is the region of origin and g is the region of destination.

A_{jk}: Quantity of the jth feed grain produced for feeding in the kth region.

D_{ik}: Quantity of the ith livestock product demanded (consumed) in the kth region.

L_{ik}: Quantity of the ith livestock product produced in the kth region.

E_{jik}: The metabolizable energy supplied per unit of the jth feed grain when fed to the ith class of livestock in the kth region.

F_{ik}: The metabolizable energy required per unit of product produced by the ith class of livestock in the kth region.

N_{jik}: The digestible protein supplied per unit of the jth feed grain when fed to the ith class of livestock in the kth region.

M_{ik}: The protein required per unit of product produced by the ith class of livestock in the kth region.

In the model the values of j, i, and k are as follows:

j = 1, 2, ..., 7 where the values of j represent the following feeds:

1 - barley

2 - wheat

3 - corn

4 - oats

5 - milo (grain sorghum)

6 - alfalfa hay

7 - protein supplement

i = 1, 2, ..., 6 where the values of i represent the following livestock products:

1 - fed beef

2 - pork

3 - broilers

4 - turkeys

5 - eggs

6 - milk

k = 1, 2, ..., 5 where the values of k represent the following feed-producing, livestock-product producing and consuming regions:

1 - Region I (Portland)

2 - Region II (Denver)

3 - Region III (Los Angeles)

4 - Region IV (Omaha)

5 - Region V (Chicago)

ASSUMPTIONS OF THE MODEL

There are several assumptions necessary to permit the real world situation, with its accompanying multivariable reality, to be reduced to a workable size, hopefully without reducing the validity of the model. These assumptions include:

(1) Feed grain production in each region, plus imports minus exports, is set as an upper bound for the particular feed grain available for feeding in that region. The model permits summing the production of each feed grain for all regions; thus, U. S. production becomes the effective upper bound for each feed grain. The model also allows interregional movements of feed grains, permitting one region to feed a larger quantity of a specified feed than is produced in the region if this reduces the total cost for producing a particular product in the region.

(2) Alfalfa hay is an exception to the above assumption and is assumed to be fed only to beef and milk cows. Alfalfa fed to beef was assumed to be one feed in the ration, but it was limited to 300 pounds of alfalfa per ton of feed fed to beef. Feeding hay to beef was limited in the model because the assumed rate of gain of 2.8 pounds per day would not usually be achieved with higher levels of hay usage. Alfalfa hay fed to milk cows was allowed in the model on the basis of five tons per cow per year except for Region V, which had a restriction because sufficient hay was not produced in that region to allow five tons per cow per year.

It was assumed that alfalfa hay did not move between regions; therefore, no transportation costs nor movement were indicated by the model.

(3) The years 1968 and 1969 were selected as the base years for this study because they are the latest years for which the basic data required for much of the analysis were available. The year 1968 was also the first year in about ten years when foreign markets for white wheat were so limited that supplies were accumulating and the prices of white wheat were thought to be sufficiently low to permit its use as a livestock feed on a volume basis.

(4) Transportation costs utilized in the model are the least cost figures available as selected from among published rail and truck rates or rail or truck rates calculated by formula from waybill surveys conducted by Texas A and M University, and obtained from Raymond A. Dietrich (9). Transportation costs of beef, pork, broilers, and turkeys are calculated on the basis of carcass or dressed shipping costs. These costs are then converted to live weight equivalents because the model indicates their production as live weight products.

(5) Coefficients utilized in the model were calculated on the assumption that conversion of feed to livestock products was a linear relationship. It is recognized that this condition will not exist in all cases. However, in the case of hogs, all regions and most states within regions produced hogs weighing between 200

and 250 pounds. In this range the relationship of gain to pounds of feed required is linear;[2] thus, the assumption is not considered unrealistic.

(6) The quantity of protein feed necessary in each region for balancing the protein requirement of each class of livestock is assumed to be available at 1968 regional weighted average prices paid by farmers for 44 percent soy bean oil meal. Other protein sources could have been used to satisfy this requirement, but each additional feed greatly enlarged the model without contributing enough to the results to justify its inclusion.

(7) Livestock and feed grain prices are entered in the model as the weighted average price received by farmers for the product or the feed grain.[3] Transfers between regions occur at these prices plus the cost of transporting the product or feed between the region of origin and the region of destination.

(8) Beef utilized in the model is fed beef, and it is assumed that 300 pounds of gain is added to the live weight of each

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[2]See Figure 24, page 21, in Publication 1599, National Academy of Sciences, Sixth Revised Edition, 1968, titled Nutrient Requirements of Swine.

[3]Regional weighted average prices as used in this writing can be illustrated by a description of the computation of the price of barley. Barley production by state was multiplied by the average price received by farmers in that state. This resulted in the value of barley produced in the state. Production and value were each summed for all states in the region and the value thus obtained was divided by production to give the regional average price.

head of beef fed in the region. The figure of 300 pounds gain was selected because this amount of gain more nearly approximates the total feed grain utilization by beef animals fed in the U. S. than does a larger per head gain.

(9) The costs of producing a pound of product or a dozen eggs as determined by the model are feed ingredient costs plus transportation costs of moving feed grains or livestock products on a least cost basis to satisfy the regional consumption requirements.

(10) The quantity of each livestock product demanded was assumed as given (see explanation in narrative of Solution Procedure).

DEVELOPMENT OF THE DATA

The approach of this study differs from the approaches used in earlier interregional studies of the livestock-feed grain sector in the following respects: (1) feeds are specified from a standpoint of metabolizable energy and protein; (2) each feed has determinable levels of metabolizable energy and protein when fed to a selected class of livestock or poultry; (3) livestock require specified quantities of metabolizable energy and protein to produce a unit of gain or product; (4) livestock producers attempt to feed a combination of feeds that will produce the specified requirements or nutrients at the lowest possible cost. Metabolizable energy values were used in this study because most of the recently published feed values and livestock and poultry requirements for production have been published using metabolizable energy. The use of the metabolizable energy values requires very few conversions from already published data and makes conversion of feed to livestock products quite simple when the computer is utilized.

To accomplish the objectives of this study, a linear programming model was developed to minimize the cost of producing the quantity of beef, pork, broilers, turkeys, eggs and milk required or demanded by consumers in each region of the contiguous United States in 1968. The 48 states are divided into five regions. The regions' boundaries are the same for livestock production and consumption. It is recognized that a larger number of regions would be more desirable, but cost of computer analysis became restrictive, and elimination of other variables in the model would have had a more serious effect on the outcome than reducing the number of regions. The model was designed to focus on the Pacific Northwest area in order to fulfill the objectives of the study. Initial work accomplished with eleven regions in the model, as compared to the five-region model, did not materially alter the detail of analysis for the western United States; but, it did materially alter the detail of the analysis for eastern regions. The five-region model is not intended to give the detail of information for the eastern United States that it does for the Rocky Mountain and West Coast regions.

The regions of the model are indicated in Figure 1. Region I includes Oregon and Washington. Region II includes the states of Montana, Idaho, Wyoming, Colorado, Utah, Nevada, Arizona, and New Mexico. Region III includes the state of California. Region IV includes the states of North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, Missouri, Oklahoma, and Texas. Region V includes all states east of the Mississippi River plus Arkansas and Louisiana.

The model was used to determine: (1) the quantity of each livestock product produced in each region, (2) the quantity of product transported between regions, (3) the quantity of each feed grain fed in each region to various classes of livestock,

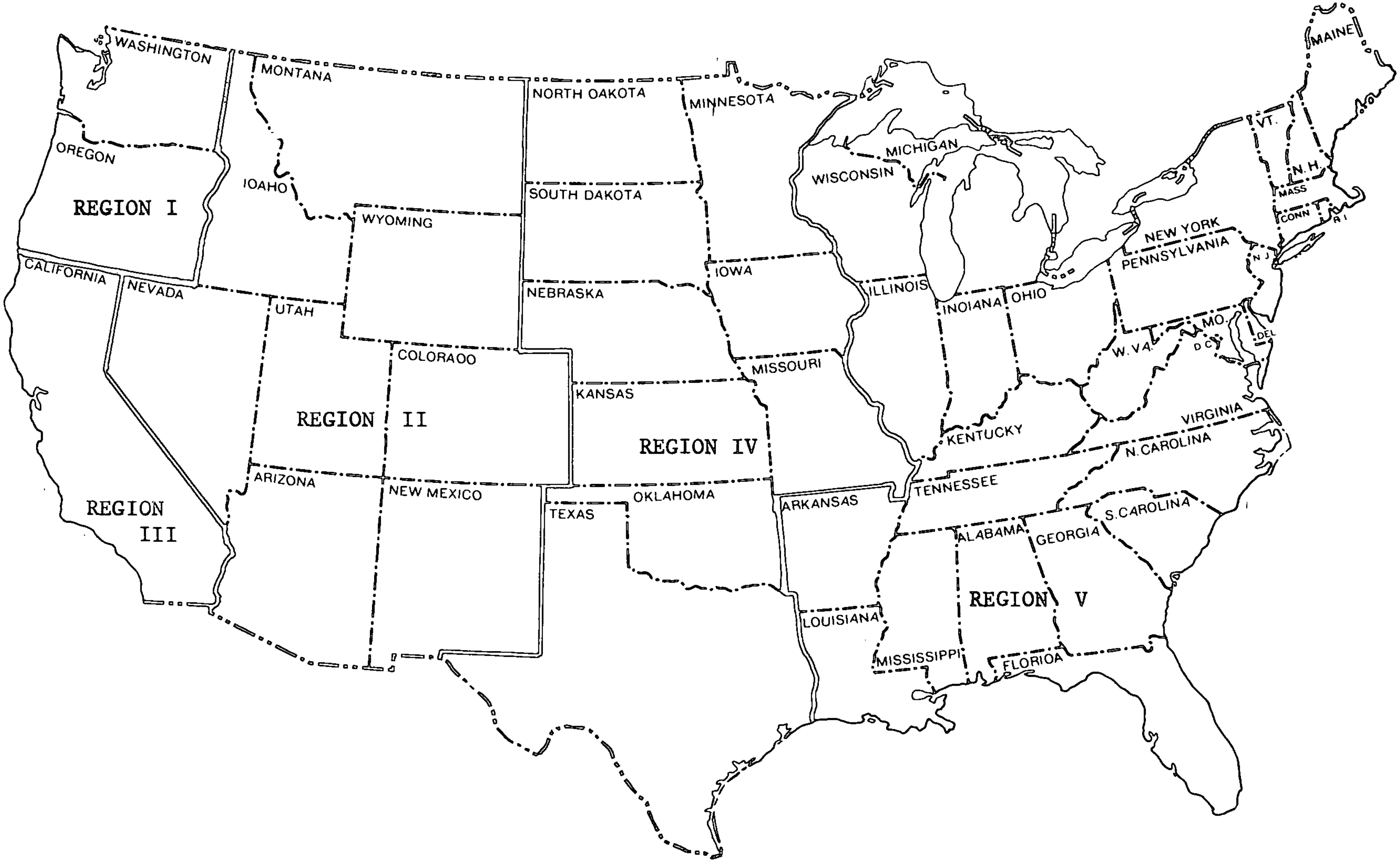

FIGURE 1. REGIONAL BREAKDOWN FOR THE UNITED STATES

and (4) the quantities of feed grain transported between regions. The feeding, transportation and production of products was accomplished so as to minimize the cost of producing the quantities of product actually consumed in 1968, subject to 1968 or 1969 costs of feed grains, livestock production costs, and transportation costs.

The coefficients of Table 2 were computed by the author from information published by the National Research Council (22). The nutritive requirements are specified as mega calories of metabolizable energy required to produce 1,000 pounds of product in the case of fed beef, hogs, broilers, turkeys, and milk, and 1,000 dozen eggs in the case of laying hens. All meat products are produced in pounds of live product rather than carcass or eviscerated weight product.

No assumptions have been made as to pounds of feed required to produce a pound of product. In each region the average live weight of each class of livestock or poultry or of egg production per hen or pounds of milk per cow were specified. The basic data for these computations were from Livestock and Meat Statistics, as published by U.S.D.A. (32). On the basis of these specifications, the metabolizable energy requirements were determined.

For example, in Region I (Portland) the average weight of laying hens was 4.4 pounds in 1968. There were 227.32 eggs produced per hen per year. A 4.4 pound hen requires 76.712 mega calories of metabolizable energy for maintenance for one year. This

TABLE 2. NUTRIENT REQUIREMENTS PER 1,000 POUNDS OF PRODUCT OR PER 1,000 DOZEN EGGS PRODUCED, BY REGIONS, 1968

REGION	VARIABLES	BEEF	PORK	BROILERS	TURKEYS	EGGS	MILK
I	Mcal ME[1]	9937	5229	3152	3659	6243	1005
I	% D.P.[2]	7.1	13.0	18.0	20.1	15.0	14.0
II	Mcal ME	9831	5230	3147	3669	6395	996
II	% D.P.	7.1	13.0	18.0	20.1	15.0	14.0
III	Mcal ME	10009	5230	3156	3663	6276	946
III	% D.P.	7.1	13.0	18.0	20.1	15.0	14.0
IV	Mcal ME	10066	5244	3149	3658	6466	994
IV	% D.P.	7.1	13.0	18.0	20.1	15.0	14.0
V	Mcal ME	9973	5231	3143	3670	6731	1005
V	% D.P.	7.1	13.0	18.0	20.1	15.0	14.0

[1]Mcal ME designates mega calories of metabolizable energy.

[2]% D.P. means percent digestible protein.

Source: Calculated based on N.R.C. tables (22).

becomes the value of "a" in the linear equation, $Y = a + bX$. The value of "X" in the equation is the level of egg production per hen per year. Applying the above equation to the rate of production per hen in Region I, it was determined that $Y = 76.712 + .1828X$, or $Y = 118.27$. That is, a 4.4 pound hen producing 227.32 eggs per year requires 118.27 mega calories of metabolizable energy for production and maintenance. Converting this total requirement to the requirement per dozen eggs, it was determined that 6.243 mega calories of metabolizable energy were required per dozen eggs produced in Region I. This value then becomes the value of the coefficient for converting the various feeds to eggs in Region I. The value of the coefficient determined above is the same value as that shown in Table 2 under the egg column of Region I, multiplied by 1,000 because the table shows values for 1,000 dozen eggs.

It will be noted that each region has a different coefficient under the egg column. Each region may have different weights of laying hens, or different levels of egg production per hen, or both. Thus, the regional coefficients are different. A similar procedure was utilized in developing the coefficients for each product as shown in Table 2.

The nutrient values of the different feeds are specified as derived from the United States-Canadian Tables of Feed Composition, published by the National Academy of Sciences (21). Table 3 shows the mega calories of metabolizable energy furnished by one ton of feed when fed to a particular class of livestock or poultry.

TABLE 3. NUTRIENTS FURNISHED BY ONE TON OF FEED IN Mcal ME OR PERCENT D.P. WHEN FED TO VARIOUS CLASSES OF LIVESTOCK

CLASS OF LIVESTOCK	VARIABLES	BARLEY	WHEAT	CORN	OATS	MILO	ALFALFA HAY	PROTEIN SUPPLEMENT
Beef	Mcal ME	2423	2598	2566	2219	2423	1683	2509
Beef	% D.P.	8.7	8.5	6.5	8.8	6.3	.114	37.3
Hogs	Mcal ME	2609	3099	2971	2420	2896	----	2718
Hogs	% D.P.	8.2	9.9	7.0	9.9	7.9	----	39.4
Broilers	Mcal ME	2400	2800	3100	2300	3000	----	2200
Broilers	% D.P.	11.6	10.8	8.8	11.8	11.1	----	43.8
Turkeys	Mcal ME	2400	2800	3100	2300	3000	----	2200
Turkeys	% D.P.	11.6	10.8	8.8	11.8	11.1	----	43.8
Layers	Mcal ME	2400	2800	3100	2300	3000	----	2200
Layers	% D.P.	11.6	10.8	8.8	11.8	11.1	----	43.8
M. Cows	Mcal ME	2423	2598	2566	2219	2423	1683	2509
M. Cows	% D.P.	8.7	8.5	6.5	8.8	6.3	11.4	37.3

Source: Calculations based on N.R.C. tables (21,22)

Tables 2 and 3 contain the technical coefficients utilized in the matrix of the linear programming model to permit the conversion of feeds to various livestock products. These coefficients have been scrutinized by various poultry, livestock and dairy production experts at Oregon State University and at Utah State University. Adjustments have been made according to the recommendations of these professors.

SOLUTION PROCEDURE

Regional demand for livestock products is a calculated demand. Regional per capita consumption indexes, as published in the National Food Situation (34), were used as the basis for red meats and poultry per capita consumption. These indexes of consumption were based on the Household Food Consumption Survey of 1965-66 (30). The quantity demanded for each state was computed by multiplying the index by the United States average per capita consumption for each product for the year. This calculation resulted in the number of pounds of product (such as beef) consumed per person in the state for a particular year. This figure was multiplied by the population to obtain total consumption of the product in the state. Product weight basis was converted to live weight basis and the quantity thus obtained was summed for all 48 states. Total United States production was compared to the converted consumption figure. Most products required a slight adjustment to obtain perfect correlation. This balance was calculated and a corrected consumption figure resulted. This figure was usually less than two percent different from calculated consumption. Thus, quantity demanded and quantity supplied were equated, and demand was assumed as given in the model.

Two parts of the model that are essential to the solution of the problem are the quantities and prices of the different feed grains available for feeding livestock. Figures 2 and 3 indicate how this segment of the linear program matrix is conceived. Another segment of the model is the portion in which feed grains are transported from region to region. The computation of transportation costs has already been described. The final portion of the basic model is the accumulation of the different livestock products in the designated regions and the transportation of these products between regions.

Total quantities of the different livestock products consumed were calculated by state and summed for the region except for beef, which was calculated by determining the number of head of fed beef produced and multiplying this by 300, which was the pounds assumed produced by feeding concentrate feeds. The quantity of beef consumed in each state was the quantity thus obtained.

Schematically, the matrix of the linear programming model was organized as shown in Figure 2. The sign of each column and row in which an "X" appears can be ascertained by relating Figure 2 to Figure 3. For example, the "X" which appears in the Feed Grain Use row and Feed Grain Available column of Figure 2 represents the quantities of feed grains produced in each region and is a positive number. Relating this to Figure 3, the rows entitled BARUS1 (barley use in Region I), BARUS2, etc., and the columns entitled BARAV1 (barley available in Region I), BARAV2, etc., are represented by a positive "1".

COLUMN NAMES / ROW NAMES	Feed Grain Available	Feed Grain Transport. Activities	Grain Feeding Activities	Livestock Producing Activities	L/S Product Transport. Activities	Product Demand
Objective Function	Prices	Transport. Costs	0	0	Transport. Costs	Prices
Feed Grain Use	X	X	0	0	0	0
Feed Grain Required	0	X	X	0	0	0
Conversion of Feed To Livestock Products	0	0	X	X	0	0
Livestock Products Available	0	0	0	X	X	X
Livestock Products Required	0	0	0	0	X	X

FIGURE 2. SCHEMATIC OF MATRIX DESIGN

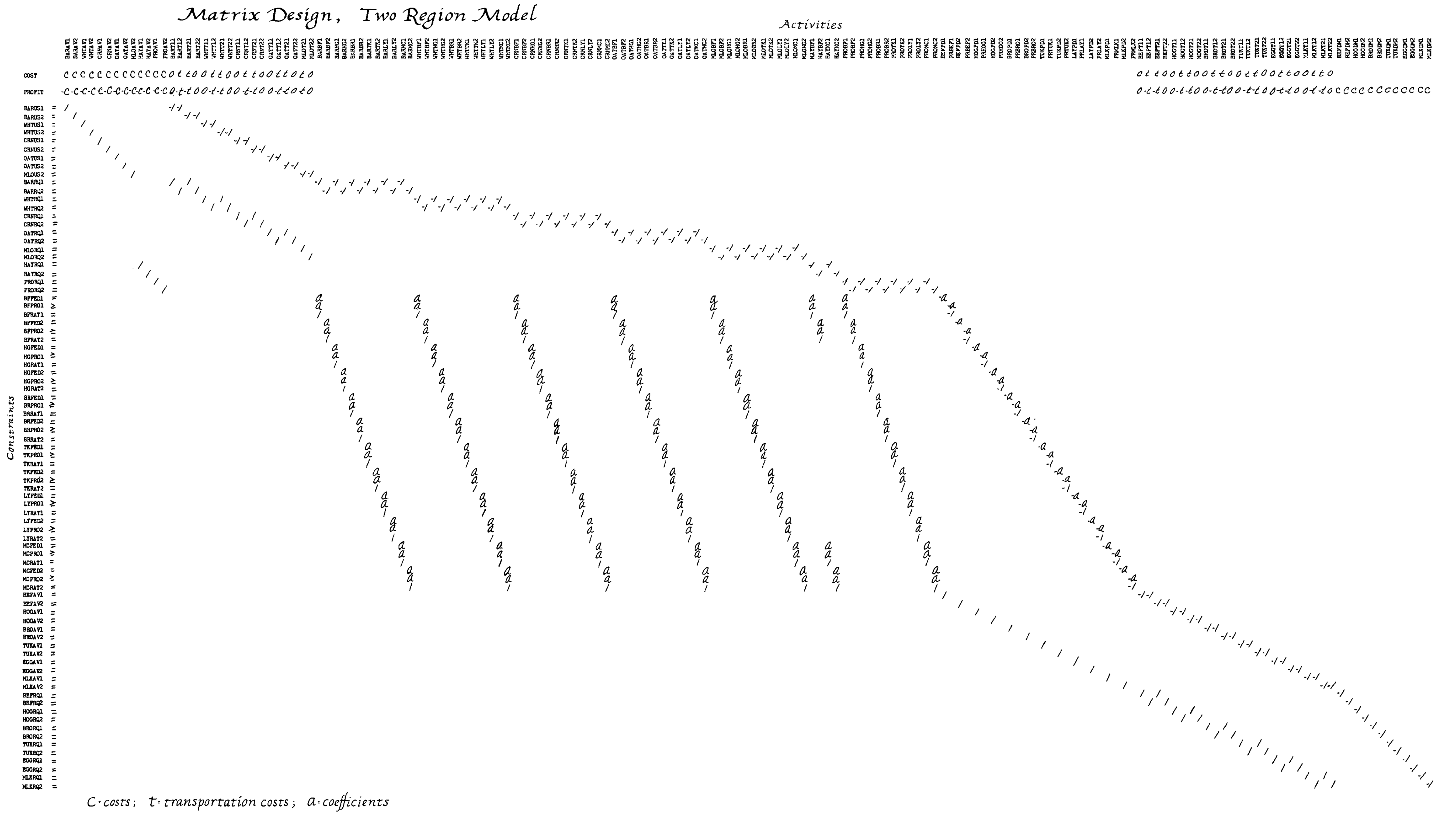

FIGURE 3. MATRIX DESIGN, TWO REGION MODEL

CHAPTER IV

ANALYSIS AND RESULTS

ANALYSIS OF REGIONS

REGION I

Region I is composed of the states of Oregon and Washington. This region traditionally has been deficit in the production of beef, pork, broilers, eggs and milk. The basing point for transportation costs and consumption is Portland, Oregon. Oregon and Washington are similar in climate and agricultural production. Because of this these states are considered together as Region I.

Questions could be asked about the various quantities of feed fed to a particular class of livestock. For example, why feed wheat to hogs and corn to broilers in Region I? These feeds are fed based on relative feeding values, relative prices, and transportation costs so as to produce the total quantity of product demanded in all regions at the least total cost. If least cost were interpreted as least cost for only one region, the quantities of each feed fed would likely be different than when all regions are considered.

Table 4 shows the quantities of the various feeds fed to each class of livestock in Region I.

It should be observed that none of the oats produced and only part of the barley produced in Region I were fed. This is

TABLE 4. FEED GRAIN PRODUCTION AND FEEDING IN REGION I UNDER MODEL SOLUTION, 1968 PRICES

(All quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	493,152	104,462	---	---	---	---	---	104,462
WHEAT	1,043,528	1,043,528	---	713,087	48,565	---	281,876	---
CORN	68,852	68,852	---	---	68,852	---	---	---
OATS	109,312	---	---	---	---	---	---	---
MILO	---	---	---	---	---	---	---	---
HAY	1,495,000	1,495,000	---	---	---	---	---	1,495,000
PROTEIN	---	276,536	---	83,734	38,105	---	41,107	113,590

because the relative prices of oats and barley were sufficiently high to prevent their being fed competitively to other classes of livestock in the region. Barley traditionally has been fed to beef in Region I; however, according to the model, beef could be imported from Region IV for less total cost than it could be produced in Region I by feeding barley. The price of barley in Region I would have had to decrease to $39.50 per ton in order for economical feeding of barley to beef to occur. Region IV produced beef and transported it to Region I for a cost of 16.20 cents per pound. This cost represents feed ingredients and transportation costs only, not total costs. Barley was priced at $40.85 per ton in Region I in 1968. Had barley been fed to beef in Region I, the cost of producing one pound of beef would have been 16.75 cents, or .55 cents per pound more than the cost of beef imported from Region IV.

The price of wheat was $43.11 per ton in 1968 in Region I. Wheat prices would have had to be $42.35 in Region I before wheat would have been fed to produce beef at a lower cost than it could be imported from Region IV.

Turkeys were not produced in Region I. If barley had been fed to turkeys in Region I, the cost of producing a pound of turkey would have been 10.09 cents. Region IV produced turkey and transported it to Region I for 9.265 cents per pound. Region IV had a .825 cent advantage over Region I in producing turkey for Region I when barley was fed.

If wheat had been fed to turkeys in Region I, turkey could have been produced for a feed ingredient cost of 9.54 cents per pound. Turkey production using wheat as the feed resulted in a cost difference of .275 cents (about one-fourth cent) per pound than when barley was fed. A decrease in feed ingredient cost sufficient to reduce the cost of producing turkey by just over one-fourth cent per pound would have resulted in turkey being produced in Region I, based on the relative prices that existed in 1968.

Region I could have produced all the broilers consumed in the region if either more wheat or more corn had been available at the 1968 prices of these feeds in the region. The feeding of barley to broilers was not feasible at its 1968 price in Region I. Barley prices would have had to be reduced enough to lower the feed ingredient costs .19 cents, or about two-tenths cent per pound of broiler produced, in order for barley to be utilized as a feed for broilers.

Table 5 shows the quantities of each livestock product produced and consumed in Region I. Detailed analysis of Table 5 indicates the competitive position of producers in Region I in the production of beef, turkeys, and broilers is not as favorable as producers would desire it to be. The costs in the model include only costs of feed ingredients and transportation of feed or livestock products as determined by the model on a least cost basis. If it is assumed that all non-feed costs are the same among regions, there remains a significant cost in beef production which has not been considered, that of feeder cattle. Region I is a feeder cattle exporting region.

TABLE 5. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION I UNDER MODEL SOLUTION, 1968 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	----	318,987[2]	318,987
PORK	466,140	----	466,140
BROILERS	137,453	143,111[3]	280,564
TURKEYS	----	51,353[4]	51,353
EGGS	140,908[1]	----	140,908
MILK	3,039,000	----	3,039,000

[1]Thousand dozen eggs.

[2]All of the beef consumed was imported from Region IV.

[3]Of the 280,564,000 lbs. of broiler consumed, the amount of 143,111,000 lbs. was imported from Region IV.

[4]All of the turkey consumed was imported from Region IV.

Theoretically, feeder cattle costs for Region IV, a feeder cattle deficit region, would be local price plus transportation costs. Analysis indicates that feeder cattle costs are greater for midwest feeders than they are for western feeders. A small additional cost amounting to .6 cent per pound of finished beef would result in Region I producing beef to the level where locally produced barley would be utilized completely.

If more wheat had been available for feeding livestock in Region I, more broilers would have been produced, according to the model. If wheat produced in the region had remained available for feeding, turkey production would have occurred in the region. If a smaller quantity of wheat had been available, broiler production would have decreased first, then egg production, and then pork production. All of the above analysis is based on relative costs and prices that existed for feed grains and livestock products in 1968.

REGION II

Region II is composed of the states of Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada. This region is large in area and varied in climate. The population of the major consumption centers of the region is widely spread. Denver is considered as the production-consumption center of the region. This means that Denver is the base point for transportation costs for Region II.

Table 6 shows the Region II feed grain production and feeding activities. Region II is a surplus feed producing region. Over 400,000 tons of barley raised in this region were not fed. None of the 710,640 tons of corn produced was fed, and none of the 297,109 tons of oats was fed.

Barley prices would have had to decrease $1.85 per ton in order for Region II to produce pork using barley. All of the wheat available for feeding was fed to hogs in Region II. If more wheat had been allocated for feeding livestock in the region at the relative prices that existed in 1968, Region II would have produced more of the pork consumed in the region.

The price of corn would have had to be reduced $2.39 per ton in order for corn to be utilized in the production of pork in Region II. The transportation cost of pork would have to increase only one-third cent per pound before pork would be produced in Region II using corn.

TABLE 6. FEED GRAIN PRODUCTION AND FEEDING IN REGION II UNDER MODEL SOLUTION, 1968 PRICES
(All quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	2,508,168	2,084,918	1,860,726	----	---	---	---	224,192
WHEAT	743,889	743,889	---	743,889	---	---	---	---
CORN	710,640	---	---	---	---	---	---	---
OATS	297,109	---	---	---	---	---	---	---
MILO	1,236,704	1,236,704	---	---	369,407	73,754	793,543	---
HAY	2,495,000	2,495,000	118,566	---	---	---	---	2,376,434
PROTEIN	---	321,612	---	87,350	98,795	28,008	107,459	---

TABLE 7. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION II UNDER MODEL SOLUTION, 1968 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	478,902	---	478,902
PORK	486,182	217,465[2]	703,647
BROILERS	421,217	---	421,217
TURKEY	77,100	---	77,100
EGGS	409,232[1]	197,675[3]	211,557
MILK	4,561,000	---	4,561,000

[1]Thousand dozen eggs.

[2]Region II produced 486,182,000 lbs. of pork and imported 217,465,000 lbs. of pork from Region IV.

[3]Region II produced 409,232,000 dozen eggs, of which 211,557,000 dozen were consumed in the region and 197,675,000 dozen were exported to Region III.

Table 7 shows the production and utilization of livestock products in Region II. The 217,500,000 pounds of pork imported from Region IV is quite realistic from a standpoint of what has happened traditionally. An analysis of production and transportation costs shows that a 39 cent per ton change in the price of milo or $1.85 per ton change in barley prices within Region II would have resulted in more pork production in the region. Transportation costs between

Omaha and Denver are relatively small because of the nearness of the two transportation basing points. Greater distance to other points in the region would have increased transportation costs a sufficient amount to reduce the quantity of pork imported by Region II, based on 1968 relative prices.

REGION III

Region III is the state of California. This region is the only one-state region in the model. California was selected as a region because of its large population and the market potential resulting from this population.

California traditionally has been a deficit region in production of beef, pork, and broilers. The state has been an exporter of turkeys and eggs and has been about self-sufficient in fluid milk production. Region III is a deficit feed grain region. The transportation basing point is Los Angeles.

Table 8 shows the feed grain production and feeding in Region III. Region III, like Region I, did not produce any beef in the region, even though there was barley produced in the region which was not fed. Region IV produced beef and exported it to Region III for 16.18 cents per pound. Region III could produce beef for 18.76 cents per pound using barley as a feed. In order for Region III to utilize barley in beef production, the barley price would have had to drop to $39.18 per ton, a decrease of $6.24 per ton below the 1968 average price of $45.42 per ton in the region.

No feed grains were imported into Region III for feeding. The oats produced were not fed, according to the model. All other feeds produced were utilized for feeding.

The price of wheat in Region I would have had to decrease about $3.00 per ton before wheat would have been transported to Region III.

TABLE 8. FEED GRAIN PRODUCTION AND FEEDING IN REGION III UNDER MODEL SOLUTION, 1968 PRICES

(All quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	1,687,200	1,184,707	---	---	---	---	---	1,184,707
WHEAT	381,930	381,930	---	381,930	---	---	---	---
CORN	492,100	492,100	---	---	492,100	---	---	---
OATS	72,080	---	---	---	---	---	---	---
MILO	705,600	705,600	---	---	106,375	---	599,225	---
HAY	3,905,000	3,905,000	---	---	---	---	---	3,905,000
PROTEIN	---	733,480	---	44,848	203,927	---	81,145	403,560

TABLE 9. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION III UNDER MODEL SOLUTION, 1968 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	---	1,160,340[2]	1,160,340
PORK	249,617	1,455,195[3]	1,704,812
BROILERS	726,639	293,935[4]	1,020,574
TURKEYS	---	186,803[5]	186,803
EGGS	314,881[1]	197,675[6]	512,556
MILK	11,052,000	---	11,052,000

[1]Thousand dozen eggs.

[2]All of the beef consumed in Region III (1,160,340,000 lbs.) was imported from Region IV.

[3]Of the 1,704,812,000 lbs. of pork consumed, the amount of 1,455,195,000 lbs. was imported from Region IV. The balance of 249,617,000 lbs. was produced in the state.

[4]Of the 1,020,574,000 lbs. of broiler consumed in Region III, there were 293,935,000 lbs. imported from Region IV and 726,639,000 lbs. produced in Region III.

[5]The entire amount of 186,803,000 lbs. of turkey was imported from Region IV.

[6]Region III produced 314,881,000 dozen eggs and imported 197,675,000 dozen eggs from Region II.

This would be about nine cents per bushel. At this price Region III would have imported over 3,000,000 tons of wheat from Region I and would have produced most of the livestock products demanded in the region rather than importing them from Region IV.

According to the model, Region III imported at least a part of all livestock products consumed except milk. About 61 percent of the eggs and 71 percent of the broilers consumed were produced in the region. About 15 percent of the pork consumed was produced in the region and none of the beef and turkeys consumed were locally produced. All the products Region III did not produce, except eggs, were imported from Region IV. The eggs necessary to meet the consumption requirement were imported from Region II.

Turkey production would have occurred in Region III if the cost of producing a pound of turkey could have been reduced by .058 cents. Corn was the feed that would require the least reduction in cost to permit its utilization. Corn prices would have had to decrease only 71 cents per ton to reduce the cost of feeding corn to the level necessary to allow turkey production in Region III. The price of corn in Region III was $48.21 per ton. A corn price of $47.50 per ton would have been a sufficient reduction to permit the production of turkey using corn as the feed, according to the model. An increase of .058 cents per pound (or from 2.1299 cents per pound to 2.1879 cents per pound) in the cost of transporting turkey from Region IV to Region III would have also permitted Region III to produce turkey using corn at the 1968 price.

REGION IV

Region IV is composed of the nine states of North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, Missouri, Oklahoma, and Texas. This is a large area and contains many of the major feed grain and livestock producing regions of the United States. There is considerable variation in climate and production conditions in the region. Omaha was selected as the transportation cost basing point for the region. Most Missouri River market points have similar transportation costs to western markets, so the selection of Omaha as the basing point is not a critical assumption.

Table 10 shows the production and feeding of feed grains in Region IV. This region is a feed surplus region. According to the model, all the barley and wheat produced in the region were fed. The milo was either fed in the region or transported to Region V for feeding. The transporting of milo from Region IV to Region V was the only feed grain transportation that occurred. Beef were fed barley and corn and hay. Hogs were fed wheat, milo, and the amount of protein required to meet the protein requirements of hogs. Broilers, turkeys and laying hens were all fed milo and protein supplement. Milk cows were fed hay and protein supplement.

Region IV has an absolute feed ingredient cost advantage over any other region for producing all products except for milk in

TABLE 10. FEED GRAIN PRODUCTION AND FEEDING IN REGION IV UNDER MODEL SOLUTION, 1968 PRICES

(All quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	4,455,080	4,455,080	4,455,080	---	---	---	---	---
WHEAT	2,725,680	2,725,680	---	2,725,680	---	---	---	---
CORN	57,170,518	7,210,440	7,210,440	---	---	---	---	---
OATS	8,938,960	---	---	---	---	---	---	---
MILO	18,461,324[1]	8,397,409	---	4,647,234	1,713,400	492,699	1,544,076	---
HAY	16,550,000	10,686,538	2,088,300	---	---	---	---	8,598,238
PROTEIN	---	3,031,712	---	1,217,822	458,235	187,101	209,094	959,460

[1]Of the 18,461,324 tons of milo shown as produced in the region, 10,063,915 tons were shipped to Region V.

Region II. Region II has a slight advantage over Region IV in feed ingredient costs of milk production.

TABLE 11. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION IV UNDER MODEL SOLUTION, 1968 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	3,259,612	1,497,981[2]	1,761,631
PORK	4,808,412	1,672,660[3]	3,135,752
BROILERS	1,952,467	437,046[4]	1,515,421
TURKEYS	516,599	238,156[5]	278,443
EGGS	787,540[1]	---	787,540[1]
MILK	16,980,000	---	16,980,000

[1]Thousand dozen eggs.

[2]There were 318,987,000 lbs. of beef exported to Region I, 1,160,340,000 lbs. transported to Region III, and 18,654,220 lbs. shipped to Region V. Region IV utilized 1,761,631,000 lbs. of beef.

[3]Region IV exported 217,465,170 lbs. of pork to Region II, 1,455,194,890 lbs. of pork to Region III, and the remaining amount of 3,135,752,000 lbs. was utilized in Region IV.

[4]Of the 437,046,000 lbs. of broiler exported, Region I received 143,110,940 lbs. and Region III received 293,934,580 lbs.

[5]Region IV transported 238,156,000 lbs. of turkey; 51,353,000 lbs. went to Region I, while Region III received 186,803,000 lbs. of turkey.

Table 11 shows the location, production and utilization of livestock products in Region IV. This region was a major exporting region for beef, pork, broilers, and turkeys. All regions produced their own milk, and most regions produced their own eggs. Regions II and V border Region IV on the west and east respectively; however, these two regions received relatively small quantities of products from Region IV. Regions I and III were the big livestock product deficit regions, according to the model.

Five to ten percent increases in transportation costs could change the advantage Region IV had in supplying west coast markets with most products. Likewise, five to ten percent decreases in transportation costs of beef, pork, broilers, or turkeys would have improved the position of Region IV to supply west coast markets with these products.

REGION V

Region V includes the 26 states east of the Mississippi River plus Arkansas and Louisiana. This region is by far the largest in area and represents a big segment of the United States population. Chicago was selected as the basing point for transportation costs and as the production-consumption center for the region. Region V produced the bulk of the livestock products consumed in the region.

Table 12 shows the production and feeding of feed grains in Region V. It shows the large quantities of feed grains required to supply Region V with the livestock products consumed in the region. Region V is the only beef-producing region where protein was required to balance the beef ration. This is because corn was the major feed grain fed to beef in the region and the digestible protein level of corn fed to beef is only 6.5 percent. Thus, protein supplement was required. The table also indicates a very high level of protein was required for hog production. Nearly 20 percent of the total tonnage of feed fed to hogs in the region was high protein feed.

Region V was short of alfalfa hay for feeding dairy cows. This is due to the fact that neither pasture nor corn silage was included as a feed in the model. This resulted in unusually heavy feeding of feed grains to dairy cows in the region. Because most of the feed grain fed to cows was corn, a high level of protein feeding was also required to balance the protein requirements of dairy cows.

TABLE 12. FEED GRAIN PRODUCTION AND FEEDING IN REGION V UNDER MODEL SOLUTION, 1968 PRICES

(All quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	852,384	852,384	852,384	---	---	---	---	---
WHEAT	1,965,315	1,965,314	---	1,965,315	---	---	---	---
CORN	64,045,856	64,045,856	23,668,629	18,735,773	3,505,423	1,235,884	---	16,900,147
OATS	5,454,464	---	---	---	---	---	---	---
MILO	274,568	10,338,483[1]	---	---	2,891,192	---	7,447,291	---
HAY	20,332,000	20,332,000	493,350	---	---	---	---	19,838,650
PROTEIN	---	16,118,425	354,833	4,488,906	2,023,222	589,261	1,008,487	7,653,716

[1]Of the 10,338,483 tons of milo fed in Region V, the amount of 10,063,915 tons was imported from Region IV.

Livestock in Region V were fed nearly 79 percent of the high protein feed utilized in all regions.

TABLE 13. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION V UNDER MODEL SOLUTION, 1968 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	6,469,429	18,654[2]	6,488,083
PORK	14,137,897	---	14,137,897
BROILERS	7,633,304	---	7,633,304
TURKEYS	1,397,170	---	1,397,170
EGGS	3,648,870[1]	---	3,648,870[1]
MILK	95,480,000	---	95,480,000

[1]Thousand dozen eggs.

[2]Of the 6,488,083,000 lbs. of beef consumed, Region V imported 18,654,000 lbs. from Region IV.

Table 13 shows the production and utilization of livestock products in Region V. This region produced most of the livestock products consumed locally. The region imported only 18,654,000 pounds of beef from Region IV. All of the feed produced in the region was fed except oats. There were no oats fed in any region, indicating that the demand for oats may come from livestock not included in the model; or alternatively, oats may be overpriced, based on comparative feeding value, for livestock included in the model.

ANALYSIS OF REGIONS USING 1969 PRICES

This section of the analysis is based on the same model as the preceding section. The only change is that 1969 relative prices for feed grains and livestock products replace the 1968 prices. Pages 134 and 146 of the Appendix contain the 1968 and 1969 relative prices of the feed grains by region. Pages 135 and 148 contain the relative livestock product prices for 1968 and 1969.

REGION I USING 1969 PRICES

Table 14 shows feed grain production and feeding in Region I using 1969 prices. Based on 1969 relative prices, Region I fed all of the feed produced in the region except oats. Oats would have been fed to laying hens for egg production had it been used in the model. In order for oat feeding to occur, the price of oats would have had to drop from $42.50 per ton to $39.52 per ton. The $3.00 decrease in the price of oats was necessary to reduce the cost of producing eggs from 13.777 cents per dozen to 13.051 cents per dozen, a decrease of .726 cents per dozen.

Analyzing the model with 1968 and 1969 prices allows some interesting comparisons. The 1968 price of barley was $49.85 per ton. At this price, other relationships _ceteris paribus_, only part of the barley produced was fed. The 1969 price of barley was $38.34 per ton and all of the barley produced in the region was fed. This is as would be expected with a $2.51 per ton decrease in price.

TABLE 14. FEED GRAIN PRODUCTION AND FEEDING IN REGION I UNDER MODEL SOLUTION, 1969 PRICES

(All quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	493,152	493,152	173,188	---	---	---	215,502	104,462
WHEAT	1,043,528	1,043,528	---	713,088	232,225	---	98,215	---
CORN	68,852	68,852	---	---	23,563	45,289	---	---
OATS	109,312	---	---	---	---	---	---	---
MILO	---	---	---	---	---	---	---	---
HAY	1,495,000	1,495,000	---	---	---	---	---	1,495,000
PROTEIN	---	331,891	---	83,734	73,210	21,593	39,764	113,590

This is a change of about six cents per bushel, or a decrease from 98 cents per bushel to 92 cents per bushel.

TABLE 15. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION I UNDER MODEL SOLUTION, 1969 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	42,229	276,758[2]	318,987
PORK	466,140	---	466,140
BROILERS	280,564	---	280,564
TURKEYS	51,353	---	51,353
EGGS	140,908[1]	---	140,908[1]
MILK	3,039,000	---	3,039,000

[1]Thousand dozen eggs.

[2]Of the 318,987,000 lbs. of beef consumed, an amount of 276,758,000 lbs. was imported from Region IV.

Table 15 shows the production and utilization of livestock products in Region I using 1969 prices. This region produced all of the livestock products consumed locally except part of the beef, which was imported from Region IV. Beef was produced in Region I for a feed ingredient cost of 15.720 cents per pound, while it cost Region IV 16.896 cents per pound to produce the beef and transport it to Region I. In 1968 Region I produced no beef, no turkey, and only part of the broilers consumed in that region. Using the relative prices that existed in 1969, beef was produced in the region until the supply of barley was exhausted. Turkeys were also produced in the region and broiler production increased until the quantity demanded was satisfied. An analysis of costs of production will be made later in this chapter.

REGION II USING 1969 PRICES

Table 16 shows feed grain production and feeding in Region II using 1969 prices. A comparison of Tables 6 and 16 shows more barley was fed in Region II to beef at 1969 prices and less milo was fed to laying hens in 1969. Hogs, broilers, turkeys, and milk cows were fed the same feeds in the same quantities both years.

The price of corn in Region II was $44.25 per ton in 1969 compared with $41.94 in 1968. No corn was fed in the region, according to the model, in either 1968 or 1969 because it was not competitively priced with barley, wheat and milo based on comparative feeding value. The 1969 price of corn would have had to be reduced nearly $3.00 per ton to make its feeding feasible to hogs in Region II. The cost of producing a pound of pork by feeding corn was 10.190 cents at 1969 corn prices. Region IV could produce pork and ship it to Region II for 9.756 cents per pound, or .434 cents per pound less than it could be produced in Region II by feeding corn at the 1969 price.

Increased production of pork would occur using milo as a feed if the price decreased $1.60 per ton for milo fed to pork. This is 4.500 cents per bushel of milo. Milo prices would have had to be reduced from $43.06 per ton to $41.46 per ton before milo feeding would have been feasible.

Transportation cost increases of about .25 cents (one-fourth cent) per pound of pork produced would permit Region II to feed

TABLE 16. FEED GRAIN PRODUCTION AND FEEDING IN REGION II UNDER MODEL SOLUTION, 1969 PRICES

(Quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	2,508,168	2,508,168	2,283,976	---	---	---	---	224,192
WHEAT	743,889	743,889	---	743,889	---	---	---	---
CORN	710,640	---	---	---	---	---	---	---
OATS	297,109	---	---	---	---	---	---	---
MILO	1,236,704	853,392[1]	---	---	369,407	73,754	410,231	---
HAY	2,495,000	2,495,000	118,566	---	---	---	---	2,376,434
PROTEIN	---	269,706	---	87,351	98,795	28,008	55,552	---

[1]Region II exported 383,312 tons of milo to Region III.

milo to hogs rather than import pork from Region IV. Present transportation costs for moving pork from Region IV to Region II are 90.97 cents per cwt., or .9097 cents per pound. An increase of .25 cents would be an increase of 21.55 percent in transportation costs. This is a relatively large percentage increase even though an increase of only one-fourth cent per pound appears small.

Table 17 shows the production and utilization of livestock products in Region II. A comparison of the production and utilization of these produces in this region using 1968 and 1969 prices shows that beef production at 1969 prices increased over 1968 levels. All of the increase was transported from Region II to Region III. Thus Region II became a beef exporting region with the relative prices that existed in 1969.

The same quantity of pork was imported by Region II from Region IV in both years.

The production of eggs in Region II was less with 1969 prices than it was with 1968 prices. The decrease in egg production occurred because Region II ceased to export eggs to Region I under 1969 prices. Region II produced all of the eggs consumed in the region in both years. Region II exported milo to Region III in 1969. This milo was fed to laying hens in Region III and that region produced all of the eggs consumed under 1969 relative prices, while Region III imported eggs from Region II under 1968 relative prices.

TABLE 17. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION II UNDER MODEL SOLUTION, 1969 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	583,218	104,316[2]	478,902
PORK	486,182	217,465[3]	703,647
BROILERS	421,217	---	421,217
TURKEYS	77,100	---	77,100
EGGS	211,557[1]	---	211,557[1]
MILK	4,561,000	---	4,561,000

[1]Thousand dozen eggs.

[2]Of the 583,218,000 lbs. of beef produced, Region II exported 104,316,000 lbs. to Region III.

[3]Of the 703,647,000 lbs. of pork consumed in Region II, an amount of 217,465,000 lbs. was imported from Region IV.

REGION III USING 1969 PRICES

Table 18 shows the production and feeding of feed grains in Region III using 1969 prices. A comparison of the 1968 and 1969 feed allocation shows that barley use and feeding was the same for both years even though the 1968 barley price was $45.42 per ton and the 1969 price was $51.25 per ton, an increase of $5.83 per ton.

Wheat feeding was the same in both years even though the price of wheat increased from $44.00 per ton in 1968 to $48.33 per ton in 1969.

Corn utilization remained the same both years even though the price of corn increased from $48.21 per ton in 1968 to $51.43 in 1969, an increase of $3.22 per ton.

Milo was fed to broilers and laying hens both years. The 1969 feeding level was expanded to both broilers and laying hens in Region III because of the milo imports from Regions II and IV. In the 1968 model the only feed grain movement that occurred was the shipping of milo from Region IV to Region V. At the relative prices that existed in 1969, milo was shipped from Region II to Region III and also from Region IV to Region III. Region IV also exported milo to Region V in 1969, but in a larger quantity than in 1968; thus Region IV fed less milo in 1968 than it did in 1969.

Table 19 shows the production and utilization of livestock products in Region III with 1969 prices.

TABLE 18. FEED GRAIN PRODUCTION AND FEEDING IN REGION III UNDER MODEL SOLUTION, 1969 PRICES

(Quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	1,687,200	1,184,707	---	---	---	---	---	1,184,707
WHEAT	381,930	381,930	---	381,930	---	---	---	---
CORN	492,100	492,100	---	---	492,100	---	---	---
OATS	72,080	---	---	---	---	---	---	---
MILO	705,600	1,340,297[1]	---	---	364,893	---	975,404	---
HAY	3,905,000	3,905,000	---	---	---	---	---	3,905,000
PROTEIN	---	853,559	---	44,848	273,065	---	132,086	403,560

[1]Of the 1,340,297 tons of milo fed in Region III, there were 251,385 tons imported from Region IV and 383,312 tons imported from Region II. The balance of 705,600 tons was produced in the region.

TABLE 19. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION III UNDER MODEL SOLUTION, 1969 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	---	1,160,340[2]	1,160,340
PORK	249,617	1,455,195[3]	1,705,812
BROILERS	1,020,574	---	1,020,574
TURKEYS	---	186,803[4]	186,803
EGGS	512,566[1]	---	512,556[1]
MILK	11,052,000	---	11,052,000

[1]Thousand dozen eggs.

[2]Of the 1,160,340,000 lbs. of beef consumed, Region III imported 104,316,000 lbs. from Region II and 1,056,024,000 lbs. from Region IV.

[3]Region III imported 1,455,195,000 lbs. of pork from Region IV.

[4]All of the turkey consumed was imported from Region IV.

A comparison of Tables 9 and 19 shows that Region III imported all of the beef consumed at both 1968 and 1969 relative prices. In 1968 all beef imported was from Region IV. Utilizing 1969 prices, part of the beef imported came from Region II and part from Region IV. All of the pork imported in both years was imported from Region IV.

All of the broilers consumed using 1969 prices were produced in the region. In the model using 1968 prices 293,935,000 pounds of broilers were imported from Region IV.

All of the turkeys consumed in Region III both years were imported from Region IV. This indicates that California was not competitive in turkey production with the relative prices that existed in 1968 and 1969 for feed grains and turkeys.

All of the eggs consumed in Region III were produced in the region in 1969. According to the model, based on 1968 relative prices, Region III imported about 39 percent of the eggs consumed.

All of the milk consumed in Region III was produced in the region both years.

REGION IV USING 1969 PRICES

Table 20 shows the feed grain production and feeding in Region IV in 1969. A comparison of Tables 10 and 20 shows that all of the barley produced in Region IV both years was fed to beef cattle even though the 1968 price for barley was $34.10 per ton and the 1969 price was $32.39 per ton, a difference of $1.71 per ton.

All of the wheat produced in Region IV was fed to hogs. The 1968 wheat price was $42.37 per ton, while the 1969 wheat price was $41.12 per ton, or $1.25 per ton less.

In 1968 Region IV fed 7,210,440 tons of corn priced at $37.30 per ton. All of this corn was fed to beef cattle. In 1969, Region IV fed 30,805,653 tons of corn to beef cattle. The price of corn was $38.91 per ton, or $1.61 per ton more than in 1968. Corn was higher priced in 1969, but more corn was fed to beef than in 1968. On the surface this appears to be contradictory to reasonable expectations. The Region IV beef price in 1968 was $25.68 per cwt., while the 1969 price was $28.49 per cwt. These prices, compared with the other relative prices in the model for the two years, remove any question of unreasonable behavior in the quantity of corn fed. A quantity of 26,000,000 tons of corn was not utilized in 1969, according to the model.

In 1969 Region IV fed oats to beef cattle and hogs. In 1968 no oats were fed in any region. Region IV was the only region that fed oats in 1969. The 1968 price of oats in Region IV was $36.34

TABLE 20. FEED GRAIN PRODUCTION AND FEEDING IN REGION IV UNDER MODEL SOLUTION, 1969 PRICES

(Quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	QUANTITY FED TO					
			BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	4,455,080	4,455,080	4,455,080	---	---	---	---	---
WHEAT	2,725,680	2,725,680	---	2,725,680	---	---	---	---
CORN	57,170,518	30,805,653	30,805,653	---	---	---	---	---
OATS	8,938,960	7,201,552	1,397,397	5,804,155	---	---	---	---
MILO	18,461,324[1]	3,317,666	---	---	1,329,868	443,722	1,544,076	---
HAY	16,550,000	10,686,538	2,088,300	---	---	---	---	8,598,238
PROTEIN	---	2,694,327	---	1,001,609	355,662	168,502	209,094	959,460

[1]Of the 18,461,324 tons of milo produced 3,317,666 tons were fed in Region IV, while 251,385 tons were exported to Region III and 14,892,274 tons were exported to Region V.

per ton while the 1969 price was $34.23 per ton, or $2.11 per ton less. The price of oats in Region IV was the lowest in any region for both 1968 and 1969. (See pages 134 and 146 of Appendix.)

All of the milo produced in Region IV was utilized both years. The 1968 and 1969 utilization varied considerably. In 1968 nearly 8,400,000 tons of milo were fed in Region IV, while in 1969 only 3,300,000 tons were fed in the region. In 1968, Region IV fed over 4,600,000 tons of milo to hogs. At 1969 prices milo was replaced by 5,800,000 tons of oats because the relative prices of oats, milo and protein supplement made this feasible. At 1969 prices all of the milo fed in Region IV was fed to broilers, turkeys and laying hens.

All hay produced in Region IV was fed in the same proportion to beef and milk cows at both 1968 and 1969 prices.

Less protein was required to balance the protein needs of the ration in 1969. The hog production ration was the major contributor to the protein decrease because oats are much higher in protein per ton of feed than is milo.

Table 21 shows the production and utilization of livestock products in Region IV using 1969 prices. A comparison of Tables 11 and 21 indicates that Region IV produced nearly three times as much beef at 1969 relative prices as was produced at 1968 relative prices. Most of the increased production resulted when Region IV produced all of the beef consumed in Region V at 1969 prices. The

TABLE 21. PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION IV UNDER MODEL SOLUTION, 1969 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	9,582,495	7,820,865[2]	1,761,631
PORK	4,808,412	1,672,660[3]	3,135,752
BROILERS	1,515,421	---	1,515,421
TURKEYS	465,246	186,603[4]	278,443
EGGS	787,540[1]	---	787,540[1]
MILK	16,980,000	---	16,980,000

[1]Thousand dozen eggs.

[2]Of the 7,820,864,000 lbs. of beef exported from Region IV, Region I received 276,758,000 lbs., 1,056,023,000 lbs. went to Region III and Region V received 6,488,083,000 lbs.

[3]Region IV exported 1,672,660,000 lbs. of pork, of which Region II received 217,465,000 lbs. and Region III received 1,455,195,000 lbs.

[4]Region IV exported 186,603,000 lbs. of turkeys to Region III.

quantity of beef transported from Region IV to Region I was less at 1969 prices than at the 1968 prices. Region IV exported less beef to Region III at 1969 prices than was transported to meet the quantity demanded by consumers in Region III in 1968.

Region IV produced and transported the same amount of pork to Region I and Region III at 1968 relative prices as was shipped to those regions at the 1969 relative prices.

At 1969 relative prices Region IV exported no broilers, while in 1968 both Region I and Region III were importers from Region IV.

The quantity of turkeys exported at 1969 relative prices was reduced to about 51,400,000 pounds below the 1968 export level. Region IV exported to Regions I and III in 1968, but only to Region III at 1969 prices.

All of the milk produced at 1968 and 1969 prices was consumed in the region.

REGION V USING 1969 PRICES

Region V analysis based on 1969 prices is shown in Tables 22 and 23. A comparison of Tables 12 and 22 indicates several large changes in feeding as a result of the difference in the relative prices of 1968 and 1969.

Region V fed all of the barley produced in the region in 1968 to beef cattle. At 1969 prices all of the barley was fed to milk cows. Beef production in Region V was eliminated from the model at 1969 prices. In 1968 Region V produced all but 18,700,000 pounds of the beef consumed in the region. At 1969 prices Region V imported 6,488,100,000 pounds of beef from Region IV and no feed grains were fed to beef.

All of the wheat produced in Region V was fed to hogs both years.

In 1968 all of the corn produced in Region V was fed in the region. At 1969 relative prices only 54 percent of the corn produced was fed in the region. Corn feeding was reduced by feeding no corn to broilers, and less corn was fed to turkeys and milk cows at 1969 prices.

Milo feeding was increased at the 1969 price by importing a larger quantity of milo from Region IV. Milo fed to broilers and turkeys was increased at 1969 prices and the same quantity of milo was fed to laying hens both years.

TABLE 22. FEED GRAIN PRODUCTION AND FEEDING IN REGION V UNDER MODEL SOLUTION, 1969 PRICES

(Quantities expressed in tons)

FEED GRAIN	QUANTITY PRODUCED	QUANTITY FED	BEEF	HOGS	BROILERS	TURKEYS	LAYERS	MILK COWS
BARLEY	852,384	852,384	---	---	---	---	---	852,384
WHEAT	1,965,315	1,965,315	---	1,965,315	---	---	---	---
CORN	64,045,856	34,872,794	---	18,735,773	---	280,332	---	15,856,689
OATS	5,454,464	---	---	---	---	---	---	---
MILO	274,568	15,166,842[1]	---	---	6,685,894	1,033,657	7,447,291	---
HAY	20,332,000	20,332,000	---	---	---	---	---	20,332,000
PROTEIN	---	15,378,450	---	4,488,906	1,788,088	526,188	1,008,487	7,566,781

[1]Region V fed 15,166,842 tons of milo at 1969 relative prices. Of this amount, Region V imported 14,892,274 tons from Region IV.

TABLE 23 PRODUCTION, TRANSPORTATION AND CONSUMPTION OF LIVESTOCK PRODUCTS IN REGION V UNDER MODEL SOLUTION, 1969 PRICES

PRODUCT	QUANTITY PRODUCED (Thousand Lbs.)	QUANTITY TRANSPORTED (Thousand Lbs.)	QUANTITY CONSUMED (Thousand Lbs.)
BEEF	---	6,488,083[2]	6,488,083
PORK	14,137,897	---	14,137,897
BROILERS	7,633,304	---	7,633,304
TURKEYS	1,397,170	---	1,397,170
EGGS	3,648,870[1]	---	3,648,870[1]
MILK	95,480,000	---	95,480,000

[1]Thousand dozen eggs.

[2]All of the 6,488,083,000 lbs. of beef consumed in Region V was imported from Region IV.

Region V imported only 18,700,000 pounds of beef from Region IV in 1968, while at the 1969 relative prices all of the 6,488,100,000 pounds of beef consumed in Region V was imported from Region IV.

Region V produced all of the pork, broilers, turkeys, eggs, and milk consumed in the region at the relative prices that existed in 1968 and 1969.

COST OF PRODUCTION COMPARISONS

This section of the analysis compares the relative feed ingredient and/or transportation costs for supplying the quantities of each livestock product necessary to satisfy the consumption requirements of the model by region at the 1968 and 1969 relative prices.

When a region imports a livestock product from another region, under the model, the importing region's cost of producing a unit of the product is the feed ingredient cost of the producing region plus the cost of transporting a unit of product from the region of origin to the region of destination.

Table 24 shows the cost of producing each livestock product under the model for each region at the 1968 and 1969 relative prices. Model cost is comprised of ingredient costs for product exporting regions and feed ingredient plus transportation costs for product deficit regions.

The cost of milk production in Region I was less at 1969 relative prices than at 1968 prices. All other products cost more to produce at 1969 prices than at 1968 prices.

The cost of the last unit of beef required to supply the quantity demanded varied from a low of 14.632 cents per pound in Region IV to a high of 16.203 cents per pound in Region I at 1968 prices. This is a difference of 1.571 cents per pound, which is the cost of transporting beef from Region IV to Region I. In the

TABLE 24. UNIT COST OF LIVESTOCK PRODUCTS BY REGION UNDER MODEL SOLUTION, 1968 AND 1969 PRICES[1]

(Cost in cents per pound)

REGION	BEEF		HOGS		BROILERS		TURKEYS		EGGS[2]		MILK	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
I	16.203	16.896	9.312	9.450	7.471	7.524	9.265	9.471	12.882	13.051	2.318	2.315
II	15.000	15.661	9.404	9.756	6.161	6.491	7.941	8.301	10.711	11.444	1.520	1.587
III	16.184	16.878	10.177	10.529	7.448	7.639	9.240	9.491	13.101	13.685	2.298	2.433
IV	14.632	15.325	8.494	8.846	5.531	5.768	7.110	7.361	9.703	10.246	1.607	1.626
V	15.430	16.124	9.159	9.577	6.212	6.419	7.938	8.151	11.570	12.101	2.176	2.256

[1]Unit cost means feed ingredient costs for regions that export or are self-sufficient in producing a livestock product, or feed ingredient plus transportation costs for regions deficit or importing livestock products.

[2]Cost in cents per dozen eggs.

section of this chapter dealing with cost of producing livestock products for Region I at 1968 prices it was determined that beef production would cost .55 cents per pound more than it cost to import beef from Region IV, using barley as the feed. When a comparison of various sized feed lots was made, it was determined through research completed by Taylor (26) that non-feed costs in selected areas of the United States were similar for operations having about the same number of cattle. The only cost not considered in the case of beef is the cost of feeder cattle. Most western states export sizable numbers of feeder cattle to the midwest for feeding. The price of these cattle, theoretically, is local price plus cost of transportation to the midwest. Again it is necessary to utilize average prices. Based on the above and published prices of feeder cattle, the transportation cost equals the difference in price between Regions I and IV. The cost of transporting feeder cattle (see page 148 in Appendix) is 3.52 cents per pound. If the average weight of feeder cattle is 400 pounds, the transportation cost is $14.08 per head. If the average weight of feeder cattle transported is 500 pounds, the cost is $17.60 per head. The average weight of cattle slaughtered in Region IV is 1040 pounds. The 400 pound feeder then increases the cost of beef in Region IV by 1.35 cents per pound, while the 500 pound feeder increases the cost of production by 1.69 cents per pound. This indicates that at 1968 relative prices Region I could have offset the feed cost advantage of Region IV and could have had an advantage of .80 cents per pound of beef produced when feeding barley, or an advantage of 1.07 cents per pound when feeding wheat to beef, if 400 pound feeder cattle were transported. If 500 pound feeder cattle were transported, the barley feeding advantage increased to 1.14 cents per pound, while beef produced utilizing wheat as the feed at 1968 relative prices would have given Region I producers an advantage of 1.41 cents per pound. This advantage would not remain valid after all locally produced feeds were fed. Thus, until locally produced feeds are utilized it would appear that at the relative prices that existed in 1968 producers in Washington and Oregon had a small advantage over Region IV producers in supplying beef for Region I consumption. Oats could not be economically utilized at 1968 relative prices for feeding beef.

At 1969 relative prices, beef was produced in Region I until all of the wheat and barley were utilized. Beef was produced in the region for 15.72 cents per pound, 1.176 cents per pound less than beef could be imported from Region IV at 1969 relative prices. Thus, differences in feeder cattle costs need not be considered to make Region I producers competitive in the production of beef at 1969 prices.

Hog costs varied from a low of 8.494 cents per pound in Region IV to a cost of 9.312 cents per pound for Region I in 1968. Region I produced all of the pork consumed; thus, at the feed ingredient costs that existed at 1968 relative prices, Region I should have produced all of the pork consumed locally, as it did under the model. The transportation cost for pork from Region IV to Region I was 1.7026 cents per pound, giving Region I producers an advantage of .8846 cents per pound over Region IV for supplying pork for Region I consumption. Again this would apply only until locally produced feed supplies were exhausted. If it is assumed that non-feed costs are the same in both regions, the feed cost advantage of Region IV is offset by the transportation cost involved in moving the pork from Region IV to Region I. A similar situation existed at 1969 relative prices except that Region I producers had an advantage of 1.0996 cents per pound over Region IV in supplying pork to Region I.

Broiler costs varied from a low of 5.531 cents per pound in Region IV to a high of 7.471 cents per pound in Region I. In 1968 Region I produced broilers by feeding all the corn produced in that region and the wheat produced in the region not fed to hogs and laying hens. This level of feeding permitted Region I to produce about half of the broilers consumed in the region in 1968. The other broilers were imported from Region IV. The cost of producing broilers in Region I feeding corn was 7.42 cents per pound. The cost of producing broilers feeding wheat was 7.17 cents per pound. Until all of the wheat and corn produced in the region were fed, producers had a slight advantage over broilers produced in Region IV and imported from that region.

Costs of producing turkey ranged from a low of 7.110 cents per pound in Region IV to a high of 9.265 cents per pound in Region I. All of the turkey consumed in Region I was imported from Region IV. The cost of transporting turkey from Region IV to Region I was 2.155 cents per pound. Turkey production would have occurred in Region I if more wheat had been available for feeding in the region. Turkey could have been produced feeding wheat at 1968 relative prices for a cost of 9.160 cents per pound. This cost is .105 cents per pound less than the cost of importing turkey from Region IV. The quantity of wheat allocated for feeding livestock in 1968 did not permit the feeding of wheat to turkeys.

Egg production costs ranged from a low of 9.703 cents per dozen in Region IV to a high of 13.101 cents per dozen in Region III. Region I had an egg feed ingredient cost of 12.882 cents per dozen, and wheat was fed to laying hens to produce eggs. Region I had an advantage of 3.011 cents per dozen over Region IV in supplying the eggs consumed in Region I. Region II had an egg production cost of 10.711 cents per dozen and could have transported eggs to Region I at a feed ingredient plus transportation cost of 13.101 cents per dozen. This allowed Region I a cost advantage of .219 cents per dozen in supplying the eggs consumed in 1968.

All of the milk consumed in all regions was produced in the region of consumption. The cost of transporting whole milk made interregional transfers prohibitive. This should not be interpreted as prohibiting movements of milk products such as cheese and dried milk. Milk production feed ingredient costs ranged from a low in Region II of 1.520 cents per pound of milk produced to a high of 2.318 cents in Region I, a range of .798 cents per pound of milk produced. The lowest transportation cost per pound of milk was 1.00 cents per pound between Region IV and Region V. Therefore no milk was transported.

ECONOMIC IMPLICATIONS OF THE MODEL

The economic implications that follow are based on a set of coefficients developed using Mcal of ME (mega calories of metabolizable energy) required per unit of product produced and Mcal of ME supplied per unit of the different feeds fed. The model shows that in general feed deficit regions have an economic advantage in producing livestock products until locally produced supplies of feed grains are utilized. After the available supply of feed grains has been utilized, the model generally indicates transportation of livestock products rather than feed grains at the relative prices that existed in 1968 and 1969.

It is implied by the above analysis that, based on the relative prices that existed in 1968 and 1969, any feed deficit region which could economically expand feed grain production through increased yields, increased acreage or a combination of both could logically expect to be able to increase production of livestock products until quantities of each product produced and consumed were in balance. According to the model, each region had one feed that had the greatest negative reduced cost value when fed to a particular class of livestock. This would be the feed that would indicate the largest potential for expansion in the region. In Region I this feed was wheat. At 1968 relative prices wheat was the only grain that was priced so that more of the wheat produced in the region could have been utilized as a livestock feed. At 1969 relative prices wheat, barley and corn could have been utilized in larger quantities for livestock feeding.

Production of the different livestock products in the model, based on feed ingredient costs for Region I, shows egg production had the greatest percent return above feed costs, followed by broilers, milk, turkey, pork, and beef in that order. This analysis does not consider the non-feed costs as an integral part of the model. Non-feed costs have been described for beef production in some detail. It would appear unless non-feed costs for pork, broiler, and egg production are significantly different between regions that these products could be produced competitively, but with narrow margins, in Region I. It is assumed that the non-feed costs of producing pork, broilers and eggs are the same for all regions. A study of published data indicates that variation in non-feed costs for operations of the same size are generally insignificant and that this assumption is not too unrealistic. If the above comparison involved different sizes of operations between regions, the validity of the assumption could be questioned. If different sizes of operations are considered between regions, they should also be considered within regions. It is generally found that as size of operation increases non-feed costs per pound of product decrease. Relatively small units have a materially higher non-feed cost per pound of product produced than do operations where labor and other efficiencies are possible because of more efficient utilization of resources.

Norton and Castle (23), in their analysis of pork production in Oregon, came to the conclusion that Oregon producers could compete, but that production would not be highly profitable.

Taylor (26), in his analysis of the economic feasibility of expanding livestock feeding in Utah, showed that Utah, Colorado, Texas, Oklahoma, and California had nearly identical non-feed costs in beef production when feedlots of the same size were compared.

Non-feed costs in turkey production vary somewhat over the United States. A slightly higher non-feed cost per pound of gain exists for the western regions when compared to midwest regions. Part of this might be due to climate and higher labor costs. According to Bawden, Carter and Dean (4), total cost differences between regions are significant in turkey production, resulting in the advantage that Region IV producers enjoy. Because of this advantage had in Region IV, turkey production in Region I will be a narrow margin industry based on 1968 and 1969 relative prices. New entry into turkey production would be a high risk type activity. Integrated operations with established producers following sound programs and with experienced management probably will survive.

The non-feed costs of producing milk are high in relation to feed costs. Non-feed costs range from about 40 percent to about 60 percent of total costs of milk production. Size of operation is critical in determining the level of non-feed costs. Management is the key to reduced costs in milk production.[4] Small dairy operations can be efficiently operated, but it is usually difficult to obtain low per-unit costs with small operations of less than 50 cows. Comparison of size of operation becomes an important factor in comparing non-feed costs between regions. The difference in total costs of producing a pound of milk should be in about the same proportion as the difference in feed ingredient costs. It would appear that milk producers in Region I should be able to compete with other regions in supplying the milk required for consumption. However, Region I would not be able to transport milk and compete for markets in Region II or Region III.

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[4]Results from an analysis (as yet unpublished) of dairy operations in Utah conducted in the winter of 1970 by Utah State University Extension Service.

NUTRITIVE SPECIFICATION OF A NEW FEED GRAIN

The analysis of the relative feeding values and relative prices of the feeds in the model has given an indication of the importance of the energy and protein content of feeds. The analysis has also shown the wide variation in energy and protein requirements of the classes of livestock considered in the model. The variations in requirements among classes of livestock make the specification of the nutritive levels of a new feed grain very difficult. If the class of livestock to which the new grain was to be fed were specified, the energy and protein levels desired would be easy to determine. For example, beef require a feed with a protein level of only 7.1 percent digestible protein. If the new grain were to be developed for feeding beef, a 7.5 percent digestible protein level would be sufficient, but if this feed were to be fed to turkeys a protein level of 15 to 20 percent would be desirable. A higher price could be received for the feed if it had a 15 percent digestible protein level as a turkey feed, but the excess protein available when the same feed was fed to beef would be worthless. Thus, to specify nutritive levels and relative prices when fed to each class of livestock results in too many variables for a unique solution.

An alternative approach is to compare the new grain with grains presently produced. If the class of livestock to which the new grain is to be fed is specified, a set of desired nutritive values and a price can be determined, but if the class of livestock is not specified there are too many variables to arrive at a single set of nutritive values that would be most desirable at a given price.

This brings one to the point of talking in generalities about a proposed new feed grain. If the grain were developed for feeding any class of livestock, the critical part of the analysis would be the potential market for the grain. Table 25 shows the metabolizable energy and digestible protein requirements of the different classes

TABLE 25. TOTAL MEGA CALORIES OF METABOLIZABLE ENERGY AND PERCENT DIGESTIBLE PROTEIN REQUIRED TO PRODUCE EACH PRODUCT CONSUMED IN REGION I IN 1968

PRODUCT	QUANTITY CONSUMED (Thousand Lbs.)	Mcal ME REQUIRED (Thousands)	PERCENT DIG. PROTEIN REQUIRED
BEEF	318,987	3,169,773.8	7.1
PORK	466,140	2,437,446.1	13.0
BROILERS	280,564	884,337.7	18.0
TURKEYS	51,353	282,108.9	20.1
EGGS	140,908[1]	879,688.6	15.0
MILK	3,039,000	3,054,195.0	14.0

[1]Thousand dozen eggs.

of livestock on the basis of the amount that each class required to produce the quantity of product demanded for consumption in Region I in 1968.

The class of livestock requiring the largest quantity of energy is beef. Dairy cows require large quantities of energy but are capable of obtaining much of the required amount from roughage type feeds. Hogs also require large quantities of energy to supply the product required.

A new feed grain would probably obtain the largest potential market if it were developed to satisfy the nutritive requirements of beef and hogs. A protein level of nine percent would be more than required by beef and less than required by hogs, and would be about the same as the wheat presently produced in Region I, if fed to hogs (21, p. 86).

If the new feed grain were to have a metabolizable energy level equal to or exceeding that of wheat when fed to beef and hogs, and a digestible protein level of about nine percent, it would be as desirable for feeding as wheat. The other considerations critical to the development of a new grain relate to the costs of seed and the relative yield per acre compared to wheat. If the proposed feed would yield as much or more per acre and the relative costs of production were the same or less than those of wheat, the new grain could be produced and marketed at a price equal to or less than the price of wheat.

If higher levels of protein could be obtained without adversely affecting yield, costs of production, or energy levels, the market for the new grain could be expanded to other classes of livestock or poultry advantageously.

ANALYSIS OF DEMAND FOR WHEAT IN REGION I USING 1968 PRICES

The analysis of the parametric procedure based on the model using 1968 prices and metabolizable energy values gives perspective to the entire model. The price of wheat in Region I was ranged from a low of $40.00 per ton to a high of $60.00 per ton.[5] All other feed grains were left in the model at their 1968 average regional prices.

Table 26 shows a summary of the quantities of wheat specified by the model for livestock feeding at a range of prices in Region I for the year 1968. The price of wheat in this region was set at $40.00 per ton for the initial basis of the model. At this price the model specified 5,231,374 tons of wheat for production of livestock products in the region. Beef were fed 1,220,082 tons of wheat, hogs received 3,321,059 tons, broilers 259,036 tons, turkeys 51,293 tons, laying hens 281,876 tons, and milk cows received 98,027 tons, under the model. Hay was the only other feed fed and all of the 1,495,000 tons allocated to feeding was fed to dairy cows.

Region I produced all of the beef, pork, broilers, turkeys, eggs, and milk consumed in the region when wheat was priced at $40.00 per ton. Region I also transported 1,704,812,000 pounds

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[5]The ranging procedure was accomplished with computer analysis utilizing the parametric package of the IBM MPS-360 program.

of pork to Region III, which represented the entire amount consumed in that region.

TABLE 26. ANALYSIS OF DEMAND FOR WHEAT IN THE PACIFIC NORTHWEST USING PARAMETRIC ANALYSIS BASED ON 1968 PRICES

BASIS CHANGE	QUANTITY SPECIFIED[1] (Tons)	PRICE (Dollars per ton)
Initial	5,231,374	40.00
1	4,849,517	40.82
2	3,629,434	42.36
3	1,403,320	43.99
4	1,352,027	44.01
5	1,254,000	44.32
6	1,124,527	46.22
7	994,964	46.31
8	916,122	47.02
9	713,087	47.03
10	0	52.09

[1]Quantity specified denotes the quantity of wheat, as determined by the model, that was available for feeding to livestock.

The first change of basis, according to the model, occurred at a price of $40.82 per ton. At this price the model specified 4,849,517 tons of wheat for livestock feeding in Region I. All of the decrease in wheat utilization was in the quantity of wheat fed to hogs. Hogs were fed 2,939,202 tons of wheat at a price of $40.82

per ton. Transfer of pork from Region I to Region III was decreased from 1,704,812,000 pounds to 1,455,194,890 pounds. The balance of the pork required in Region III was produced in that region.

Change of Basis 2 occurred at a price of $42.36 per ton. At this price 3,629,434 tons of wheat were specified for use in the region. At this price no wheat was fed to beef in Region I and the region ceased to feed beef. All of the beef consumed was imported from Region IV. All other activities continued unchanged.

The third change of basis took place at a wheat price of $43.99, when feeding of wheat in the region dropped to 1,403,320 tons. Of the wheat allocated by the model 713,087 tons were fed to hogs, 259,036 tons to broilers, 51,293 tons to turkeys, 281,876 tons to laying hens, and 98,027 tons to milk cows. No change in feeding occurred except for hogs. At a wheat price of $43.99, transfer of pork from Region I to Region III was discontinued. Region III received the pork required from Region IV.

The fourth change of basis took place at a wheat price of $44.01, when wheat feeding in the region was reduced to 1,352,027 tons. This change occurred when wheat feeding to turkeys was discontinued. Turkey production in Region I was also discontinued and all turkey consumed in the region was imported from Region IV, according to the model.

The fifth change of basis occurred at a wheat price of $44.32 per ton. At this price 1,254,000 tons of wheat were specified by the model for feeding in Region I. The 98,027 tons of wheat fed to milk cows was replaced by 104,462 tons of barley. No change in production of livestock products took place. The price of wheat at this point was $1.21 per ton above the Region I average 1968 price, but the model was still specifying 210,472 tons of wheat above the 1968 quantity allocated in the basic model.

The sixth change of basis occurred at a price of $46.22 per ton. At this price the model specified 1,124,527 tons of wheat for feeding in Region I. Of the wheat allocated by the model 713,087 tons were fed to hogs, 129,564 tons to broilers, and 281,876 tons to laying hens. This change reduced the quantity of wheat fed to broilers in Region I. The demand for broilers in the region was satisfied by producing 225,183,940 pounds of broilers in Region I with wheat and importing 55,380,060 pounds from Region IV.

The seventh change of basis came at a wheat price of $46.31 per ton. At this price 994,964 tons of wheat were specified by the model for feeding in the region. Wheat feeding to broilers was terminated. Corn replaced wheat in feeding broilers to the extent that corn was available. All of the corn produced, 68,852 tons, was fed to broilers. There were 84,852,580 pounds of broilers produced in the region, while 195,711,420 pounds were imported from Region IV.

The eighth change of basis occurred at a wheat price of $47.02 per ton, when 916,122 tons of wheat were specified by the model for feeding in the region. This change resulted when wheat fed to laying hens was reduced from 281,876 tons to 203,035 tons. At the price of $47.02 per ton for wheat, corn feeding to broilers was terminated and the 68,852 tons of corn produced in Region I were fed to laying hens. All of the pork, eggs and milk were still produced in the region with locally produced feed grains.

The ninth change of basis occurred at a wheat price of $47.03 per ton. At this price 713,087 tons of wheat were fed to hogs in Region I according to the model. Wheat feeding to laying hens was terminated in the region. Wheat was replaced in feeding laying hens by barley. There were 238,235 tons of barley fed to layers. In addition, 68,852 tons of corn were fed to layers and Region I continued to produce all the pork, eggs and milk consumed in the region. All the beef, broilers and turkeys were transported from Region IV.

The tenth change of basis took place at a wheat price of $52.09, when all wheat feeding in Region I was terminated according to the model. The products required to meet the demand for beef, pork, broilers, turkeys, eggs, and milk in Region I were obtained as follows: The beef, pork, broilers, and turkeys required for consumption were transported from Region IV. Region I produced all of the eggs and milk required in the region. Eggs were produced by feeding 238,235 tons of barley and 68,852 tons of corn to laying hens. Milk was produced by feeding 104,462 tons of barley and 1,495,000 tons of hay to milk cows.

None of the oats produced in Region I were ever fed, according to the model, at the 1968 price of oats. At a price of $40.00 per ton for wheat, more wheat was specified for feeding than was actually produced in Region I in 1968.

Considerable analysis was accomplished with the 1968 price model using the results from the parametric procedure. A price elasticity of demand was computed using several approaches. All of the work indicated that the price elasticity of demand coefficients were elastic, that is, greater than 1. If the calculated coefficient is greater than 1, demand is said to be elastic, that is, a given percentage change in price will result in a greater percentage change in quantity demanded. Since price times quantity gives total revenue, a decline in price will increase total revenue because quantity demanded increases proportionately more than price declines. The demand curve for wheat in Region I as determined from the parametric analysis is shown in Figure 4. The price and quantity are calculated as the average price and quantity for each change of basis.

The arc elasticity formula is:

$$\eta = (-) \frac{\Delta q}{\Delta p} \frac{(P_2 + P_1)}{(q_2 + q_1)}$$

Using the average approach, that is the average price and average quantity at each change of basis, the arc elasticity formula applied gives the following for the total demand curve:

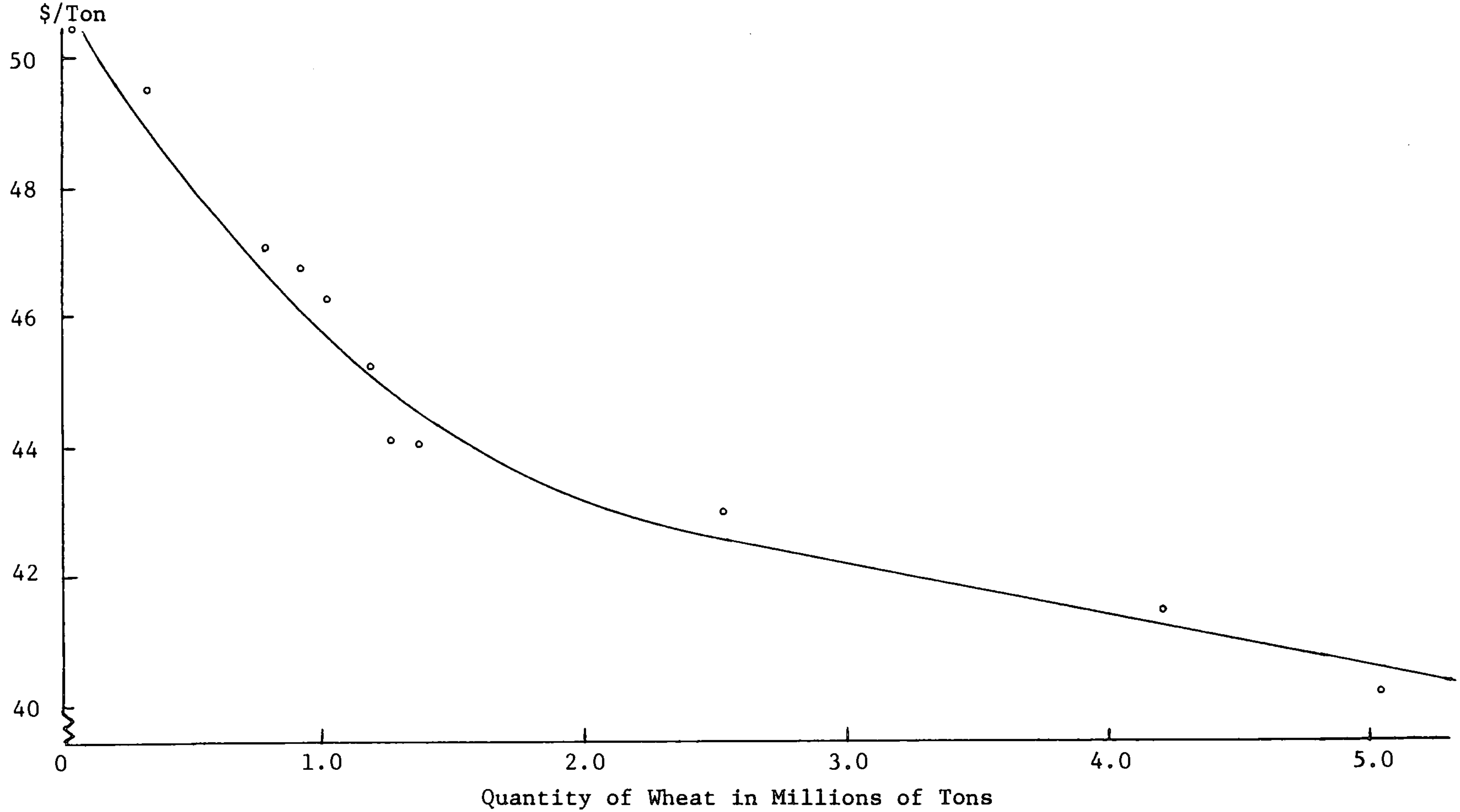

FIGURE 4. DEMAND CURVE FOR WHEAT IN REGION I

$$= (-)\ \frac{5{,}040{,}446 - 356{,}544}{49.56 - 40.41} \left(\frac{40.41 + 49.56}{(5{,}040{,}446 + 356{,}544)}\right)$$

$$= (-)\ \frac{4{,}683{,}902}{9.15} \left(\frac{89.97}{(5{,}396{,}990)}\right)$$

$$= (-)\ 511{,}901.858 \quad (.0000166704)$$

$$= (-)\ 8.5336$$

The elasticity between the third and tenth basis change is:

$$= (-)\ \frac{2{,}516{,}377 - 356{,}544}{49.56 - 43.18} \left(\frac{49.56 + 43.18}{(2{,}516{,}377 + 356{,}544)}\right)$$

$$= (-)\ \frac{2{,}159{,}833}{6.38} \left(\frac{92.74}{(2{,}872{,}921)}\right)$$

$$= (-)\ 338{,}531.818 \quad (.0000322807) = (-)\ 10.928$$

It should be realized that these elasticities are based only on the demand for wheat as a feed grain and are based only on 1968 relative prices. The elasticities developed here should be used with caution.

A price predicting equation was developed using a least squares analysis. The data on which the equation is based are the 1968 data generated by the parametric analysis. Using these data a price predicting equation was generated.

$$Y = a + bX$$

Where "Y" is the price of wheat in dollars per ton, "a" is the "Y" intercept and "b" is the slope of the demand curve for wheat. "X", the variable representing quantity, was transformed to $\frac{1}{X}$ to more nearly approximate the curve of the demand function.

The unknown of the equation is the price of wheat. For example, if wheat producers in Washington and Oregon desired to market 2,000,000 tons of wheat as a livestock feed, the equation predicts the price as follows:

a = 39.564

b = 7,127,897.2603

X = 2,000,000

$$Y = 39.564 + \frac{7,127,897.2603}{2,000,000}$$

$$= 39.564 + 3.564$$

$$= 43.127$$

The price of wheat should be $43.13 per ton.

Another example indicates that when using 1,043,000 as the value of "X", the equation predicts the price of wheat as $46.40 per ton.

The R^2 of this equation is .9624, which indicates the vertical deviation from the regression line is small and that the fit is good.

If it is assumed that the farmers desired a certain price for their wheat and wanted to know what quantity to sell to obtain that price, quantity could also be determined.

If it is assumed that a price of $46.00 per ton was desired and quantity "X" is to be determined, "X" can be computed as follows:

$$X = \frac{b}{Y - a}$$

$$= \frac{7,127,897.2603}{46.00 - 39.564}$$

$$= \frac{7,127,897.2603}{6.436} = 1,107,504$$

Farmers should market 1,107,504 tons of wheat to obtain the price of $46.00 per ton, according to the equation.

Caution should be used in the application of this formula because it is based only on 1968 relative prices. If relative prices changed materially, the formula would be nearly worthless for predicting the price of wheat for use as a feed grain without adjustment. The formula does a good job of telling theoretically what the 1968 price of wheat should have been for different quantities offered for sale.

ANALYSIS OF DEMAND FOR WHEAT IN REGION I USING 1969 PRICES

This analysis is based on metabolizable energy and 1969 prices. Wheat was in the model as an unbounded variable in Region I, and the price of wheat was varied from $40.00 per ton to $60.00 per ton.[6] All other feed grains were in the model initially at the level of the cost minimizing optimal solution based on 1969 costs of feed grains and livestock products.

Table 27 shows a summary of wheat utilization in Region I. Based on the initial allocation utilizing the parametric procedure and permitting the model to determine the quantity of wheat specified for feeding, there were 10,653,553 tons of wheat produced in Region I. Of this quantity 9,603,193 tons were utilized in the region. There were 5,259,230 tons fed to beef, 3,653,731 tons fed to hogs, 259,036 tons fed to broilers, 51,293 tons fed to turkeys, 281,876 tons fed to laying hens, and 98,027 tons fed to milk cows. When wheat was priced at $40.00 per ton no other feeds produced in the region were fed because the relative prices and feeding values of the other grains could not compete with wheat. In addition there were 1,050,360 tons of wheat shipped to Region III.

Region I produced all of the products--beef, pork, broilers, turkeys, eggs, and milk--consumed in the region and exported

[6]Unbounded variable denotes that no maximum quantity of wheat was specified and the model could specify any quantity of wheat that would be economically advantageous at the price specified in Region I.

TABLE 27. ANALYSIS OF DEMAND FOR WHEAT IN REGION I BASED ON METABOLIZABLE ENERGY AND 1969 PRICES

BASIS CHANGE	QUANTITY SPECIFIED (Tons)	PRICE ($ per ton)	QUANTITY FED (1,000 tons)	QUANTITY TRANSPORTED (1,000 tons)
Initial	10,653,553	40.000	9,603.2	1,050.4
1	10,598,635	40.084	9,603.2	995.4
2	10,256,963	40.178	9,270.5	995.4
3	10,000,314	40.203	9,270.5	729.8
4	9,941,260	41.057	9,211.5	729.8
5	9,481,326	41.109	8,751.5	729.8
6	5,501,233	41.218	4,771.4	729.8
7	4,771,440	43.993	4,771.4	-
8	4,011,291	44.174	4,011.3	-
9	3,913,264	44.678	3,913.3	-
10	3,531,407	46.430	3,531.4	-
11	1,305,293	46.617	1,305.3	-
12	1,254,000	46.883	1,254.0	-
13	1,227,189	47.384	1,227.2	-
14	945,313	47.449	945.3	-
15	893,782	47.896	893.8	-
16	843,784	48.775	843.8	-
17	713,087	49.431	713.1	-
18	-	54.630	-	-

1,056,024,000 pounds of beef to Region III. Region I also exported 217,465,170 pounds of pork to Region II and 1,704,812,000 pounds of pork to Region III.

The first change of basis occurred at a price of $40.084 per ton. The quantity of wheat exported to Region III was reduced from 1,050,360 tons to 995,441 tons. The balance of the model was unchanged.

Basis Change 2 occurred at a price of $40.178 per ton. The quantity of wheat fed in Region I was reduced from 9,603,193, tons to 9,270,522 tons allocated as follows: beef unchanged at 5,259,230 tons; hogs reduced from 3,653,731 tons to 3,321,059 tons; all other classes unchanged. Because of the increase in the price of wheat, pork production was reduced by 217,465,170 pounds and exporting of pork from Region I to Region II was eliminated.

The third change of basis occurred at a price of $40.203 per ton when the specified quantity was reduced to 10,000,314 tons of wheat. All of this change took place in a reduction of the quantity of wheat exported to Region III. This quantity was reduced from 995,441 tons to 729,793 tons. All other allocations were unchanged.

The fourth change of basis took place at a price of $41.057 per ton, when the quantity of wheat specified by the model was reduced from 10,000,314 tons to 9,941,260 tons. This reduction took place in Region I where feeding was reduced from 9,270,552 to 9,211,467 tons of wheat. Wheat fed to beef was reduced from

5,259,230 tons to 5,200,176 tons and the quantity of beef exported to Region III was reduced from 1,056,024,000 pounds to 1,040,584,010 pounds. The rest of the model was unchanged.

The basis changed for the fifth time at a price of $41.109 per ton. The quantity of wheat specified by the model was reduced from 9,941,260 tons to 9,481,326 tons. The allocation within Region I changed from 9,211,467 tons to 8,751,534 tons. Beef feeding was reduced to 4,740,242 tons of wheat. This feed was replaced by feeding barley to beef in Region I. The quantity of beef produced and utilized within the region and exported was unchanged. All other feeding activities were unchanged.

The sixth change of basis occurred at a price of $41.218 per ton. The quantity of wheat specified for feeding in Region I was reduced from 8,751,534 tons to 4,771,440 tons. All of the reduction occurred in wheat fed to beef, which was reduced from 4,740,242 tons to 760,149 tons. Other wheat feeding remained unchanged. The exporting of beef to Region III was terminated when the price of wheat in Region I reached $41.218. Region I was still exporting wheat, but no longer exported livestock products.

The seventh change of basis occurred at a price of $43.993 per ton, when exporting of wheat to Region III was terminated. Feeding within Region I was unchanged and Region I was still exporting pork to Region III.

The eighth change of basis occurred at a price of $44.174 per ton. There were 4,011,291 tons of wheat specified by the model which were fed as follows: wheat fed to hogs was unchanged at 3,321,059 ton; broilers were fed 259,036 tons, turkeys 51,293 tons, laying hens 281,876 tons, and milk cows 98,027 tons.

The ninth change of basis occurred at a price of $44.678 per ton. At this price 3,913,264 tons were fed in the region. The decrease from the eighth change of basis was the result of ceasing to feed wheat to milk cows.

The tenth change of basis occurred at a price of $46.430 per ton. At this price 3,531,407 tons of wheat were specified for feeding. This change resulted from a reduction in feeding wheat to hogs. There were 2,939,202 tons of wheat fed to hogs, a decrease of 381,857 tons from previous iterations. The quantity of pork exported to Region III was reduced from 1,704,812,000 pounds to 1,455,194,890 pounds.

The eleventh change of basis occurred at a price of $46.617 per ton. The quantity of wheat specified by the model for feeding hogs was reduced from 2,939,202 tons to 713,087 tons and all pork exports were discontinued.

The next change of basis occurred at a price of $46.883 per ton. The wheat specified by the model for feeding was reduced to 1,254,000 tons. This change occurred because turkey feeding was eliminated from the model.

The thirteenth change of basis occurred at a price of \$47.384 per ton. The specified quantity was reduced to 1,227,189 tons of wheat. This was fed as follows: hogs 713,087 tons; broilers 232,225 tons, a reduction of 26,811 tons; laying hens were fed 281,876 tons.

The next change occurred at a price of \$47.449 per ton. This change took place because the feeding of wheat to laying hens was eliminated from the model. Beef production was reduced from 94,776,590 pounds to 14,129,110 pounds, and the rest of the beef required in the region was imported from Region IV. All other products were still produced in the region.

The fifteenth change of basis took place at a price of \$47.896 per ton. The wheat specified by the model for feeding in Region I was reduced from 945,313 tons to 893,782 tons. This change occurred because of a reduction in the feeding of wheat to broilers. The quantity of wheat fed to this class of livestock was reduced from 232,225 tons to 180,694 tons. Turkey production was eliminated in the region and turkey was imported from Region IV to Region I.

The next change of basis occurred at a price of \$48.775 per ton. At this price the quantity of wheat specified for feeding was reduced to 843,784 tons and feeding of wheat to broilers was reduced from 180,694 tons to 130,696 tons.

The seventeenth change of basis occurred at a price of \$49.431 per ton. Wheat feeding was eliminated for broilers and feeding of wheat to hogs was the only activity for wheat that occurred in the model. All of the beef, all of the turkey and about half of the broilers consumed in Region I were imported from Region IV. All of the pork, eggs and milk, and about half of the broilers were produced in the region.

The last change of basis took place at a wheat price of $54.630 per ton. At this price wheat specified for feeding was terminated in the model. The following livestock feeding and product producing activities occurred in the region: 57,945 tons of barley were fed to broilers; 330,745 tons of barley were fed to laying hens and 104,462 tons of barley were fed to milk cows; all of the 68,852 tons of corn produced in Region I were fed to broilers; all of the hay produced was fed to dairy cows. All of the 318,987,000 pounds of beef consumed were imported from Region IV. All of the 466,140,000 pounds of pork consumed were imported from Region IV. Region I produced 139,005,790 pounds of broilers and imported 141,558,210 pounds from Region IV. All of the 51,353,000 pounds of turkey consumed were imported from Region IV. Region I produced all of the 140,908,000 dozen eggs consumed in the region. All of the milk consumed in Region I, 3,039,000,000 pounds, was produced in the region.

The general conclusions suggested by this analysis are:

(1) At the wheat price of $42.08 per ton that existed in Region I in 1969, more wheat could have been fed to livestock and

exported to Region III than was actually produced in the region, given the relative prices of other feeds and products as specified by the model.

(2) Wheat prices in Region I could have increased by about $4.00 per ton, or to $46.00 per ton, before any products required to satisfy the level of consumption specified in the model would have been imported from outside the region.

(3) As wheat prices increased above $40.00 per ton, the region changed from a feed grain, beef and pork exporting region to a region of feed grain and pork exporting, thence to a pork exporting region, and finally to a self-sufficient region for all products. As wheat prices continued to increase above $46.00 per ton, the region imported first beef, then beef and turkey, then beef, turkey and part of the broilers, and finally when no wheat was fed in the region all of the beef, turkey, pork, and part of the broilers were imported in the quantities necessary to satisfy the quantities demanded.

(4) The use of wheat as a feed grain is dependent on the relative prices and feeding values of all feed grains in the region. When wheat is priced based on these considerations, the quantities producers would be willing to make available for feeding on a consistent year to year basis would appear to be the only real problem in utilizing wheat as a feed grain.

(5) The potential use of wheat in feeding hogs would appear to be a highly desirable alternative. The production of all the pork consumed in Region I continued until the price of wheat reached $54.63 per ton.

CHAPTER V

SUMMARY AND CONCLUSIONS

The linear programming model designed and utilized in the analysis of the livestock-feed grain economy of the United States has produced results that have added to the information and understanding of the author. The model is based only on 1968 livestock and feed grain production levels and 1968 and 1969 relative prices. The model developed accomplished the objectives of the study and gave a good insight into the competitive position of the producers of Region I.

Based on the relative feed ingredient costs that existed in 1968, producers of pork, broilers, eggs, and milk in Region I are competitive with other regions in the production of these products at the levels of consumption that existed in 1968. The 1969 relative prices made Region I even more competitive and beef production occurred as well as production of pork, broilers, eggs, and milk, according to the model. All of the feed grains except oats were fed in the region at 1969 relative prices.

The model was designed to determine for the entire nation the least cost method of producing the quantity of each product required for consumption in each region. Based on feed ingredient costs (not total costs), only pork, broilers, eggs, and milk would be produced at 1968 prices in Region I. At 1969 prices beef, pork, broilers, eggs, and milk would be produced in Region I.

Region IV had the lowest feed ingredient costs for producing most livestock products. These costs were sufficiently low to permit Region IV to supply most of the products that Region I and Region III imported at the relative prices and transportation costs that existed in 1968 and 1969.

A parametric procedure, part of the MPS-360 linear programming package at Utah State University, was used to analyze the demand for wheat in Region I. Based on 1968 relative prices, the analysis indicated according to the model that wheat would have been utilized in larger quantities at the price of $43.11 than was allowed for the feeding of livestock by the basic model. There were 1,043,528 tons of wheat allocated for livestock feeding in the basic analysis. The parametric analysis specified a quantity of 3,629,434 tons for livestock feeding at 1968 relative prices. When this quantity of wheat was specified for feeding, wheat was used to produce all of the pork, broilers, turkeys, eggs, and milk required in Region I and Region I exported all the pork consumed in Region III.

The parametric analysis at the 1969 relative prices indicated that the price of wheat in Region I could have increased from $42.08 per ton to $46.00 per ton, and at that cost Region I could have produced all of the livestock products consumed in the region.

The parametric analysis indicated that the use of wheat as a feed grain in quantity is largely dependent on the availability of wheat in Region I on a consistent basis at a competitive price.

Fluctuations in the quantity of wheat available for livestock feeding from year to year could be just as difficult for livestock producers to cope with as price fluctuations.

CONCLUSIONS

Feed deficit regions generally have a slight advantage in producing the livestock products consumed in the region until locally produced feed grains are utilized.

Freight rate increases tend to restrict trade and increase costs, while freight rate decreases encourage trade between regions and reduce costs.

Feed cost differences between regions are generally of about the same magnitude as transportation costs of moving the livestock products between regions. This results in narrow margins in most cases for either the exporting or importing region. The narrow margins would appear to give neither the low feed cost region nor the high feed cost region a large absolute advantage based on feed costs only.

Slight year to year changes in regional feed costs can make relatively large changes in the allocation and production of livestock products among regions.

Based on the parametric analysis, Region I could have utilized much larger quantities of white wheat for livestock feeding in the region than were allocated in the basic model.

At 1969 relative prices and the 1969 price of wheat of \$42.08 per ton in Region I, the region could have produced all of the beef, pork, broilers, turkeys, eggs, and milk consumed in the region and no imports would have been required. In addition to the above, Region I could have supplied Region III with all of the pork consumed in that region, according to the model. This conclusion could be questioned because most of the wheat produced in Region I would have been fed to livestock. This is unrealistic because other market alternatives would have allowed a higher price for producers.

POLICY IMPLICATIONS

It would appear that the same transportation rate for carcass beef and pork might be causing misallocation of production resources. Most regions produced their own pork, while nearly 1,500,000,000 pounds of beef were transported between regions in 1968. A review of the rate structure of these two commodities might result in some adjustment downward in pork freight rates.

A two-price plan for wheat to allow production of wheat as a feed grain or the development of a new feed grain as desirable in feeding quality as wheat and with higher production potential at similar costs would permit expansion of livestock feeding in the Pacific Northwest.

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APPENDIX

DEFINITION OF TERMS USED IN FIGURE 3, THE TWO-REGION MATRIX

ROWS

BARUS	Barley use means barley production in the region specified.
WHTUS	Wheat use means wheat production for livestock feeding in region specified.
CRNUS	Corn use means corn production in the region specified.
OATUS	Oat use means oat production in the region specified.
MLOUS	Milo use means milo production in the region specified.
BARRQ	Barley required means barley required for feeding in region specified.
WHTRQ	Wheat required.
CRNRQ	Corn required.
OATRQ	Oats required.
MLORQ	Milo required.
HAYRQ	Hay required means hay produced in the region and available for feeding.
PRORQ	Protein required means the protein necessary to satisfy the nutrient requirements for protein as specified for each class of livestock.
BFFED	Beef fed in the region specified.
BFPRO	Beef protein: the percent digestible protein required by beef for production in the region specified.
BFRAT	Beef ration: an accounting row for protein use in the ration.
HGFED	Hogs fed in the region specified.
HGPRO	Hog protein: the percent digestible protein required by hogs for production by region.
HGRAT	Hog ration: an accounting row for protein use in the ration.

BRFED Broilers fed in the region specified.

BRPRO Broiler protein: the percent digestible protein required by broilers for production by region.

BRRAT Broiler ration: an accounting row for protein use in the ration.

TKFED Turkeys fed in the region specified.

TKPRO Turkey protein: the percent digestible protein required by turkeys for production.

TKRAT Turkey ration: an accounting row for protein use in the turkey ration.

LYFED Layers fed in the region specified.

LYPRO Layer protein: the percent digestible protein required in the ration.

LYRAT Layer ration: an accounting row for protein use in the layer ration.

MCFED Milk cows fed in the region specified.

MCPRO Milk cow protein: the percent digestible protein required in the dairy ration.

MCRAT Milk cow ration: an accounting row for protein use in the dairy ration.

BEFAV Beef available, or beef production in the specified region.

HOGAV Hog available, or pork production in the specified region.

BROAV Broiler available, or broiler production in the specified region.

TUKAV Turkey available, or turkey production in the specified region.

EGGAV Eggs available, or egg production in the region specified.

MLKAV Milk available, or milk production in the region specified.

BEFRQ Beef required, or the quantity of beef demanded (consumed) in the specified region.

HOGRQ Hog required, or the quantity of pork demanded (consumed) in the specified region.

BRORQ Broiler required, or the quantity of broilers demanded (consumed) in the region specified.

TUKRQ Turkey required, or the quantity of turkey demanded (consumed) in the region specified.

EGGRQ Eggs required, or the quantity of eggs demanded (consumed) in the region specified.

MLKRQ Milk required, or the quantity of milk demanded (consumed) in the region specified.

COLUMNS

BARAV Barley available for feeding in the region specified.

WHTAV Wheat available for feeding in the region specified.

CRNAV Corn available for feeding in the region specified.

OATAV Oats available for feeding in the region specified.

MLOAV Milo available for feeding in the region specified.

HAYAV Hay available for feeding in the region specified.

PROAV Protein available for feeding in the region specified.

BART12 Barley transportation. First number indicates region of origin and second is region of destination. Interpretation is the same for all feeds in the model except hay and protein, which are not transported.

BARBF Barley beef means barley fed to beef in the region specified. The same applies for all feed grains and all classes of livestock.

BEFPD Beef production in region specified. Same for all feed grains fed to all classes of livestock.

BEFT12 Beef transportation between regions where the first number is the region of origin and the second is the region of destination. Interpretation is the same for all classes of livestock produced.

BEFDM Beef demand, or the quantity of beef required to satisfy demand in the region specified. Same interpretation for all livestock products in the model.

TABLE 28. REGIONAL PRODUCTION OF FEED GRAINS, 1968[1]

(Quantities expressed in tons)

REGION	BARLEY	WHEAT[2]	CORN	OATS	GRAIN SORGHUM	HAY[3]
I	493,152	1,043,528	68,852	109,312	---	1,495,000
II	2,508,168	743,889	710,640	279,637	1,236,704	2,495,000
III	1,687,200	381,930	492,100	72,080	705,600	3,905,000
IV	4,455,080	2,725,680	57,170,518	8,938,960	18,461,324	16,550,000
V	852,384	1,965,315	64,045,856	5,454,464	274,568	20,332,000
TOTAL	9,995,984	6,860,342	122,487,966	14,871,925	20,678,196	44,777,000

[1]Source: Crop Production, 1969, U. S. Dept. of Agriculture.

[2]Quantity of wheat assumed available for livestock feeding in each region.

[3]Quantity of hay assumed available for feeding beef animals and dairy cows.

TABLE 29. REGIONAL WEIGHTED AVERAGE FEED GRAIN PRICES FOR 1968

(Dollars per ton)

	BARLEY	WHEAT	CORN	OATS	MILO	ALFALFA	SOYBEAN
REGION I	40.85	43.11	47.23	46.88	--	25.79	124.00
REGION II	36.97	38.43	41.94	41.41	37.21	22.75	113.71
REGION III	45.42	44.00	48.21	51.25	43.60	25.00	120.00
REGION IV	34.10	42.37	37.30	36.34	32.89	20.29	102.56
REGION V	36.10	38.46	38.23	40.12	34.78	22.05	107.81

TABLE 30. REGIONAL WEIGHTED AVERAGE PRICES RECEIVED BY FARMERS, 1968[1]

(Dollars per cwt.)

	BEEF	PORK	BROILERS	TURKEY	EGGS[2]	MILK
REGION I	24.57	19.48	17.70	21.20	31.10	5.45
REGION II	25.74	18.74	16.90	21.10	32.60	5.22
REGION III	26.20	18.90	16.60	20.30	28.40	5.01
REGION IV	25.68	18.57	15.10	19.70	27.10	4.72
REGION V	24.63	18.67	14.10	21.30	37.20	5.46

[1]Source: Agricultural Prices, 1969, U. S. Dept. of Agriculture.

[2]Dollars per 100 dozen eggs.

TABLE 31. TRUCK FEED GRAIN TRANSPORTATION RATES[1]

(Dollars per ton)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	---	14.37	11.34	18.43	22.56
REGION II	14.37	---	12.95	7.12	11.79
REGION III	11.34	12.95	---	18.14	22.39
REGION IV	18.43	7.12	18.14	---	6.49
REGION V	22.56	11.79	22.39	6.49	----

[1]Derived from Texas A & M formula.

TABLE 32. BASIC TRUCK CARCASS RATES[1]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	---	2.24384	1.90812	2.69401	3.15290
REGION II	2.24384	---	2.08688	1.43942	1.95826
REGION III	1.90812	2.08688	---	2.66240	3.13437
REGION IV	2.69401	1.43942	2.66240	---	1.36966
REGION V	3.15290	1.95826	3.13437	1.36966	---

[1]Source: Texas A & M formula.

TABLE 33. COST OF TRANSPORTING BEEF CARCASSES IN LIVE WEIGHT EQUIVALENT[1]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	---	1.3082	1.1124	1.5706	1.8381
REGION II	1.3082	---	1.2167	.8392	1.1417
REGION III	1.1124	1.2167	---	1.5522	1.8273
REGION IV	1.5706	.8392	1.5522	---	.7985
REGION V	1.8281	1.1417	1.8273	.7985	---

[1]Source: Texas A & M formula, conversion factor from carcass to live equivalent = live weight X .583 X carcass rate.

TABLE 34. COST OF TRANSPORTING PORK CARCASSES IN LIVE WEIGHT EQUIVALENT[1]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	--	1.4181	1.2059	1.7026	1.9926
REGION II	1.4188	--	1.3189	.9097	1.2376
REGION III	1.2059	1.3189	--	1.6826	1.9809
REGION IV	1.7026	.9097	1.6826	--	.8656
REGION V	1.9926	1.2376	1.9809	.8656	--

[1]Source: Texas A & M transportation formula, conversion factor from carcass to live weight equivalent = live weight X .632 X carcass rate.

TABLE 35. COST OF TRANSPORTING BROILERS RTC[1] IN LIVE WEIGHT EQUIVALENTS[2]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	--	1.6155	1.3738	1.9397	2.2701
REGION II	1.6155	--	1.5026	1.0364	1.4099
REGION III	1.3738	1.5026	--	1.9169	2.2567
REGION IV	1.9397	1.0364	1.9169	--	.9862
REGION V	2.2701	1.4099	2.2567	.9862	--

[1]Ready to cook.

[2]Source: Texas A & M formula, conversion factor from RTC to live weight equivalent = live weight X .720 X RTC rate.

TABLE 36. COST OF TRANSPORTING TURKEY RTC[1] IN LIVE WEIGHT EQUIVALENTS[2]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	--	1.7951	1.5265	2.1552	2.5223
REGION II	1.7951	--	1.6695	1.1515	1.5666
REGION III	1.5265	1.6695	--	2.1299	2.5075
REGION IV	2.1552	1.1515	2.1299	--	1.0957
REGION V	2.5223	1.5666	2.5075	1.0957	--

[1]Ready to cook.

[2]Source: Texas A & M formula, conversion factor from RTC to live weight equivalent = live weight X .800 X RTC rate.

TABLE 37. RAIL TRANSPORTATION COSTS FOR FRESH EGGS[1]

(Cents per dozen)[2]

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	--	5.75	2.65	6.19	6.34
REGION II	2.39	--	2.39	2.86	3.85
REGION III	2.65	5.75	--	6.19	6.34
REGION IV	2.39	2.39	2.39	--	2.37
REGION V	2.78	3.85	2.78	2.37	--

[1]Source: Ph.D. dissertation of Harry G. Witt, Univ. of Florida, 1970, Appendix Table 16.

[2]Figured on 1273.89 dozen eggs per ton, or 1.57 pounds per dozen.

TABLE 38. TRUCK TRANSPORTATION COSTS FOR WHOLE MILK[1]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	--	2.23	1.75	3.13	3.54
REGION II	2.23	--	2.00	1.16	1.80
REGION III	1.75	2.00	--	2.73	3.54
REGION IV	3.13	1.16	2.73	--	1.00
REGION V	3.54	1.80	3.54	1.00	--

[1]Source: Ph.D. dissertation by Harry G. Witt, Univ. of Florida, 1970, Appendix Table 17.

TABLE 39. MEGA CALORIES OF METABOLIZABLE ENERGY PER TON OF FEED FED TO VARIOUS CLASSES OF LIVESTOCK[1]

PRODUCT	BARLEY	WHEAT	CORN	OATS	MILO	HAY	PROTEIN
BEEF	2423	2598	2566	2219	2423	1683	2509
HOGS	2609	3099	2971	2420	2896	--	2718
BROILERS	2400	2800	3100	2300	3000	--	2200
TURKEYS	2400	2800	3100	2300	3000	--	2200
LAYING HENS	2400	2800	3100	2300	3000	--	2200
MILK COWS	2423	2598	2566	2219	2423	1683	2509

[1]Calculated by author from U. S.-Canadian Feed Composition Tables, National Research Council.

TABLE 40. MEGA CALORIES OF METABOLIZABLE ENERGY REQUIRED FOR MAINTENANCE AND PRODUCTION[1]

	BEEF[2]	HOGS[2]	BROILERS[2]	TURKEYS[2]	LAYERS[3]	MILK COWS[2]
REGION I	9937	5229	3152	3659	6243	1005
REGION II	9831	5230	3147	3669	6395	991
REGION III	10009	5230	3156	3663	6276	946
REGION IV	10066	5244	3149	3658	6466	994
REGION V	9973	5231	3143	3670	6731	1005

[1]Source: Calculated by the author from Nutritive Requirements of Livestock, National Research Council.

[2]Per thousand pounds of product produced.

[3]Per thousand dozen eggs produced.

TABLE 41. WEIGHTED AVERAGE 1969 FEED PRICES BY REGION[1]

(All prices in dollars per ton)

	BARLEY	WHEAT	CORN	OATS	MILO	HAY	PROTEIN[2]
REGION I	38.34	42.08	49.15	42.50	--	26.00	122.00
REGION II	36.45	40.05	44.25	38.68	43.06	24.36	113.60
REGION III	51.25	48.33	51.43	51.25	47.14	27.50	113.20
REGION IV	32.39	41.12	38.91	34.23	37.53	20.73	102.00
REGION V	36.66	39.20	41.61	39.99	37.85	24.56	106.00

[1] Source: Agricultural Statistics, 1970 edition.

[2] Protein cost based on simple average price by region (prices paid by farmers.) Source: Agricultural Prices, 1970 edition.

TABLE 42. WEIGHTED AVERAGE 1969 PRICES OF LIVESTOCK PRODUCTS BY REGION[1]

	BEEF $/CWT	HOGS $/CWT	BROILERS $/CWT	TURKEYS $/CWT	EGGS $/100 DOZ.	MILK $/CWT
REGION I	27.23	21.97	18.40	24.01	38.27	5.89
REGION II	28.89	22.46	18.01	22.85	39.14	5.60
REGION III	28.50	22.50	17.30	23.00	34.10	5.46
REGION IV	28.49	22.16	15.81	21.83	34.45	4.90
REGION V	26.82	22.11	15.05	22.53	42.69	5.74

[1]Source: Agricultural Statistics, 1970 edition.

TABLE 43. COST OF TRANSPORTING FEEDER CATTLE BY TRUCK[1]

(Dollars per cwt.)

	REGION I	REGION II	REGION III	REGION IV	REGION V
REGION I	--	2.711	2.102	3.525	4.352
REGION II	2.711	--	2.427	1.244	2.193
REGION III	2.102	2.427	--	--	--
REGION IV	3.525	1.244	--	--	--
REGION V	4.352	2.193	--	--	--

[1]Source: Texas A & M formula.